SINHGAD TECHNICAL EDUCATION SOCIETY'S®
SMT. KASHIBAI NAVALE COLLEGE OF ENGINEERING®
Approved by AICTE Vide F. No. 740-89-004 (NDEGAPR/ET/2000) &
Affiliated to Savitribai Phule Pune University ID. No. PU/PN/ENGG/155/2001
Accrediated by NBA & NACC
Recognized by UGC under Section 2 (f) & 12 (B) of UGC Act 1956
Sinhgad Institutes
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FOUNDER - SECRETARY

DR. A. V. DESHPANDE
B. E., M. E. (Computer Engg.), Ph. D.
PRINCIPAL

17/05/2022

To,
The Director
National Assessment and Accreditation Council (NAAC)
P.O. Box No. 1075, Nagarbhavi,
Bengaluru- 560 072

Subject: Proofs of Metric No. 1.2.1

Reference: Metric No. 1.2.1: Percentage of programs in which Choice Based Credit System (CBCS)/elective course system has been implemented

Dear sir/Madam,

Percentage of programs in which Choice Based Credit System (CBCS)/elective course system has been implemented as follows:

Programme Code	Programme name	Year of Introduction	Status of implementation of CBCS / elective course system (Yes/No)	Year of implementation of CBCS / elective course system
617824510, 617824520	B E Computer Engineering	2001	Yes	2015
617824510	M E Computer Engineering	2011	Yes	2015
CEGP013380	Ph.D. Computer Engineering	2012	No	2012
617824610	B E Information Technology	2001	Yes	2015
617837210, 617837220	BE E&TC Engineering	2001	Yes	2015
617861210, 617861220	B E Mechanical Engineering	2006	Yes	2015
617810110	Master of Business Administration	2008	Yes	2015

Percentage of programs in which Choice Based Credit System (CBCS)/elective course system = [(06/07) *100] = 85%

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Programme Code	Programme name	Year of Introduction	Status of implemetation of CBCS / elective course system (Yes/No)	Year of implemetation of CBCS / elective course system
617824510, 617824520	B E Computer Engineering	2001	Yes	2015
617824510	M E Computer Engineering	2011	Yes	2015
CEGP013380	Ph.D Computer Engineering	2012	No	2012
617824610	B E Information Technology	2001	Yes	2015
617837210, 617837220	BE E&TC Engineering	2001	Yes	2015
617861210, 617861220	B E Mechanical Engineering	2006	Yes	2015
617810110	Master Of Business Administration	2008	Yes	2015

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Index

Syllabus (elective highlighted with colour)

Principal
(Dr. A. V. Deshpande)
Principal
Smt. Kashibai Navale
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Third Year of Computer Engineering (2019 Course)
(With effect from Academic Year 2021-22)

Semester V

Course Code	Course Name	Teaching Scheme (Hours/ week)			Examination Scheme and Marks						Credit Scheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Term work	Practical	Oral	Total	Lecture	Practical	Tutorial	Total
310241	Database Management Systems	03	-	-	30	70	-	-	-	100	03	-	-	03
310242	Theory of Computation	03	-	-	30	70	-	-	-	100	03	-	-	03
310243	Systems Programming and Operating System	03	-	-	30	70	-	-	-	100	03	-	-	03
310244	Computer Networks and Security	03	-	-	30	70	-	-	-	100	03	-	-	03
310245	Elective I	03	-	-	30	70	-	-	-	100	03	-	-	03
310246	Database Management Systems Laboratory	-	04	-	-	-	25	25	-	50	-	02	-	02
310247	Computer Networks and Security Laboratory	-	02	-	-	-	25	-	25	50	-	01	-	01
310248	Laboratory Practice I	-	04	-	-	-	25	25	-	50	-	02	-	02
310249	Seminar and Technical Communication	-	01	-	-	-	50	-	-	50	-	01	-	01
	Total	15	11	-	150	350	125	50	25	700	15	06	-	21
310250	Audit Course 5												Grade	
										Total Credit	15	06	-	21

Elective I

- Internet of Things and Embedded Systems
- Human Computer Interface
- Distributed Systems
- Software Project Management

Audit Course 5

- Cyber Security
- Professional Ethics and Etiquettes
- MOOC- Learn New Skills
- Engineering Economics
- Foreign Language

Laboratory Practice I

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Semester VI

Course Code	Course Name	Teaching Scheme (Hours/ week)			Examination Scheme and Marks						Credit Scheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Term work	Practical	Oral	Total	Lecture	Practical	Tutorial	Total
310251	Data Science and Big Data Analytics	03	-	-	30	70	-	-	-	100	03	-	-	03
310252	Web Technology	03	-	-	30	70	-	-	-	100	03	-	-	03
310253	Artificial Intelligence	03	-	-	30	70	-	-	-	100	03	-	-	03
310254	Elective II	03	-	-	30	70	-	-	-	100	03	-	-	03
310255	Internship**	-	**	-	-	-	100 **	-	-	100	-	04 **	-	04
310256	Data Science and Big Data Analytics Laboratory	-	04	-	-	-	50	25	-	75	-	02	-	02
310257	Web Technology Laboratory	-	02	-	-	-	25	-	25	50	-	01	-	01
310258	Laboratory Practice II	-	04	-	-	-	50	25	-	75	-	02	-	02
										Total	12	09	-	21
	Total	12	10	-	120	280	225	50	25	700	12	05	-	21
310259	Audit Course 6													Grade

Elective II

- Information Security
- Augmented and Virtual Reality
- Cloud Computing
- Software Modeling and Architectures

Audit Course 6

- Digital and Social Media Marketing
- Sustainable Energy Systems
- Leadership and Personality Development
- Foreign Language
- MOOC- Learn New Skills

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Fourth Year of Computer Engineering (2015 Course)
(with effect from 2018-19)

Semester I

Course Code	Course	Teaching Scheme Hours / Week		Examination Scheme and Marks						Credit	
		Theory	Practical	In-Sem	End-Sem	TW	PR	OR/ *PRE	Total	TH/ TUT	PR
410241	High Perfomiance Computing	04	--	30	70	--	--	--	100	04	--
410242	Artificial Intelligence and Robotics	03	--	30	70	--	--	--	100	03	--
410243	Data Analytics	03	--	30	70	--	--	--	100	03	--
410244	Elective I	03	--	30	70	--	--	--	100	03	--
410245	Elective II	03	--	30	70	--	--	--	100	03	--
410246	Laboratory Practice I	--	04	--	--	50	50	--	100	--	02
410247	Laboratory Practice II	--	04	--	--	50	--	*50	100	--	02
410248	Project Work Stage I	--	02	--	--	--	--	*50	50	--	02
									Total Credit	16	06
Total		16	10	150	350	100	50	100	750	22	
410249	Audit Course 5									Grade	

Elective I	Elective II
410244 (A) Digital Signal Processing	410245 (A) Distributed Systems
410244 (B) Software Architecture and Design	410245 (B) Software Testing and Quality Assurance
410244 (C) Pervasive and Ubiquitous Computing	410245 (C) Operations Research
410244 (D) Data Mining and Warehousing	410245 (D) Mobile Communication

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Fourth Year of Computer Engineering (2015 Course)
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Semester II

Course Code	Course	Teaching Scheme Hours / Week		Examination Scheme and Marks						Credit	
		Theory	Practical	In-Sem	End-Sem	TW	PR	OR/ *PRE	Total	TH/ TUT	PR
410250	Machine Learning	03	–	30	70	–	–	--	100	03	--
410251	Information and Cyber Security	03	–	30	70	–	–	--	100	03	--
410252	Elective III	03	–	30	70	–	--	--	100	03	--
410253	Elective IV	03	–	30	70	–	--	--	100	03	--
410254	Laboratory Practice III	--	04	--	–	50	50	--	100	–	02
410255	Laboratory Practice IV	–	04	--	–	50	–	*50	100	–	02
410256	Project Work Stage II	--	06	–	–	100	–	*50	150	–	06
								Total	Credit	12	10
Total		12	14	120	280	200	50	100	750	22	
410257	Audit Course 6									Grade	

Elective III	Elective IV
410252 (A) Advanced Digital Signal Processing	410253 (A) Software Defined Networks
410252 (B) Compilers	410253 (B) Human Computer Interface
410252 (C) Embedded and Real Time Operating Systems	410253 (C) Cloud Computing
410252 (D) Soft Computing and Optimization Algorithms	410253 (D) Open Elective

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SAVITRIBAI PHULE PUNE UNIVERSITY
BE (COMPUTER ENGINEERING)- 2012 COURSE STRUCTURE
Term-I

Subject Code	Subject	Teaching Scheme			Examination Scheme				Total Marks
		Lect	Tut	Pract	In Sem Asmnt	PR/ TW	OR/ TW	End Sem Asmnt	
410441	Design & Analysis of Algorithms	03	—	—	30	—	—	70	100
410442	Principles of Modern Compiler Design	04	—	—	30	—	—	70	100
410443	Smart System Design and Applications	03	—	—	30	—	—	70	100
410444	Elective-I	03	—	—	30	—	—	70	100
410445	Elective-II	03	—	—	30	—	—	70	100
410446	Computer laboratory-I	—	—	04	—	50	50	—	100
410447	Computer Laboratory-II	—	—	04	—	50	50	—	100
410448	Project	—	02	—	—	50	—	—	50
	Total	16	02	08	150	150	100	350	750
	Term-II								
410449	Software Design Methodologies & Testing	03	—	—	30	—	—	70	100
410450	High Performance Computing	03	—	—	30	—	—	70	100
410451	Elective-III	03	—	—	30	—	—	70	100
410452	Elective-IV Open Elective	03	—	—	30	—	—	70	100
410453	Computer laboratory-III	—	—	04	—	50	50	—	100
410454	Computer Laboratory-IV	—	—	04	—	50	50	—	100
410455	Project	—	06	—		50	100	—	150
	Total	12	06	08	120	150	200	280	750

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Electives:

Semester-I		Semester-II	
	ELECTIVE-I		ELECTIVE-III
1.	Image Processing	1.	Mobile Computing
2.	Computer Network Design and Modeling	2.	Web Technology
3.	Advanced Computer Programming	3.	Cloud Computing
4.	Data Mining Techniques and Applications	4.	Cyber Security
	ELECTIVE-II		ELECTIVE-IV (Open Elective)
1.	Problem Solving with Gamification	1.	Business Analytic and Intelligence
2.	Pervasive Computing	2.	Operations Research for Algorithms in Scientific Applications
3.	Embedded Security	3.	Mobile Applications
4.	Multidisciplinary NLP	4.	Open Elective

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Savitribai Phule Pune University

Honours* in Cyber Security

With effect from 2020-21

Year & Semester	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks						Credit Scheme		
		Theory	Tutorial	Practical	Mid-Semester	End-Semester	Term work	Practical	Presentation	Total Marks	Theory / Tutorial	Practical	Total Credit
TE & V	Information and Cyber Security	04	--	--	30	70	--	--	--	100	04	--	04
	Information and Cyber Security Laboratory	--	--	02	--	--	50	--	--	50	--	01	01
	Total	04	-	02	100		50	-	-	150	04	01	05
									Total	Credits =		05	
TE & VI	Enterprise Architecture and Components	04	--	--	30	70	--	--	--	100	04	--	04
	Total	04	-	-	100		-	-	-	100	04	-	04
									Total	Credits =	04		
BE & VII	Internet of Things and Embedded Security	04	--	--	30	70	--	--	--	100	04	--	04
	Risk Assessment Laboratory	--	--	02	--	--	50	--	--	50	--	01	01
	Total	04	-	02	100		50	-	-	150	04	01	05
									Total	Credits =	05		
BE & VIII	Information Systems Management	04	-	--	30	70	--	--	--	100	04	--	04
	Seminar	--	02	--	--	--	-	--	50	50	02	--	02
	Total	04	-	02	100		-	--	50	150	06	-	06
									Total	Credits =	06		
Total Credit for Semester V+VI+VII+VIII = 20													

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Savitribai Phule Pune University

Honours* in Data Science

With effect from 2020-21

Year & Semester	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks						Credit Scheme		
		Theory	Tutorial	Practical	Mid-Semester	End-Semester	Term work	Practical	Presentation	Total Marks	Theory / Tutorial	Practical	Total Credit
TE & V	Data Science and Visualization	04	--	--	30	70	--	--	--	100	04	--	04
	Data Science and Visualization Laboratory	--	--	02	--	--	50	--	--	50	--	01	01
	Total	04	-	02	100		50	-	-	150	04	01	05
									Total	Credits =	05		
TE & VI	Statistics and Machine Learning	04	--	--	30	70	--	--	--	100	04	--	04
	Total	04	-	-	100		-	-	-	100	04	-	04
				Total	Credits =	04							
BE & VII	Machine Learning and Data Science	04	--	--	30	70	--	--	--	100	04	--	04
	Machine Learning and Data Science Laboratory	--	--	02	--	--	50	--	--	50	--	01	01
	Total	04	-	02	100		50	-	-	150	04	01	05
								Total	Credits =	05			
BE & VIII	Artificial Intelligence for Big Data Analytics	04	-	--	30	70	--	--	--	100	04	--	04
	Seminar	--	02	--	--	--	-	--	50	50	02	--	02
	Total	04	-	02	100		-	--	50	150	06	-	06
					Total	Credits =06							
Total Credit for Semester V+VI+VII+VIII = 20													

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Savitribai Phule Pune University, Pune
Master of Computer Engineering (2017 Course)
(with effect from June 2017)

Semester I

Course Code	Course	Teaching Scheme Hours / Week		Examination Scheme and Marks					Credit	
		Theory	Practical	In-Sem	End-Sem	TW	OR/ PRE	Total	TH	PR
510101	Research Methodology	04	--	50	50	--	--	100	04	--
510102	Bio-Inspired Optimization Algorithms	04	--	50	50	--	--	100	04	--
510103	Software Development and Version Control	04	--	50	50	--	--	100	04	--
510104	Embedded and Real Time Operating Systems	04	--	50	50	--	--	100	04	--
510105	Elective I	05	--	50	50	--	--	100	05	-
510106	Laboratory Proficiency I	--	08	--	--	50	50	100	--	04
								Total Credit	21	04
	Total	**21**	**08**	**250**	**250**	**50**	**50**	**600**	**25**	
510107	Non-Credit Course I								Grade	

Elective I

510105A	Advanced Digital Signal Processing	510105B	Data Mining
510105C	Network Design and Analysis	510105D	Data Algorithms
510105E	Open Elective		

Semester II

Course Code	Course	Teaching Scheme Hours / Week		Examination Scheme and Marks					Credit	
		Theory	Practical	In-Sem	End-Sem	TW	OR/ PRE	Total	TH	PR
510108	Operations Research	04	--	50	50	--	--	100	04	--
510109	System Simulation and Modeling	04	--	50	50	--	--	100	04	--
510110	Machine Learning	04	--	50	50	--	--	100	04	--
510111	Elective II	05	--	50	50	--	--	100	05	--
510112	Seminar I		04	--	--	50	50	100	--	04
510113	Laboratory Proficiency II	--	08	--	--	50	50	100	--	04
								Total Credit	17	08
	Total	**17**	**12**	**200**	**200**	**100**	**100**	**600**	**25**	
510114	Non-Credit Course II								Grade	

Elective II

510111A	Image Processing	510111B	Web Mining
510111C	Pervasive and Ubiquitous Computing	510111D	Network Security
510111E	Open Elective		

Abbreviations: TW: Term Work , **TH:** Theory, **OR:** Oral, **PRE:** Presentation, **Sem:** Semester

Head
Department of Computer Engineering
SKNCOE, Pune 411041

Savitribai Phule Pune University, Pune
Master of Computer Engineering (2017 Course)

Semester III

Course Code	Course	Teaching Scheme Hours / Week		Examination Scheme and Marks					Credit	
		Theory	Practical	In-Sem	End-Sem	TW	OR/ PRE	Total	TH	PR
610101	Fault Tolerant Systems	04	--	50	50	--	--	100	04	--
610102	Information Retrieval	04	--	50	50	--	--	100	04	--
610103	Elective III	05	--	50	50	--	--	100	05	--
610104	Seminar II	--	04	--	--	50	50	100	--	04
610105	Dissertation Stage I	--	08	--	--	50	50	100	--	08
								Total Credit	13	12
	Total	**13**	**12**	**150**	**150**	**100**	**100**	**500**	**25**	
610106	Non-Credit Course III								Grade	

Elective III

610103A	Cloud Security	610103B	Speech Signal Processing		
610103C	Mobile Ad-hoc Network	610103D	Pattern Recognition	610103E	Open Elective

Semester IV

Course Code	Course	Teaching Scheme Hours / Week	Examination Scheme and Marks			Credit
		Practical	TW	OR/PRE	Total	PR
610107	Seminar III	05	50	50	100	05
610108	Dissertation Stage II	20	150	50	200	20
	Total	**25**	**200**	**100**	**300**	**25**

Non-Credit Courses

Typically curriculum is constituted by credit, non-credit and audit courses. These courses are offered as compulsory or elective. Non Credit Courses are compulsory. No grade points are associated with non-credit courses and are not accounted in the calculation of the performance indices SGPA & CGPA. However, the award of the degree is subject to obtain a PP grade for non credit courses. Conduction and assessment of performance in said course is to be done at institute level. The mode of the conduction and assessment can be decided by respective course instructor. Recommended but not limited to- (one or combination of) seminar, workshop, MOOC Course certification, mini project, lab assignments, lab/oral/written examination, field visit, field training. Examinee should submit report/journal of the same. Reports and documents of conduction and assessment in appropriate format are to be maintained at institute. Result of assessment will be PP or NP. Set of non-credit courses offered is provided. The Examinee has to select the relevant course from pool of courses offered. Course Instructor may offer beyond this list by seeking recommendation from SPPU authority. The selection of 3 distinct non-credit courses, one per semester (Semester I, II & III). The Contents of Non Credit Courses are Provided at page 63 onwards.

Open Elective: The open elective is to invite the attention to multidisciplinary, interdisciplinary, exotic, employability or update to technology course. The institute may design the syllabus accordingly. However such designed syllabus needs to be approved by SPPU authority before implementation.

Recommended Set of Non-Credit Courses(510107, 510114, 610106):

NCC1: Game Engineering	**NCC2:**Advanced Cognitive Computing
NCC3: Reconfigurable Systems	**NCC4:** Convergence Technology
NCC5: Machine Learning	**NCC6:**Storage Area Networks
NCC7: Search Engine Optimization	**NCC8:**Virtual Reality
NCC9: Machine Translation	**NCC10:** Infrastructure Management

Head
Department of Computer Engineering
SKNCOE, Pune 411041

UNIVERSITY OF PUNE

RULES & REGULATIONS, STRUCTURE and SYLLABUS

for

Ph.D. COURSE WORK

Under

FACULTY OF ENGINEERING

RULES & REGULATIONS

Appendix for Revised rules for Ph. D under Faculty of Engineering

The candidates who have registered for Ph.D. Program on or after 11th July 2009 are governed by

UGC (MINIMUM STANDARDS AND PROCEDURE FOR AWARD OF M.Phil/Ph.D. DEGREE), REGULATION, 2009 PUBLISHED IN THE GAZETTE OF INDIA, DATED 11TH July, 2009.

Based on and adhering to this, University of Pune has formulated the Revised rules for Ph.D. and circulated vide circular no.406/2009 dated 29th December 2009.

All the Procedures, rules and regulations regarding Short title, Applications, Commencement, Supervisor Eligibility Criterion, Procedure for Admission, Course work, Evaluation and Assessment methods etc. as laid down in these revised rules, are applicable to PhD Programs under Faculty of Engineering, University of Pune.

The following guidelines are a supplement to these rules and regulations; for only those sections, which require better and adequate comprehension.

1 - COURSE WORK:

TABLE- 1

STRUCTURE FOR Ph.D. COURSE WORK (common for all branches)

CODE	NAME OF COURSE	CONTACT HOURS	EXAMINATION SCHEME			CREDITS
			CONTINUOUS ASSESSMENT	END SEMESTER EXAM	TOTAL	
700001	**Research Methodology**	**5**	**50**	**100**	**150**	**5**
700002	**Seminar**	**10**	**50**	**50**	**100**	**5**
700003	**Faculty Specific Topics for Engineering Research** **Part-A** (700003-A) Mathematics for Engineering Research **Part-B** (700003-B) Branch Specific Topics	**10**	**100**	**100**	**200**	**10**
Total		**25**	**200**	**250**	**450**	**20**

CODE	Branch Specific Topics		CODE	Branch Specific Topics
700003-B1	Advances in Civil Engineering		700003-B8	Advances in Chemical Engineering
700003-B2	Advances in Mechanical Engineering		700003-B9	Advances in Computer Engineering
700003-B3	Advances in Electrical Engineering		700003-B10	Advances in Production & Industrial Engineering
700003-B4	Advances in Electro & Tel Engineering		700003-B11	Advances in Petroleum & Petro chemical. Engineering
700003-B5	Advances in Metallurgy Engineering		700003-B12	Advances in Architecture
700003-B6	Advances in Instrumentation Engg.		700003-B13	Advances in Information technology
700003-B7	Advances in Printing Engineering		700003-B14	Advances in Biotechnology

R-1.1

After having been admitted, each Ph.D. student shall be required to undertake course work for a minimum period of one semester. The course work shall be treated as pre- Ph.D. preparation.

R-1.2

If found necessary, course work may be carried out by doctoral candidates in sister departments / institutes either within or outside the University for which due credit will be given to them.

R-1.3

The Ph.D. Course work for all branches under Faculty of Engineering shall be offered with credit system.

R-1.4

The total credit requirement for entire course work shall be of 20 credits. Students are required to earn these 20 credits in maximum three semesters.

R-1.5

The structure for Ph.D. course work for all branches under Faculty of Engineering shall be as given in Table- 1.

R-1.6

The course, Faculty Specific Topics for Engineering Research will consists of;
Part-A: Mathematics for Engineering Research, the contents of syllabus of which will be based on the advance topics from engineering mathematics. It will consist of minimum 15 units of 2 credits each.
Part-B: Branch Specific Topics, the contents of syllabus of which will be based on the advance topics/technology pertaining to the branch. It will consist of minimum of 10 units with 2 credits each.

The students shall require to appear to earn the credit for 2 units from Mathematics for Engineering Research and 3 units from Branch Specific Topics, related to their area of research, selected in consultation with the guide and approved by the head of research centre.

2 AWARD OF GRADE:

For each course, undertaken by the students, he/she shall be assigned a letter grade based on the total marks obtained by him/her in all the heads of examination of that course. The letter grades and the guidelines for conversion of marks to letter grades shall be as given in Table-2.

Table -2

Grade	Percentage of Marks obtained	Remarks
P	**50-100**	**Pass**
F	**Below 50**	**Fail**
FX	**----------**	**Detained, Repeat the course**
II	**----------**	**Incomplete-Absent for Exam but continue the course**

R- 2.1 P Grade

The grade 'P' is passing grade. The candidate acquiring 'P' grade in a course shall be declared to have passed that course.

R -2.2 F Grade

The grade 'F' shall be treated as failure grade**.** The candidate acquiring 'F' grade in a course shall be declared to have failed in that course. The student with F grade in any course shall have to pass the concerned course by re-appearing for the examination as and when it is conducted by the appropriate authority.

R-2.3 FX Grade

The grade 'FX' in a course is awarded by the research centre, if the student does not maintain the minimum attendance in the theory/class as prescribed by the University and/or his /her performance during the semester is not satisfactory.

R- 2.4 II Grade

Grade 'II 'shall be awarded to a candidate in a course in which he has the minimum attendance as prescribed by the University and satisfactory in-semester performance but could not appear for the end semester examination. Such a student shall have to appear for the End Semester Examination as and when it is conducted by the authorities.

3 COURSE WORK ASSESSMENT:

The rules given below are specified for the examination scheme mentioned in typical Course Work Structure as given in Table- 1.

R-3.1 CONTINUOUS ASSESSMENT:

The continuous assessment of all the courses of Ph.D. course work shall be done by concerned and appropriate faculty of the Research Centre.

R-3.1.1 Theory Courses:
The continuous assessment of theory course shall be evaluated on the basis of the class tests/assignments/case studies/quizzes. There shall be minimum two class tests/assignments/case studies/quizzes for each theory course. It shall be of minimum 25 marks. The marks obtained shall be displayed on the notice board within 10 days of conducting it.
R-3.1.2 Seminar:
The continuous assessment of seminar shall be based on the following heads;

	Head	Marks
a.	Performance of the student in the collection of the reference material and its understanding for seminar	40 Marks
b.	Punctuality, Enthusiasm and aptitude of student in Preparing seminar / completing the report	10 Marks

3.2 END SEMESTER EXAMINATION (ESE)

R- 3.2.1

The End Semester Examination for the theory course shall be of 100 marks and three hours duration.
R -3.2.2
Grade II shall be awarded to a candidate in a course in which he/she could not appear for the end-semester examination. Such a student shall have to appear for the ESE as and when conducted by the appropriate authority.
R- 3.2.3

Research Methodology-
The Authority of the University of Pune will be responsible for paper setting, preparing the schedule of the examination, conducting the examination, appointment of examiners and assessment, awarding the marks for the ESE of the Course, Research Methodology.
R -3.2.4

Faculty Specific Topics for Engineering Research -
The concerned and appropriate faculty of the Research Centre. will be responsible for paper setting, preparing the schedule of the examination, conducting the examination, assessment, awarding the grades for the ESE of the Course, Faculty specific Topics.

R- 3.2.5
End semester presentation-
The Research Progress Monitoring Committee; duely constituted by the head of Research centre, shall review the End semester presentation and assign the marks based on the following heads

c. Content and Quality of the seminar	30 Marks
d. Presentation and Viva-Voce	20 Marks

The examiners will prepare the mark / grade sheet in the format as specified by the University of Pune, authenticate it, seal it, and shall submit it to the Head of the concern Research Center.

4. RULES OF EXAMINATIONS & PERFORMANCE REQUIREMENTS

R- 4.1
To pass the examination of a course/seminar, student should earn passing grade in the examination of that course/seminar.
R -4.2
For successful completion of the course work, student should pass in all the courses/ seminar of the course work.

5. RESULT:

Based on the performance of the candidate in the course work, the head of the research centre shall declare that the candidate has successfully completed the course work and accordingly inform University of Pune in due course of time.

SYLLABUS

Ph.D. COURSEWORK UNDER FACULTY of ENGINEERING

700001: Research Methodology

Teaching Scheme: **Marking Scheme:**
Contact Hours: 5 hrs/week **Continuous Assessment: 50 Marks**
Credits: 5 **End Semester Examination: 100 Marks**

Objectives

- Learn to focus on a research problem using scientific methods
- Learn methods to devise and design an experimentation set-up
- Learn basic instrumentation and data collection methods
- Learn parameter estimation and related modelling methods

Unit 1: Research Problem
Meaning of research problem, Sources of research problem, Criteria / Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Unit 2: Basic instrumentation
Instrumentation schemes, Static and dynamic characteristics of instruments used in experimental set up, Performance under flow or motion conditions, Data collection using a digital computer system, Linear scaling for receiver and fidelity of instrument, Role of DSP is collected data contains noise.

Unit 3: Applied statistics
Regression analysis, Parameter estimation, Multivariate statistics, Principal component analysis, Moments and response curve methods, State vector machines and uncertainty analysis.

Unit 4: Modelling and prediction of performance
Setting up a computing model to predict performance of experimental system, Multi-scale modelling and verifying performance of process system, Nonlinear analysis of system and asymptotic analysis, Verifying if assumptions hold true for a given apparatus setup, Plotting family of performance curves to study trends and tendencies, Sensitivity theory and applications.

Unit 5: Developing a Research Proposal
Format of research proposal, Individual research proposal, Institutional proposal
Proposal of a student – a presentation and assessment by a review committee consisting of Guide and external expert only. Other faculty members may attend and give suggestions relevant to topic of research.

Reference Books:

1. 'Research methodology: an introduction for science & engineering students', by Stuart Melville and Wayne Goddard
2. 'Research Methodology: An Introduction' by Wayne Goddard and Stuart Melville
3. 'Research Methodology: A Step by Step Guide for Beginners', by Ranjit Kumar, 2nd Edition
4. 'Research Methodology: Methods and Trends', by Dr. C. R. Kothari
5. 'Operational Research' by Dr. S.D. Sharma, Kedar Nath Ram Nath & co.
6. Software Engineering by Pressman

700002: Seminar

Teaching Scheme: **Marking Scheme:**
Contact Hours: 5 hrs/week **Continuous Assessment: 50 Marks**
Credits: 5 **End Semester Examination: 50 Marks**

Unit 1: Formulating Problem Statement

Overview of research process: Formulating the Research Problem, Extensive Literature Review, Developing the objectives, preparing the Research Design including Sample Design, Collecting the Data, Analysis of Data, Generalization and Interpretation, preparation of the Report or Presentation of Results-Formal write-ups of conclusions reached.

Problem statement – Conditions and steps in selecting a research problem, Understanding the Key research area of interest, How to get new ideas (Criticizing a paper), Finding a good problem: Top-down and Bottom-up approach, Creative thinking techniques, Coming up with a problem statement

Defining objectives – How to find objectives, characteristics of objectives

Unit 2: **Literature survey**

Overview – What is literature survey, Functions of literature survey, maintaining a notebook, developing a Bibliography

Methods of data collection – Observation, survey, contact methods, experimental, determining sample design

Searching for publications – Publication databases, search engines and patent databases, Find some/all of the references for a given paper, including those that are not on the web

Online tools – google, CiteSeer, ACM Digital Library, IEEE, The on-line Computer Science bibliography, Survey papers, Finding material not on the web, Searching patents

Unit 3: How to study a scientific paper

Summarizing paper – Reading abstracts and finding ideas, conclusion, Advantages of their approach, the drawbacks of the papers (What is lacking – can be found in the sections such as future work) Generalize results from a research paper to related research problems

Comparing the approach - Identify weaknesses and strengths in recent research articles in the subject

Unit 4: Publishing a paper
How to write scientific paper - Structure of a conference and journal paper, how (and How Not) to write a Good Systems Paper: Abstract writing, chapter writing, discussion, conclusion, references, bibliography, and In-class discussion of technical writing examples, Poster papers, review papers, how to organize thesis/ Project report, How to write a research proposal? How research is funded?
Research ethics – Legal issues, copyright, plagiarism
General advice about writing technical papers in English - Tips for writing correct English

Unit 5: How to present scientific paper
Talk structure, basic presentations skills
Documentation and presentation tools – LATEX, Microsoft office, PowerPoint and SLITHY

Reference Books:
1. Lecture Notes and presentations

700003-A: Mathematics for Engineering Research

Note: Each Unit is of 2 credits. A candidate has to take any *two* units (4 credits)

Unit 1: Linear algebra
Linear system solution: full and sparse matrices, least squares solution, Eigenvalues

Reference Books:
1. I. S. Sokolnikiff, "Mathematical Methods of Physics and Engineering", McGraw Hill
2. Murray R. Spiegel, "Advanced Mathematics for engineers and scientist", Schaum's out line series, McGraw Hill Intl Co., New Delhi.

Unit 2 : System of nonlinear equations
Newton (and related) methods, Limiters

Reference Books:
1. I. S. Sokolnikiff, "Mathematical Methods of Physics and Engineering", McGraw Hill
2. Murray R. Spiegel, 'Advanced Mathematics for engineers and scientist', Schaum's out line series, McGraw Hill International Book Co., New Delhi.

Unit 3: Dynamical System
Analytical and numerical solutions, Stability of numerical methods, Dynamical system stability

Reference Books:
1. I. S. Sokolnikiff, "Mathematical Methods of Physics and Engineering", McGraw Hill
2. Erwin Kreyszig, 'Advanced Engineering Mathematics', John Wiley and sons Inc., 8th Edition, 2003.

Unit 4: Partial differential equations I
Elliptic systems, Solution methods, multi grid and other efficient algorithms

Reference Books:
1. Numerical Partial differential equations: finite difference methods, J W Thomas, Springer
2. Mathematical Methods of Physics and Engineering, I. S. Sokolnikiff, McGraw Hill

Unit 5: Partial differential equations II
Parabolic and Hyperbolic systems, 1-d and 2-d solution methods, stability analysis

Reference Books:
1. I. S. Sokolnikiff, "Mathematical Methods of Physics and Engineering", McGraw Hill
2. J W Thomas, "Numerical Partial differential equations: finite difference methods", Springer

Unit 6: Complex Analysis
Integration in the complex plane, residues, improper integral evaluation

Reference Books:
1. Serge Lang, Complex Analysis, Springer Verlag

Unit 7: Transform Techniques
Laplace, Fourier transforms, FFT, z-transforms, Other linear transforms, Applications, Karhunen-Loeve transforms, System analysis in transform domain,

Reference Books:
1. N. Sneddon: The use of Integral Transform, McGraw Hill, New York 1972.
2. L Debnath: Integral Transforms and their Applications CRC Press, Inc. 2nd Ed. R.

Unit 8: Optimisation
Linear systems with constraints, unconstrained nonlinear systems constrained nonlinear cases, Tabu Search, Simulated Annealing, Swarm Intelligence

Reference Books:

1. Jorge Nocedal and Stephen Wright; Numerical Optimization, Springer, 2nd edition, (2006)
2. S. S. Rao; Engineering Optimization: Theory and Practice, Wiley, 4th edition, (2009)

Unit 9: Stochastic Processes

Games theory, Probability, Reliability and Random numbers, CDF and PDF, Random processes, Moments, Models of random processes.

Reference Books:

1. Kishor S. Trivedi, Probability and Statistic with Reliability, Queuing and computer Science Applications, Prentice-Hall of India.

Unit 10: Soft Computing

Genetic Algorithms, Fuzzy Logic, Neural Networks, Hyper Heuristics, Support Vector Machines

Reference Books:

1. Jorge Nocedal and Stephen Wright, "Numerical Optimization", Springer, 2nd edition, (2006)
2. S. S. Rao, "Engineering Optimization: Theory and Practice", Wiley, 4th edition, (2009)
3. Edmund Burke and Graham Kendall (Ed.), "Search Methodologies: Introductory tutorials in optimization and decision support systems", Springer, 2005.

Unit 11: Signal Detection and Estimation

Signal Detection and Estimation, Mathematical Modelling and analysis of various filters

Unit 12: Switching and Queuing Theory

Various models, Design requirements and issues, transmission techniques, media, switching theory, performance issues

Unit 13: Joint Time-Frequency Analysis

Wavelet transforms and its variants, analysis, limitations, applications, multi-resolution theory, Wigner-Viley distribution, Time series analysis and applications.

Unit 14: Computational Wave Theory

Maxwell equations, Poynting vector, wave types, interface conditions, orthogonality, hybrid computational methods, method of moments, low and high frequency applications

Unit 15: Finite Differences and Interpolation

Differences of polynomial, Factorial Notation, Newton's Interpolation Formulae, Interpolation with unequal intervals, Numerical differentiation, Numerical integration.

Reference Books:

1. Higher Engineering Mathematics.-by Dr B.S Grewal, Khanna Publishers.
2. Advanced Engineering Mathematics. - by C.Ray Wylie, L.C.Burret International Students Edition
3. Advanced Engineering Mathematics. -by Erwin Kreyszig, 8th Edition Wilay Students Edition.

Unit 16: Numerical Solutions of Ordinary Differential Equations

Taylor Series Method, Euler's method, Modified Euler's method, Runge's Method, Runge Kutta method, Predictor -Corrector methods. Simultaneous first order differential equations. Applications to Engineering problems.

Reference Books:

1. Numerical methods for Engineers, S.C Chapra, R.P.Canale 3rd Edition Mc Graw Hill Publishers.
2. Introductory Methods of Numerical Analysis - S.S Sastry Prentice Hall of India
3. Numerical Methods, Balguruswamy, Tata. Mc Graw Hill
4. Numerical Solutions of Partial Differential Equations, K. W. Morton, and D. F. Mayers.

Unit 17:

Difference Equations , Solutions of difference equations. Finite difference approximations to partial derivatives. Finite difference method of finding solution of one dimensional heat equation, two dimensional heat equation and wave equation. Solutions of Laplace and Poisson equation.

Reference Books

1. Numerical methods for Engineers-by S.C Chapra, R.P.Canale 3rd Edition Mc Graw Hill Publishers.
2. Numerical Methods - by Dr.B.S.Grewal Khanna Publishers
3. Advanced Engineering Mathematics. -by Erwin Kreyszig, 8th Edition Wilay Students Edition.

Unit 18: .Statistical Quality Control and Stochastic Processes

Control charts: $\tilde{X}$ Chart,R-Chart,P-chart and np charts etc. Markov process, Markov chain, Stochastic differential equations. Applications to physical problems.

Reference Books:

1. Advanced Methods of Mathematical Physics -by R S.Kaushal and D.Parashar, Narosa Publishing House
2. Advanced Engineering Mathematics. -by Erwin Kreyszig, 8th Edition Wiley Students Edition.

Unit 19: Matrices

Definitions of various types of matrices, Elementary matrix transformations linear transformation formations .Orthogonal trans formation. Eigen values and Eigen vectors. Problems orizing from Markov's stochastic process. Numerical method for finding Eigen value and Eigen vectors and applications to mass spring problems and coupled masses. Applications of matrices for finite element methods.

Reference Books:

1. Applied Mathematics for Engineers and physicists by Pipes and Harvill International students edition.
2. The finite Element method 3rd edition , -by O.C.Zienkiewicz, Tata Mc Graw Hill
3. Advanced Engineering Mathematics. -by Erwin Kreyszig, 8th Edition, Wilay Students Edition.

Unit-20: Analysis of Algorithms

Algorith Analysis, Proof Techniques, Asymptotics, Recurrences, algorithmic strategies, Parallel Algorithms, Amortized Analysis, Integer and Polynomial Arithmetic, Pattern-Matching Algorithms, NP-Complete Problems, Some Provably Intractable Problems, Lower Bound on Numbers of Arithmetic Operations, **empirical algorithmics**

Reference Books:

1. Holger H. Hoos & Thomas Stützle, Morgan Kaufmann, "Design & Analysis of Computer Algorithms- Stochastic Local Search Foundations and Applications", Elsevier, 2004

Unit-21: Randomized Algorithms

Geometric algorithms and Linear Programming- Randomized incremental construction, Convex Hulls in the plane, Duality, Half-space intersections, Delaunay Tringulations, Trapezoidal Decompositions, Binary space partitions, random sampling, Linear programming

Reference Books:

1. Rajiv Motwani, Prabhakar Raghavan, "Randomized Algorithms", Cambridge University Press

Unit-22: Graph Theory

Graph as mathematical model, Planar and Dual Graphs, Vector Spaces of a Graph Matrix Representation of Graphs, Graph Coloring, Covering, and Partitioning, Directed Graphs, Enumeration of Graph, Graph Theoretic Algorithms and Computer Programs

Reference Books:

1. G- Narsingh Deo, "Graph Theory with Applications to Engineering and Computer Science" PHI Learning (2009)
2. Harray Frank,"Graph Theory", Narosa Book Distributors Private Ltd (2001**)**

Unit-23: Coding Theory
Uncertainty, acquisition of information, entropy, noiseless coding, noisy coding, cyclic redundancy checks, integers

Reference Books:
1. Paul Garrett, "The mathematics of coding theory – information, compression, Error correction and finite fields", Pearson Education, 2005

Unit-24: Mathematical Foundations of Computer Networks
Basic algorithms on directed graphs, weighted shortest paths, Networks and routing algebras - fixed-point equations, sequential algorithm to solve the fixed-point equations, generalized distance-vector and link-state routing protocols, applications to quality-of-service intra-domain routing and to policy-based inter-domain routing in the Internet, Network flows - flows and residual networks, Max-flow Min-cut theorem, Ford-Fulkerson method and Edmonds-Karp algorithm, Network calculus- Min-plus calculus: integrals and convolutions, Arrival curves and token buckets; service curves and schedulers, Applications to integrated and differentiated services in the Internet.

References:

1. Thomas Cormen, Charles Leiserson, Ronald Rivest, and Clifford Stein. *Introduction to algorithms*, 2th edition. The MIT Press 2001 [Chapter VI]
2. Jorgen Bang-Jensen and Gregory Gutin. *Digraphs: theory, algorithms and applications*. Springer, 2002 [Section 7.3 and 9.5]
3. J. L. Sobrinho, An algebraic theory of dynamic network routing, *IEEE/ACM Transactions on Networking*, 13(5), October 2005.
4. Jean-Yves Le Boudec and Patrick Thiran. *Network calculus*. Springer, 2006. [Chapter 1, 2, and 3]
5. Cheng-Shang Chang. *Performance guarantees in communication networks*. Springer 2000 [Chapter 1 and 2]

Unit 25: Correlations and Regression
Auto correlation based on statistical methods, linear / Non-Linear regression analysis.

Unit 26: Geometrical Modeling
Measurements, properties and relationships of curves, surfaces and volumes, computer aided geometric design (CAGD), intersection algorithms and CAGD, real time algebraic surface modelling

Assignments:
- Each unit will have at least 1 assignment.
- Programming assignments will be based on engineering problems

700003-B1: Advances in Civil Engineering

Note: Each Unit is of 2 credits. A candidate has to take any *three* units (6 credits)

STRUCTURAL ENGINEERING:

Unit 1
Three dimensional elasticity problems, Torsion of open section, Thermal Stresses, Fracture mechanics. Kirchoff and Mindlin theory of plates, higher order shear deformation theories, classical theories of skew plates, Shell surfaces, bending theory of shells.

Unit 2
Mechanics of modern materials, laminated composites, functionally graded materials. Application to plate and shell structures.Structural dynamics, Forced and Damped vibration, modal analysis, response spectra, seismic design of multistoried buildings, codal provisions.

Unit 3
Finite Element Method, 2D and 3D applications in plane and three dimensional elasticity problems. Analysis of plate and shell structures. Applications using proper software.Nonlinear analysis of structural elements. Material and geometric nonlinearity. Applications for beam, plates and shells.

Unit 4
Multi- variable and Multi-objective optimization. Non linear and non traditional techniques of optimization. Design for reliability, reliability based optimization.Stability Analysis: Beam column, buckling of frames. Lateral buckling of beams, torsional buckling, energy criterion and energy based methods, dynamic stability

Reference Books:

1. Timoshenko and Goodier - Theory of Elasticity, McGraw-Hill Publications
2. S. Crandall, N. Dahl and T. Lardner - Mechanics of Solids, McGraw Hill Publications
3. Anil K Chopra – Dynamics of Structures Theory and Applications to Earthquake Engineering, Prentice-Hall Publications
4. R.W Clough and J Penzin – Dynamics of Structures, McGraw Hill Publications
5. R.C. Roy - Structural Dynamics an Introduction to Computer Methods, John Wiley & Sons Publications
6. S. Timoshenko and W. Krieger, Theory of Plates and Shells, Mc Graw Hill.
7. Ansel C. Ugural, Stresses in Plates and Shells, Mc Graw Hill
8. Chandrashekhara K., Analysis of Plates, New Age International Edition
9. J.N. Reddy – An Introduction to the finite element method – Tata McGraw Hill Publishing Co. Ltd

10. C.S. Krishnamoorthy – Finite Element Analysis – Theory & Programming - Tata McGraw Hill Publishing Co. Ltd
11. Zienkiewicz & Taylor - The Finite Element Method 4th Edition – Vol – I & II – McGraw Hill International Edition
12. Robert D. Cook, D.S. Malkus, M.E. Plesha – Concepts & Applications of Finite Element Analysis – John Wiley & Sons.
13. Timoshenko S.P. and and Gere J.M., Theory of Elastic Stability, Mc Graw Hill,
14. Ashwini Kumar, Stability of Structures , Allied Publishers Ltd
15. R. Ranganathan, Reliability Analysis and Design of Structures, Mc Graw Hill.
16. M.Sathyamoorthy, 'Nonlinear Analysis of Structures', CRC Press, New York
17. S.S.Rao, 'Engineering Optimisation- Theory and Practice', New Age International.
18. U. Kirsch, 'Optimum structural design',McGraw –Hill, New York

HYDRAULIC ENGINEERING:

Unit 5

Water resources systems analysis, design and management for water supply, irrigation, drainage, hydropower, food control, droughts.Surface and ground water hydrology, stochastic hydrology, physical and numerical modeling, use of finite difference, finite element and boundary element methods.

Unit 6

Instrumentation and monitoring of hydraulic systems, computer simulation and optimization of hydrosystems.Computational fluid dynamics, coastal hydrodynamics, watershed management, application of numerical methods.

Unit 7

Ground water systems planning and management, ground water pollution investigation. Hydroinformatics, multi criterion decision support system, applications of ANN and GA.

Unit 8

Hydraulics of spillways and energy dissipators, pressure fluctuations in hydraulic jump, static and dynamic uplift pressures in stilling basins.Remote sensing and GIS applications, Dam break analysis using softwares.

Reference Books:

1. Principles of water resources planning and management – Goodman
2. Applied hydrology – Linsley Kolhar and Paulhas (McGraw Hill)
3. Computational fluid dynamics – Anderson
4. Neural network fundamentals with graphs, algorithms, applications – Bose N.K. and Liang P (McGraw Hill)
5. Practical handbook of GA applications, Vol I – L. Chambers (CRC Press)

6. Hydraulics of spillways and energy dissipators – R. M. Khatsuria (Marcel Dekker Publisher, New York)
7. Energy dissipators and hydraulic jump – W. H. Hager (Kluwer academic publishers, Netherland)
8. Hydrodynamics of coastal zones – Massel S.R.
9. Ground water systems planning management – Robert WillisHager, W.H. (1992). "Energy dissipators and hydraulic jump". Kluwer academic publishers, Netherland.
10. Hager, W.H., Bremen, R. (1989). "Classical hydraulic jump : post jump depths". *J. Hydr. Res.*,27(5), 565-581.
11. Jeppson, R.W. (1970). "Graphical solution to hydraulic jump". *J. Hydr. Engg., ASCE*, 96(1), 103-108.
12. Khatsuria R. M. (2005). "Chapter 20- Hydraulic jump stilling basins". Hydraulics of spillwaysand energy dissipators. Marcel Dekker Publisher, New York.
13. Fox and McDonald, " Introduction to fluid Mechanics", John Wiley
14. R. H. F. Rao, " Fluid Dynamics", Charles E Morn'll Books Inc. 1967
15. I. H. Shames, "Mechanics of Fluids", McGraw Hill, 1962
16. Y. L. Steeter, "Fluid Dynamics", McGraw Hill, 1948
17. Vallentine - Hydrodynamics
18. S. W. Yuan – Fluid Mechancis.

GEOTECHNICAL ENGINEERING:

Unit 9

Advanced Geotechnical Engineering

Stress distribution under earth embankments and evaluation of settlement profile. Field problems to monitor movement of slopes, foundations, etc.

Advanced Foundation Engineering

Foundations in difficult soils: expansive soils, chemically aggressive environment, soft soils,fill, regions of subsidence.

Unit 10

Rockmechanics and Tunelling

Deformation characteristics of rocks and its measurement. Instrumentation, Underground excavation and subsidence. Bearing capacity of homogeneous as well as discontinuous rocks.

Soil Dynamics and Geotechnical Earthquake Engineering

Soil behaviour under dynamic loads. Seismic response, strong ground motion, its parameters and their estimation, seismic hazard analysis, local site effects and design ground motion, seismic slope stability

Unit 11

Finite Element Methods in Geotechnical Engineering

Stress deformation analysis: One-, Two,Three-dimensional formulations; Discretization; Analysis of foundations, dams, underground structures and earth retaining structures.

Geoenvironmental Engineering

Landfills, in ash ponds and tailing ponds, and in rocks. Detection, control and remediation of subsurface contamination; Engineering properties and geotechnical reuse of waste.

Unit 12

Soil Structure Interaction

Elastic and plastic analysis of stress distribution on yielding bases. Analysis of conduits. Interaction analysis of piles and pile groups. Elastic continuum and elastoplastic analysis of piles, Non-linear load-deflection response.

Geotechnics for Infrastructure

Exploration studies for different Infrastructure Projects, Investigation reports, Analysis and required measures

Reference Books:

1. Aki K and Richards P G (2002), Quantitative Seismology, University Science Books
2. Bowles J E (1996), Foundation Analysis and Design, McGraw Hill.
3. Das B M (1997), Advanced Soil Mechanics, Taylor and Francis.
4. Das B M (1993), Principles of Soil Dynamics, Brooks/Cole
5. Coduto D P (2001), Foundation Design: Principles and Practices, Prentice -Hall
6. Kaniraj S R (1988), Design Aids in Soil Mechanics and Foundation Engineering, Tata McGraw Hill
7. Poulos H G and Davis E H (1980), Pile Foundation Analysis and Design, John Wiley and Sons
8. Koerner R M (1997), Designing with Geosynthetics, Prentice Hall
9. Karl Terzaghi (1954), Theoretical Soil Mechanics, Chapman and Hall,.
10. Rock Mechanics in Engineering Practice: Stag and Zienkiewez, John Willey & Sons
11. J.C. Jagger and N.G.W. Cook(1971), Fundamentals of Rock Mechanics, Methuen and Co.,
12. London.
13. Sarsby R (2000), Environmental Geotechnics, Thomas Telford
14. Hsai-Yang Fang, Introduction to Environmental Geotechnology, CRC Press.
15. Kramer S L (1996), Geotechnical Earthquake Engineering, Prentice Hall
16. Prakash Shamsher and Puri V K (1988), Foundations for Machines; Analysis and Design, John Wiley and Sons
17. Wolf J P (1985), Dynamic Soil-Structure Interaction, Prentice-Hall

ENVIRONMEMTAL ENGINEERING:

Unit 13

Water Treatment

Water Quality: Requirement, Standards, Stream & Effluent standards. Water quality indices. Water purification, physical, chemical processes. Unit operations, unit processes.

Aeration, Sedimentation, Coagulation & flocculation, Filtration: Adsorption, adsorption, Ion Exchange Membrane Processes, RO, Ultrafiltration, Electrodyalisis, Disinfection

Wastewater Treatment

Waste waters-Sources, nature, characteristics, Analysis:- BOD progression & its formulations, Fundamentals of Process Kinetics, Zero order, First order, Second order Reactions, Different Reactors based on type of flow, Design of W/W treatment systems-Primary, secondary and tertiary; ASP, Nitrification-denitrification, Ponds and aerated Lagoons, Attached Growth Biological Treatment Systems: TF, RBC, Activated Biofilters etc., Expanded /fluidized bed reactors, USAB, Expanded granular bed reactors,. Sludge Digestion: anaerobic and aerobic, Waste water reclamation and reuse, Effluent disposal.

Unit 14 Air Quality Monitoring and Control Techniques:

Air pollutants: Sources, classification, Combustion Processes, pollutant emission, Effects on Health, vegetation, materials, atmosphere, Reactions of pollutants Scales of AP studies, effects as per scales, Air sampling, pollution measurement methods, Ambient air quality and emission standards, Air pollution indices, Air Act, legislation and regulations, Removal of gaseous pollutants. Particulate emission control; bioscrubers, biofilters, Indoor air quality

Models for Water and Air Quality

Introduction to Mathematical Models: Modelling approaches to water quality - classification and considerations in selecting models, Model requirements and limitations. D.O. Models for Streams: DO model for streams,Streeter - Phelps model - oxygen 'sag' curve, Benthal oxygen demand, Study of Mathematical Models, Models for Estuary and Lakes, Air quality models : Gaussian dispersion model, Regional air quality models

Unit 15 :Environmental Management and Impact Assessment

Environmental management, problems and strategies; Future strategies; multidisciplinary environmental strategies, Environmental impact assessment (EIA), Sustainable development (SD), initial environmental examination (IEE), environmental impact statement (EIS), environmental appraisal, environmental audit (EA); Environmental impact factors and areas of consideration, measurement of environmental impact,

SWM:Waste Management -Sources, Classifications, Characteristics, Generations, Onsite Handling and Storage, Collection, Transfer Recycling and Disposal Techniques of Municipal Solid Waste (MSW), Economic Evaluation of the Systems. Hospital Waste Management.

Unit 16

Remote Sensing, GIS and GPS Techniques and their applications in Environmental Studies. Softwares in Environmental Engineering.Pollutant Transport Mechanisms and Modelling, Hazardous Waste Management, Waste Minimisation Techniques, Environmental Risk Management

Reference Books:

1.Manual on water supply and Treatment ", CPHEEO, Ministry of Urban Development, GOI, New Delhi, 1999.

2. Manual on Sewerage and Sewage Development ", CPHEEO, Ministry of Urban Development, GOI, New Delhi, 1993.
3. B.A. Hauser, " Practical Hydraulics Hand Book ", Lewis Publishers, New York,1991.
4. M.J. Hammer, " Water and Wastewater Technology ", Regents/Prentice Hall, NewJersey, 1991.
5. Wastewater Treatment and Reuse: Metcalf and Eddy.
6. Air Pollution: Stern
7. Wastewater Treatment for Pollution Control; Arceivala and DR. Asolekar
8. Industrial Wastewater Treatment: Nelson – Numero
9. Industrial Wastewater Treatment: Dr. A. D. PAtwardhan
10 Kiely, G., Environmental Engineering. McGraw Hill, 1996. ISBN: 007091272
11. Wanielista, M., Kersten, R., and R. Eaglin.. Hydrology: Water Quantity and Quality Control. Wiley Interscience, 1996. ISBN: 0471072591
12. Zipparro, V.J., Davis' Handbook of Applied Hydraulics Fourth Edition. McGraw Hill, 1993. ISBN: 0070730024
13. Franzini, J., Freyberg, D., Linsley, R., and G. Tchobanoglous, Water ResourcesEngineering. McGraw Hill, 1991. ISBN: 0070380104 14
14 Reed, S.C. and Crites, R.W., Natural Systems for Waste Management and Treatment. McGraw Hill, 1996. ISBN: 0071346627
15 Eckenfelder, W.W. (Jr)., Industrial Water Pollution Control, (2nd Ed). McGraw-Hill, 1989. ISBN: 007018903X.
16 Guyer, H.H., Industrial Processes and Waste Stream Management.Wiley Interscience, 1998. ISBN: 0471299847.
17 Bishop, P., Pollution Prevention: Fundamentals and Practice. McGraw Hill, 2000. ISBN: 0073661473
18 American Water Works Association, Water Treatment Plant Design, (3rd Ed.). McGraw-Hill, 1997. ISBN: 0070016437.
19 American Water Works Association, Water Quality and Treatment: A Handbook of Community Water Supplies. McGraw Hill, 1998. ISBN: 0070015406
20 Kawamura, S., Integrated Design and Operation of Water Treatment Facilities**.** Wiley and Sons, 2000. ISBN: 0471350931
21 Nyer, E.K., Groundwater Treatment Technology, (2nd Ed.). Wiley Interscience, 1992. ISBN: 0471284149**.**

CONSTRUCTION MANAGEMENT :

Unit 17 : Essentials of Construction Management

CPM ,PERT networks, Cost / Resource based networks, scheduling, monitoring and updating, resource planning and allocation, LOB, network crashing, time cost tread off..

Computer Application in Construction Management- Softwares for .Precedence network analysis, CPM, ,PERT, GERT, decision tree analysis,

Unit 18

Financial Aspects of Construction Projects

Means of Finance, Working Capital Requirements, Project Cash Flow Projections and Statements, Project Balance Sheet, Profit Loss Account Statements, Concept of Debt Equity Ratio, Tax – Need and types

Risk Management

Introduction, Principles, types, origin, risk control, Use of mathematical models: Sensitivity Analysis, Break Even Analysis, Simulation Analysis, Decision Tree Analysis, Risk identification, analysis and mitigation of project risks, Role of Insurance in Risk Management.

Unit 19

Construction Techniques

Introduction to construction operations, erection work, automation processes and specialEquipments for Infrastrucure Projects- Dams, bridges, ports, harbours,flyovers
Recent trends in construction techniques

Material Management:

Material planning, accounting and material reconciliation. Systems of material classification. Deterministic and probabilistic models and applications, ABC analysis, replenishment and replacement policies, VED analysis, lead time demand, purchase planning, EOQ model. Wastage audit at site, Site waste material management plan.
Computer applications based upon available softwares

Unit 20

Equipment management :

New trends and construction equipment of future.Planning and selection of equipments, for earthmoving, hauling, hoisting, conveying, pneumatic, pumping, aggregate production, concrete production, pile driving, tunnelingand road construction applications.Equipment procurement, purchase, import of equipment, procedural formalities for Import

Operations Research in Construction-

Decision Theory, Game Theory, Linear Programming, Non linear programming

Reference Books-

1. Construction Engineering and Management by. S. Seetharaman, Umesh Publications, New Delhi
2. Total Project Managemtn- the Indian Context by P. K. Joy Macmillan India Ltd. Financial Managemnt by Prasanna Chandra, Tata Mc Graw Hill Publicaitons
3. Construction Project Management-Planning, Scheduling and Controlling by K. K. Chitkara, Tata McGraw Hill Publishing Company, New Delhi
4. Materials Management – Gopalkrishnan and Sunderasan, Prentice Hall Publications
5. Construction Planning, Methods & Equipment: Puerifoy – Tata McGraw Hill
6. Operations Research- Hamdy A. Taha
7. Engineering Optimisation- S. S. Rao

TOWN & COUNTRY PLANNING

Unit 21

Historic Development & Planning Theory-Origin ,evolution and contemporary developments in planning.,Formation of metropolitan areas &impacts of Industrial Revolution,Socio-economic & technological,impacts of growth of population; rural-urban migration,Characteristics of the urban environment: Land uses, physical structure ,The interim and comprehensive plans: Structure Plan, Master Plan, Zonal Development Plan - their purpose and contents,Surveys, analyses and design methods and practices in comprehensive planning,Residential Areas : Neighborhood and Sector Planning, Planning of New Towns in India and abroad.

Spatial & Environmental Aspects of Planning-Environmental degradation and its impact,environmental impact assessments ,principles of environmental approach to planning. Indicators of sustainabity in planning & development of settlement,Environmental design w.r.t natural resource management. Environmental impacts of traffic; energy issues in transportation; transportation safety.Spatio-environmental Planning principles and techniques.

Unit 22

Transportation & Utility Services-Transportation systems;Land use-transportation inter-relationships; transportation planning process;Traffic management.,Recent innovations in technologies and its probable impacts,Transport policies and evaluation of transportation proposals,Water supply systems,Waste water disposal systems&Solid wastes collection and disposal,Reuse and recycle Techniques,Planning for urban electrical distribution system and communication systems,Economic feasibility tests.

Planning Administration & Professional Practices-Planning legislation ,Constitutional basis and provisions relating to land, Evolution of planning laws,Land Acquisition Act of India, MRTP Act 1966,UDPFI Guidelines (implications of 73rd and 74th amendment of the constitution),EPA, Conservation of natural resources, Conservation and Management of Ancient Monuments and Archaeological sites and ruins., Land Development Control,Urban Arts Commission Act, Transportation, Landscape, Housing and slum clearance legislation. ,Role in interdisciplinary groups

Unit 23

Social formation & Housing.Housing problems: Urbanization and Industrialization,Slums and squatters settlements - problems and possibilities,Residential layouts, housing densities, neighborhood unit, community facilities,Social aspects : built environment and human behavior, Evaluation of user's satisfaction,Finance for housing: priority in the national plans - role of public and private agencies, role of cooperatives and various institutions,Cost reduction techniques in housing,Housing norms and standards.

Rural & Urban Planning Decentralized planning: conceptual framework; Dimensions of District and Block planning : their spatial disparities and sectoral variations; identification of spatial units under decentralized planning, Infrastructure planning with application of forecasting techniques,Resource mobilization and credit planning; organizational aspects; participatory planning approach; training needs and plan execution,,Rural development schemes and programs, Plan financing, monitoring and

evaluation of rural development schemes ,Urban design: Design Survey,Modern Techniques,Issues in urban design;Principles of urban spatial organization;Conservation with historic preservation.Case studies from India and abroad.,Urban renewal: Designing Central Business District (CBD) and Business Improvement District (BID) ,Growth and trends of metropolitan development, Components of a metropolitan plan ,Multi-nuclei developments: hierarchy of urban centers and their functional linkages,Metropolitan region and problems,Case studies of metropolitan planning in India and abroad.

Unit 24

Remote Sensing and GIS in Planning & Disaster management-Aerial photography,Application of aerial photography in town planning studies,Satellite remote sensing. ,Application of remote sensing in regional studies,G.I.S applications in planning and its role in remote sensing ,Disaster, Prevention, Preparedness (Warning),Relief

Quantitative Method in Planning -Survey, analysis and projections in City Planning; Ranking and Scaling; Applications of Probabilistic Modeling in City Planning; Applications of Queueing Theory in City Planning; Applications of Network Models in City Planning; Simulation in the Urban Context. Implementation Problems.

Reference Books :

1. K.S.Rangwala and P.S.Rangwala,. "Town Planning ",Charotar Publishing House,15th Edition,1999.
2. Michael Hord, R. Remote sensing methods and application, John Wiley and Sons, New York, 1986.
3. National Building Code of India- Part-III.
4. Municipal and Panchayat bye-laws, CMDA Rules and Corporation bye-laws.
5. KA. Ramegowda, Urban and regional planning , University of Mysore
6. M/s DVan, The urban pattern, city planning and design.
7. Time saver standards for site planning, Mc Graw Hill Book company
8. John Rate life, An Introduction to town and country planning,London
9. The art of home landscaping – Mc Graw Hill Book company
10. Harvey M. Rubenstain ,A Guide to site and Environmental planning, Newyork
11. The Small Town Planning Handbook by: Thomas L. Daniels, John W. Keller, Mark B. Lapping.

TRANSPORTATION ENGINEERING

Unit 25

Regional analysis and development concepts, the role of transportation planning in the overall regional system, Methodology and models for regional transportation system, Planning and implementation framework.Introduction, Basic for traffic engineering, Planning and design of facilities, Travel forecasting principles and techniques, Design Hourly volumes and speed, Highway capacity and performance characteristics, Parking, simulation in Traffic engineering design.

Unit 26

Theory of uninterrupted and interrupted traffic flow, Traffic Planning Process, Demand Analysis, Transportation Economics, capacity & Delay analysis, The planning process, Sequential demand analysis Models of trip generation, distribution, traffic assignment, and modal split.Introduction to transportation systems, transportation innovations, social and economic impacts of transportation; Decision makers and their options, demand modeling and predictions; Modelling transportation technologies;

Unit 27

Analysis of network flows; Transportation network; Network theory, wardrops external principle of traffic assignments, evaluation of impacts; Basic physics of transportation; Concepts in transportation models and location models. Materials for road construction; Specifications and tests; Macadam construction, surfacing and surface treatment; Asphal mix design pavement structure Sub grade evaluation; , Construction and maintenance of concrete pavement, Construction of interlocking block pavements, Quality control tests; Construction of various types of joints. Types of pavement structures, Factors affecting design and performance of pavements, Estimation of layer thicknesses**,** Pavement drainage, Stresses and strains in flexible pavement, IRC method of pavement design, Stresses in rigid pavements: Types of stresses and causes; Introduction to Westergaard's equations for calculation of stresses in rigid pavement due to the influence of traffic and temperature; Considerations in rigid pavement analysis, EWL; wheel load stresses, warping stresses, frictional stresses, combined stresses.

Unit 28

Rigid pavement design: Design of cement concrete pavement for highways and runways; Design of joints, reinforcements, tie bars, dowel bars. IRC method of design; Design of continuously reinforced concrete pavements. Highway alignment study, controls for selection of Alignment, Engineering Surveys, Geometric design of highways: cross-sectional elements, horizontal and vertical alignments, Geometric Design of Intersections – rotaries, Safety; Characteristics and design considerations for freeways/expressways; At-grade intersections - types, design considerations; Grade separations and interchanges - structures, interchange types and general design considerations.

Reference Books:

1. D. Salvo Perspectives in Regional Transportation Planning, Laxington Books, USA, 1974.
2. Mishra ,Sundaram and Prakash Rao, Regional Development Planning in India, Vikas Publishing House Pvt. Ltd., 1974.
3. G.J. Pingnataro, Principles of Traffic Engineering, Mc Graw-Hill, 1970.

4. Wohl and Martin, Traffic System Analysis for Engineering and Planners, Mc Graw Hill, 1983.
5. Ronald D. Drew, Traffic Flow Theory, Mc Graw Hill, 1964.
6. Manheim, Analysis of Transportation Systems, MIT, USA, 1980.
7. R.G. Weilson, Entropy in Urban and Regional Transportation, McGraw-Hill, 1980.
8. Miller and Mayor, Decision Analysis and Decision Making Oriented Urban Transportation, McGraw-Hill, 1984.
9. Hails, J.R. Ed., Applied Geomorphology and Engineering, Downden, Hutchinson and Ross, Stroundsburg, 1976.
10. Coats, D.R. Ed., Environmental Geomorphology and Landscape Conservation, Vols. II and III Dowen, Hutchinson and Ross, Stroudsburg, 1973.
11. Yoder and Witzech, Pavement Design, McGraw-Hill, 1982.
12. Sharma and Sharma, Principles and Practice of Highway Engg., Asia Publishing House, 1980.
13. Teng, Functional Designing of Pavements, Mc Graw - Hill, 1980.
14. Asce Journal papers.

700003-B2: Advances in Mechanical Engineering

Note: Each Unit is of 2 credits. A candidate has to take any *three* units (6 credits)

Unit 1: Convective Heat Transfer:
Fully developed flows, exact and similarity solutions, boiling and condensation, special topics

Reference Books:
1. W.M Kays and M.E. Crawford, "Convective Heat and Mass Transfer", McGraw Hill Intl.
2. T Cebeci, "Convective Heat Transfer", Springer

Unit 2: Mass Transfer:
Mass transfer - 1, Droplet vaporization -1, Mass transfer-2, Droplet vaporization – 2, Mass transfer- 3 (Any two)

Reference Books:
1. W.M Kays and M.E. Crawford, "Convective Heat and Mass Transfer", McGraw Hill Intl.
2. D. Brian Spalding, "Combustion and mass Transfer', 1st edition, Pergamon Press, 1979

Unit 3: Combustion:
Premixed and Diffusion flames

Reference Books
1. Kenneth K.Kuo, " Principles of Combustion", John Wiley and sons. Inc, 2005
2. Irvin Glassman, "Combustion", Academic Press, 1987
3. Turns,S.R., "An Introduction to Combustion, Concepts and Applications", Mc-Graw Hill, 2000
4. Williams,F.A., "Combustion Theory" The Benjamin and Cummings Publishing Company Inc.,1985
5. Law,C.K., "Combustion Physics", Cambridge University Press,2006

Unit 4: Computational Fluid Dynamics – I (CFD – I)
Finite volume algorithm, up-winding, Solution of pressure field on Cartesian meshes

Unit 5: Computational Fluid Dynamics – II (CFD-II) :
Mesh generation techniques, Solution on Non-Cartesian meshes.

Reference Books (*Common for both unit 4 and 5*)
1. Wesseling P, "Principles of Computational fluid dynamics", Springer
2. Ferziger J.H., "Computational methods for fluid dynamics", Springer

3. Anderson, J.D. ”Computational Fluid Dynamics: The Basics with Applications”, McGraw Hill, 1995
4. Ferziger,J.H. and Peric,M., “Computational Methods for Fluid Dynamics”, Springer, 1999
5. Patankar,S.V., “Numerical Heat Transfer and Fluid Flow”, Narosa Publishing House, USA, 1980
6. Date,A.W., “Introduction to Computational Fluid Dynamics”, Cambridge University Press, 2005
7. Wilcox,D.C., “Turbulence Modelling for CFD”, DCW Industries Inc., 1994
8. Chunng,T.J., “Computational Fluid Dynamics”, Cambridge University Press, 2002
9. Thompson,J.F., Warsi,Z.U.A. and C.W. Mastin, “Numerical Grid Generation-Foundations and Applications” North Holland, 1985

Unit 6: Turbulence
Governing equations, Free shear flows, Near wall behavior, Energy spectrum, Turbulence models

Reference Books:
1. Stephen B. Pope, “Turbulent flows”, Cambridge Univ. Press
2. Hinze J.O., “Turbulence”, McGraw Hill

Unit 7: Vibrations
Multi-degree freedom systems, Approximate and numerical methods, Continuous systems, Nonlinear systems

Reference Books
1. Balakumar Balachandran and Edward Magrab, “Vibrations”, Thomson Brooks/Cole, 2004.
2. Kelly S.G., “Mechanical vibrations”, McGraw-Hill, 2007

Unit 8: Acoustics
Wave propagation, generation/transmission of sound, noise control

Reference Books
1. Kinsler, Frey and Coppens, “Fundamentals of Acoustics”, John Wiley & Sons
2. Allan D Pierce, “Acoustics: An Introduction to its Physical Principles and Applications”, Acoustical Society of Amer, 1989.

Unit 9: Fracture Mechanics
Linear Elastic Fracture Mechanics,Elastic Plastic Fracture Mechanics, Fracture Mechanisms in Metals

Reference Books

1. T L Anderson, Fracture Mechanics- Fundamentals and Applications, CRC Publishers, 2nd edition, 1995
2. Ashok Saxena, Nonlinear Fracture Mechanics for Engineers, CRC Publications
3. Hertzberg R.W., Deformation and Fracture Mechanics of Engineering Materials, Wiley, 4th edition, 1996.

Unit 10: Advanced Topics in Refrigeration and Cryogenics

Refrigeration applications in preservation of Food, transport by trucks and containers; Railway cars; Marine

Refrigeration; Fans and Blowers, Sound Control. Construction of psychrometric charts, enthalpy deviation curves (Any two)

Reference Books

1. ASHRAE HANDBOOKS (i) Fundamentals (ii) Refrigeration
2. Threlkeld J.L., "Thermal Environmental Engineering", Prentice Hall
3. Dossat R.J., Principles of Refrigeration, Pearson Education Asia
4. Handbook of air-conditioning system design, Carrier Incorporation,McGraw Hill Book Co., U.S.A.
5. Hainer R.W. 'Control Systems for Heating, Ventilation and Air – Conditioning', Van Nastrand Reinhold Co., New York, 1984.

Unit 11: Advanced Theory of Elasticity (3-dimensional problems):

Theories of Stress and strain, Transformation of stress and strain, Linear stress-strain – temperature relations, Applications of energy methods, Torsion, Bending, Plates

Reference Books

1. Boresi A.D., Schmidt R.J, and Sidebottom O.M, "Advanced Mechanics of Materials", Wiley
2. Richard Budynas, "Advanced strength of applied stress analysis", McGraw Hill
3. Cook R.D., Young W.C., "Advanced Mechanics of Materials", Prentice Hall
4. Timoshenko and Goodier, "Theory of Elasticity", McGraw-Hill Publications
5. Ugural and Fenster, "Advanced Strength and Applied Elasticity", 4th Ed., Prentice Hall, PTR, 2003.
6. Srinath L.S, "Advanced Mechanics of Solids", Tata Mc-Graw Hill, New Delhi, 2003.

Unit 12: Advanced gas dynamics:

Liberalized flow, Method of characteristics, Shock boundary layer interaction, Numerical methods

Reference Books

1. Anderson J.A., "Compressible Flow", McGraw Hill.
2. Shapiro A.H., "Dynamics and Thermodynamics of Compressible Fluid Flow", MIT Press

3. Zucker R. D. and Biblarz Oscar, "Introduction to Gas Dynamics", John Wiley and Sons. Inc., Second Edition, 2002

Unit 13: Robotics
Kinematics, Dynamics, Trajectory, Control

Reference Books
1. John J Craig, "Introduction to Robotics – Mechanics and Control", Prentice Hall, 3rd Edition, 2004.
2. Fu K.S., Gonzales R.C., and Lee C.S.G., "Robotics: Control, Sensing, Vision and Intelligence, Tata Mc-Graw Hill, 2008.

Unit 14: Advanced Topics in I C Engines:
Engine Emissions & Control, Engine Electronics, Modelling Real Engine Flow and Combustion Process, Fuel/Air Mixture Requirements (Any two)

Reference Books
1. Charles Fayette Taylor, "The Internal Combustion Engine in Theory and Practice", Vol. I & II, The MIT Press.
2. John B Heywood, "Internal Combustion Engine Fundamentals", McGraw Hill International Edition, 1998.
3. Makartchouk, A., "Diesel Engine Engineering: Thermodynamics, Dynamics, Design, and Control". New York, and Basel: Marcel Dekker, Inc., 2002.
4. SAE publications
5. Blair, G., "The Basic Design of Two-Stroke Engines", Warrendale, PA: Society of Automotive Engineers, 1990.
6. Owen, K., and Coley.T., "Automotive Fuels Handbook". Warrendale, PA: Society of Automotive Engineers, 1990.

Unit 15: Finite Element Methods
Thermal analysis (temperature effects), 2D, 3D elements,Contact analysis, Non-linear static analysis

Reference Books:
1. Bathe K J "Finite Element Procedures", Cambridge, MA 2007
2. Sequerlind L J, "Finite Element Analysis", Wiley, 2nd edition, 1984
3. Reddy J.N., "An Introduction to Finite Element Method", McGraw Hill

Unit 16: Micro Electro Mechanical Systems (MEMS)
From Microphysics to Macrophysics, Thermodynamics of Microstructures, Reliability of MEMS

Reference Books
1. Balian Roger, "From Microphysics to Macrophysics",1st edition, Springer, 2006.
2. Thermodynamics of Microstructures, ASM International, 2008
3. Younes Shabany, "Heat transfer Thermal Management of electronics", CRC Press.
4. Electronics cooling magazine issues from 1997 -2010

Unit 17: Bio-medical device design
Applications, FDA approval procedures, A Certification

Reference Books
1. Shiegly J.E., Machine design
2. Richard Fries and Paul King www.crcpress.com
3. Anatomy by Gray 1918
4. Pathology by Simpson
5. Principles of Orthopedic deformity correction - by Dror Paley www.springer.com
6. FDA procedures – Class notes

Unit 18:
Systems design for Cooling of Electronic Equipments Enclosure design, power packing factors, electronic packing

Reference Books
1. Faghri Amir, "Heat Pipe Science and Technology", Taylor & Francis, 1995.
2. Dunn and Reay, "Heat Pipes", Pergamon, 4th Edition,
3. Kaveh Azar, "Thermal Measurements in Electronic Cooling", CRC Press, 1997.

Unit 19: Reliability Engineering:
Reliability evaluation of complex systems, Safeties and certifications, Terro technological Aspects

Reference Books
1. M/c standard 8005
2. Kapur K.C., and Lamberson L.R., "Reliability in Engineering Design", Wiley India Pvt. Ltd., 2009.

Unit 20: Turbo Machinery:
Analysis of flow, Design aspects, Cooling of turbo-machines, Special topics (Thermal and Hydro turbo machines)

Reference Books
1. Lakshminarayana B., "Fluid Dynamics and Heat Transfer of Turbo Machinery", Wiley – Interscience, 1995.
2. Rangwala A.S., "Turbo-Machinery Dynamics", McGraw Hill,
3. Earl Logan, Jr, Ramendra Roy, "Handbook of Turbo Machinery", 2nd Edition (Mechanical Engineering, No. 158)
4. Rama S.R. Gorla, "Turbo Machinery: Design and Theory", Marcell Dekker
5. Duncan Walker, "Torsional Vibration of Turbo-Machinery",
6. R. I. Lewis, "Turbo machinery Performance Analysis"

Unit 21: Metal Forming:
Yield criteria, Slip line field theory,Temperature Field in Material.- Plastic and Visco-plastic behaviour of material, Surfaces of Discontinuity, Numerical Models of Plasticity.

Reference Books

1. Sluzalec and Andrzej, “Theory of Metal Forming Plasticity - Classical and Advanced Topics” Springer Publications
2. Avitzur B., “Metal Forming - Process and analysis” Tata Mc-Graw Hill
3. Mielnik E.M., “Metal working science and Engineering”, Mc-Graw Hill. Inc

Unit 22:

Metal Machining - Modelling and control of Chip Formation, Machining of hard materials and metal matrix reinforced composites, Characterization and surface integrity in hard machining, Modern concepts of machining

Reference Books

1. Milton C Shaw, “Metal Cutting Principles” 2nd Edition, Oxford series in Advanced Manufacturing.
2. Paulo Davim (Ed.), “Machining – Fundamentals and Advances” Springer-Verlag, London, 2008.
3. Childs Thomas, Maekawa K., Obikawa T., and Yamane Y., “Metal machining – Theory and Applications” John Wiley & Sons, New York, 2000

Unit 23: Modelling of Manufacturing Systems

Markov chains –Continuous and Discrete, Petri nets – Timed and Stochastic

Reference Books

1. Viswanadham, N and Narahari, Y. “Performance Modelling of Automated Manufacturing Systems”, Prentice Hall of India, New Delhi, 2000
2. Hruz B. and Zhou M.C., “Modelling and Control of Discrete Event Dynamic Systems”, Springer, London, 2007.
3. Curry G., Feldman R.M., “Manufacturing Systems Modelling and Analysis”, Springer-Verlag, Heidelberg, 2009.

Unit 24: Reverse Engineering :

Reverse engineering – Methodologies and Techniques, Hardware and software, Rapid prototyping –Relationship with reverse engineering

Reference Books

1. Vinesh Raja and Kiran J Fernandes, “Reverse Engineering – An Industrial perspective”, Springer, London, 2008
2. Pham D and Dimov S, “Rapid manufacturing - The technologies and applications of rapid prototyping and rapid tooling. Springer-Verlag, London, 2001.

Unit 25: Advanced Machining Processes:

Hybrid electro-chemical processes, Hybrid thermal processes, Solid, liquid and powder based material addition processes (Analytical Study)

Reference Books

1. Hassan El-Hofy, "Advanced Machining Processes – Non Traditional and Hybrid Machining Processes", Mc-Graw Hill, London, 2005
2. Brown J., "Advanced Machining Technology Handbook", Mc-Graw Hill, New York, 1998

Unit 26: Manufacturing Systems:

Machine tool design, control, automation and analysis, Computerized process planning

Reference Books

1. George Chryssolouris, "Manufacturing Systems: Theory and
2. Practice", 2nd Edition, Springer, New York, 2006.
3. Chang T.C., "Expert Process Planning for Manufacturing", Addison – Wesley, MA, 1990
4. Slocum A.H., "Precision Machine Design", SME, Prentice-Hall Inc, 1992.

Unit 27: High Integrity Die Casting

Vacuum die casting, Squeeze casting, Semi solid metal working, Design considerations for high integrity die Castings

Reference Books

1. Edward J Vinarcik, "High Integrity Die Casting Processes", John Wiley & Sons Inc., New York, 2003.
2. Campbell John, "Castings", Butterworth – Heinemann, 2000.

Unit 28: Computational Welding Mechanics:

Models for welding heat sources, Thermal analysis of welds, Fracture Mechanics of welded structures

Reference Books

1. Goldak J.A., and Akhlaghi M., "Computational Welding Mechanics", Springer, New York, 2005.
2. Radaj D., "Heat Effects on Welding: Temperature field. Residual stress and Distortion", Springer, 1992.

Unit 29: Composite Materials:

Elastic behavior of unidirectional and multi directional composites, Laminated composite beams and plates (Any one)

Reference Books

1. Isaac and Daniel M., "Engineering Mechanics of Composite Materials", Oxford University Press, 1994.
2. Jones R.M., "Mechanics of Composite Materials", McGraw Hill, New York, 1975
3. Calcote L.R., "Analysis of Laminated Composite Structures", Van Nostrand Rainfold, New York, 1969

700003-B3: Advances in Electrical Engineering

Note: Each Unit is of 2 credits. A candidate has to take any *three* units (6 credits)

Unit 1: Intelligent Control

Neural network architecture for modeling and Control, System identification and control, Fuzzy, Neuro-fuzzy, Typical applications of ANN , Classification, Clustering, Pattern Recognition, Different architectures of neural network, Learning algorithms, Knowledge based systems, Genetic algorithms.

Reference Books:

1. Simon Haykin, 'Neural Networks: A Compressive Foundation', Second Edition, Person Education.
2. Zimmermann, H.J, 'Fuzzy Set Theory and its Applications', Second Edition, Kluwer Academic Publishers.
3. M. Ganesh, 'Introduction to fuzzy sets and fuzzy Logic', Prentice Hall India.
4. Mohamed H. Hassoun, 'Fundamentals of Artificial Neural Network', Prentice Hall India.
5. Jacek Zurada, 'Introduction to Artificial Neural Network', Jaico Publishing House India.

Unit 2: Multivariable and Optimal Control Systems

Introduction, general structure Examples, state space and transfer matrix forms; Controllability and observability, state Estimation, decoupling , model matching control, classical control extended to multivariable control system. Pontryagins minimum principle and its application to optimal control. Continuous and discrete time systems , linear regulator problem, minimum time optimal control ,bang bang control.

Reference Books:

1. 'Linear Multivariable Control Systems', Y. S. Apte, New Age International Publications.
2. 'Multivariable Control System': W.M. Wonham.
3. 3. 'Optimal Control: An Introduction' O Kirk, Prentice Hall.
4. 'Multivariable Feedback Control', S.Skogestad, I.Postlethwaite,
5. John Wiley and Sons, 2005

Unit 3: Control System Design

Design of linear and non-linear systems, continuous and discrete time, SISO and MIMO systems by state variable techniques. Advanced PID design techniques, Application of softwares, Simulink and CAD for control system design.

Reference Books:

1. 'Control System Design', G.C.Godwin, S.F.Graebe, M.E.Salgada, Prentice Hall of India .

2. 'Control System Design Guide: A practical Guide', George Eills, Academic Press(3rd Edition).
3. 'Control System Principles and Design', M.Gopal.
4. 'Control System Engineering', Norman S.Nise, Willey (Third Edition)

Unit 4: Modeling of Dynamic Systems

Modeling and simulation techniques applied to dynamic systems covering physical systems such as electrical, mechanical, thermal, chemical, biomedical and biological.

Reference Books:

1. 'System modeling and response: Theoretical and Experimental Approaches', Ernst O.Dobling, John Wiley and Sons , 1980.
2. 'Modeling and Identification of Control Systems',M.Gopal
3. 'Modeling and Simulation of Dynamic Systems', Robert Woods, Kent L. Lawrence, Prentice Hall.

Unit 5: Renewable Energy Sources

Solar Photovoltaic, new organic photovoltaic materials and devices, Modeling and characterization of PV cells and modules, Grid integration of PV systems. Wind Energy systems, wind turbine Electrical generators and converters, Wind turbine system reliability, Wind resources and its characterization, grid integration of wind turbines and wind farms., Power quality and reliability issues related with wind farm interfaced to weak gird.fuel cells systems. Hybrid systems, standalone hybrid systems, other sustainable Energy sources such as biomass, tidal, wave, geothermal, small and mirco hydel systems.

Reference Books:

1. Renewable Energy technologies: R.Ramesh, Narosa Publications .
2. Energy Technology: S.Rao, Parulkar.
3. Non-Conventional Energy Systems: Mittal , Wheeler Publication
4. Wind and solar Systems by Mukund Patel , CRC press.
5. Solar Photovoltaic for terrestrials, Tapan Bhattacharya.
6. Wind Energy Technology: Njenkins, John Wiley Sons.
7. Grid integration of wind Energy conversion Systems: Siegfried, Wiley Publications , John Wiley and Sons.

Unit 6: Power Electronics and Drives

Modern power switching devices, Voltage source converter topologies, Multi pulse converters, Inverter, Multilevel Inverters and Chopper, Current source converters, Harmonics elimination schemes.

Variable speed drives for various industrial applications, advanced control techniques. (16 Hours)

Reference Books :

1. Power Electronics : M.H.Rashid (Prentice Hall India Pvt.Ltd.)
2. Power Electronics Handbook : M.H.Rashid, Academic Press Series in Engineering.
3. First Course in Power Electronics : Ned Mohan, MNPERE publications.
4. Electric Drives:Ion Boldea, Sayd Nasar ,CRC Press, Boca Raton London New York Washington, D.C.

5. Practical Variable Speed Drives and Power Electronics : Malcolm Barnes,ELSEVIER Newnes Publications,Linacre House, Jordan Hill, Oxford OX2 8DP,200 Wheeler Road, Burlington, MA 01803

Unit 7: Power system restructuring

Power tariff , pricing issues , market reforms and models , policies, methods of comparing investment options , Electricity market pricing and non pricing issues, spot pricing , reactive power pricing .(10 Hours)

Reference Books:

1. Sally Hunt, 'Making compettion work in Electricity' , 2002 John Wiley Inc.
2. 'Regulation in infrastructure services: Progress and the way Forward', TERI .
3. 'Market operations in electric power systems forecasting , Scheduling and Risk Management', Mohammad Shaedepur , Hatim, Zuri Li.

Unit 8: Numerical protection

Numerical protection, Numerical protection of transmission line, synchronous generator, power transformer, relay co-ordination.(10 Hours)

Reference Books:

1. 'Digital protection' , L.P. Singh , New Age International (P) ltd. Publishers, New Delhi. ,
2. 'Transmission network protection', Paithankar , Marcel and Dekker , New York
3. 'Fundamental of power system protection', Paithankar and Bhide , Prentice hall of India Pvt.Ltd. New Delhi.
4. 'Protective relaying for power system II' , Stanley Horowitz , IEEE press , New York.

Unit 9 : Power System Analysis

Synchronous machine modeling, excitation system, modeling, transmission line modeling, analysis of single machine and multi machine, power system stabilizers, voltage stability, islanding (10 Hours)

Reference Books:

1. Power system dynamics :K.R.Padiyar , B.S.Publications.
2. Power system Control and Stability :Vol.I, Anderson & Foud , IEEE Press New York.
3. Power system Dynamics and Control :Kundur , IEEE Press New York.
4. 4 .Power System operation and control :P.S.R Murthy
5. Power System stability : E.W.Kimbark, IEEE Press , N.Y.Vol.3
6. Power system control and stability , Vol.1 , Anderson and Foud , IEEE Press New York.
7. Power System Voltage Stability :C.W.Taylor, McGraw Hill International student Edition .

Unit 10 : Computer Applications in power system

Optimization techniques, classical techniques, single variable and multivariable optimization, Newton Raphson's method, Descent method, non linear programming, load flow under linear as well as non linear load connected to power system, motor starting

analysis, symmetrical and un-symmetrical power system fault analysis, decoupled load flow, methods of optimal power flow (10 Hours)

Reference Books:

1. Computer Aided Applications in power system operation and Analysis: R.N.Dhar, Tata Mc-Graw Hills , New Delhi.
2. 2.Computer techniques in power system Analysis: M.A.Pai, Tata Mc Graw Hills , New Delhi.
3. Optimization Techniques: S.S Rao , Wiely Eastern Ltd., New Delhi .
4. Electrical Energy System Theory: An Introduction , Olle Elgred, TMH Publishing Company , New Delhi.

Unit 11: Power Quality

Power quality definitions as per IEEE Std. 1159, RMS Voltage variations , such as voltage sag, swell, under and over voltage , Flicker , its sources, effects on equipments and solutions , IEEE Std 1346 . Waveform distortion , various factors governing waveform distortion , Harmonic sources , its effect on equipment , harmonic mitigation techniques K Rated transformer , series and parallel resonance , IEEE Std 519-1992. Power quality monitoring as per IEEE Std. 1159. Transients , impulsive and oscillatory transients , capacitor switching transient , Methods to control transient , TVSS.(10 Hours)

Reference Books:

1. IEEE std. 1159, IEEE Press,USA.
2. IEEE Std, 1346 , IEEE Press, USA.
3. IEEE Std 519, IEEE Press , USA.
4. Understanding power quality Problems , Voltage Sag and interruptions :M.H.Bollen ,IEEE Press , 2000 , Series on Power Engineering.
5. Electrical power System Quality :Dugan, Mar F.McGranghan.MC Graw Hill Publication.
6. Power System Quality assessment :J.Arrillaga. M.R. Watson, S.Chan, John Wiley and Sons.

Unit 12 : Grounding

Objectives of grounding , Factor affecting soil resistivity , single layer and multilayer homogeneous and heterogeneous soil modeling , Sub station grounding Design as per IEEE standard 80 , Grounding of sensitive Electronic equipments as Per IEEE std. 1100 .EMI and Electrostatic shielding .(10 Hours)

Reference Books:

1. Power System Analysis , B.R.Gupta
2. IEEE Std. 80 , IEEE Press , USA
3. IEEE Std, 1100 , IEEE Press, USA.

Unit 13: Energy Management

Energy management and audit, Energy and mass balance , Energy modeling , Energy conservation opportunities in Thermal , HVAC, Electrical , compressed air , Centrifugal pumps , Blowers . Waste heat recovery, CHP , Energy Efficient technologies ,Energy conservation Building Codes.(10 Hours)

Reference Books:

1. IEEE recommended Practice for Energy Managent in Industrial and commercial facilities , IEEE Std 739 -1995
2. Energy Efficiency in Electrical utilities , Guide Book for National Examination for Energy Managers and Energy Auditors , BEE, New Delhi.
3. Energy Efficiency in Thermal utilities , Guide Book for National Examination for Energy Managers and Energy Auditors , BEE, New Delhi.
4. Energy performance assessment for equipment and utility systems , Guide Book for National Examination for Energy Managers and Energy Auditors , BEE, New Delhi.
5. Hand book on Energy Management and Audit , TERI , New Delhi.

Unit 14: Condition Monitoring

Condition monitoring of transformer, soild , liquid and gaseous phase monitoring , SFRA techniques , On line off site condition monitoring of transformer , residual life assessment of transformer , Noninvasive testing on transformer for condition assessment, Condition monitoring of OLTC . Condition monitoring of induction motor by MCSA , rotor and bearing fault analysis of induction motor , condition monitoring of cables and switch gears.

Unit 15: Smart Grid

1. Formation of microgrids and interconnections to established grid.
2. Integration of wind, solar and other renewable generation into the present distribution.
3. Dispersed generation including captive power co-generation and mini-hydal.
4. Disaster and emergency management in case of disturbance in distribution.
5. Communication requirement protocols and standards.
6. Development of microgrid management software
7. Present status of microgrids in the world power system (10 Hours)

700003-B4: Advances in E and TC/ Electronics Engineering

Note: Each Unit is of 2 credits. A candidate has to take any *three* units (6 credits)

Unit 1: Microelectronics and VLSI

Microelectronic devices, characteristics, mathematical modeling, performance parameters, design aspects, parasitics, integration issues, layout rules, optimization techniques.

Unit 2: RFIC Design

RF Amplifiers, characteristics, mathematical models, power relations, stability considerations, stability circles, unconditional stability, stabilization methods, designs, circles, circles.

Unit 3:Mixed Signal Analysis

Signal integrity, techniques, equivalent models, characteristics, limitations, mixed signal processing, simulation, physical parameters.

Unit 4: RF Systems

The techniques of RF amplifier, mixer and local oscillator designs, Advanced YIG and narrow band filters, amplifiers, Transmission line design, Design challenges in satellite frequency bands.

Unit 5: Microwave and Antennae

Microwave sources, Passive devices, MMIC, MMIC fabrication techniques, Thick and Thin film technologies and materials, Microstrips, Microwave antennae.

Unit 6: Coding and Modulation Techniques in Communication

Digital communication system architectures, Source coding, Channel coding, Performance measures of communication systems, PLD based system implementations and related issues.

Unit 7: Communication Network

Various IEEE standards, Performance issues, Trade-offs, Network architectures, Security algorithms with their performance measures.

Unit 8: Wireless & Broadband Communication

IEEE/ITU/ ETSI communication standards and specifications, various trade-offs in functionality, implementation, Transmitter/Receiver architectures and related issues, Wireless embedded approach, Antennae and front end design issues.

Unit 9:Advanced Topics in Signal Processing

Modeling different Signals and systems, various transforms, System design and Implementation issues, DSP architectures and related issues, Evaluation parameters for the various applications.

Unit 10: Image Processing & Pattern Recognition

Image representation formats, noise, processing techniques, Performance measures, various algorithms, Pattern classifications and recognition techniques, Biometrics.

Unit 11:Speech Processing

Speech recognition and synthesis techniques, modeling the speech signal, various algorithms, trade-offs and implementation issues.

Unit 12:Processor Architectures

Design philosophy of RISC, CISC, Multi-core, Various processor architectures, Design of microcontroller CPU.

Unit 13: Programmable Architectures and Memories

HDL programming, PLDs, floating point arithmetic, multipliers, modeling a sequential machine, Barrel shifter, HDL models for memories and buses.

Unit 14: System on Chip and MEMs

Chip architecture, Clock & power related issues, SRC, DRC, I/O architectures, Wire parasitic, Design validation, MEMs.

Unit 15:Modern Control Theory

Control mechanisms and their modeling, Implementation aspects and related trade-offs, various applications, Selection criteria's of control systems for various applications, Performance evaluation techniques.

Unit 16: Human Machine Interface

Different techniques used for HMI, Algorithms, Related issues and constraints, Performance issues, Applications.

Unit 17:Machine Vision

Human vision, Expert systems, Algorithms, Implementation issues and trade offs, Performance measures and analysis.

Unit 18:Biomedical Engineering

Biomedical Signals, Biomedical Systems, Analysis, Implementation issues, Performance measures.

Unit 19:Nano Technology

Present devices and materials, Advance materials such as Carbon nano tubes etc., advance devices, constraints, applications, Trade offs.

Reference Books:

1. M.J. Roberts, "Signals and Systems", Tata McGraw Hill Publications, 2003.

2. M. Burns, “Introduction to Mixed Signal IC Test and Measurement”, Oxford University Press Publications, New York.
3. Xilinx, “The Programmable Logic Data Book”, Xilinx, California.
4. Hu, Yu Hen, “Handbook of Neural Network Signal Processing”, CRC Press Publications.
5. Yacoub M.D., “Wireless Technology”, CRC Press Publications.
6. Gold B., “Speech and Audio Signal Processing”, John Wiley Publications.
7. Kuo B.C., “Digital Control System”, Sounders College Publications, New York.
8. Comer “Digital Logic and State Machine Design”, Sounders College Publications, New York.
9. Prokis J.G., “Digital Signal Processing”, PHI Publications.
10. Alley, Charles L, “Micro Electronics”, McGraw Hill Publications.
11. Ha, Tri T., “Digital Satellite Communication”, McGraw Hill Publications.
12. Peebles, “Probability and Random Signals”, McGraw Hill Publications.
13. Balanis, “Antenna Theory analysis and Design”, John Wiley Publications.
14. Gray R.P.,” Analysis and Design of Analog ICs”, John Wiley Publications.
15. Tompkins J.W., “Biomedical Digital Signal Processors”, PHI Publications.
16. Collin E.R., “Foundations for Microwave Engineering”, McGraw Hill Publications.
17. Freeman R.L., “Radio System Design for Telecommunication”, John Wiley Publications.
18. Kronsjo L., “Advances in Parallel Algorithm”, Blackwell Scientific Publication, London.
19. Xavier, Eugune S.P., “Statistical Theory of Communication”, New Age International Publication.
20. Baker R.J., “CMOS: Circuit Design, Layout and Simulation”, IEEE Press Publication.
21. McGillen C.D., “Continuous and Discrete Signal and System Analysis”, Oxford University Press.
22. Russ J.C., “The Image Processing Handbook”, CRC Press Publications.
23. Franssila S., “Introduction to Micro fabrication”, John Wiley Publications.
24. Park J., “Practical Embedded Controllers”, Elsevier Publications, Amsterdam.
25. Kabatiansky G., “Error Correcting Coding and Security for Data Network”, John Wiley Publications.
26. Lee K., “Semiconductor Device Modeling For VLSI”, PHI Publications.
27. Maxfield C.M., “The Design Warriors Guide to FPGA”, Elsevier Publications, Amsterdam.
28. ***Carsten Steger, Markus Ulrich, Christian Wiedemann, “***Machine ***Vision Algorithms and Applications”,*** Wiley-VCH, Weinheim Publications.
29. Pires, J. Norberto, “Human Machine Interface for Industrial Robotic Cells”, Springer Publications.

700003-B5: Advances in Metallurgical Engineering

Note: Each Unit is of 2 credits. A candidate has to take any *three* units (6 credits)

Unit 1 : Characterization and testing of Materials

X-ray Diffraction (XRD), Determination of lattice parameters, Applications of XRD to metallurgical problems, Scanning electron microscope (SEM), Wavelength dispersive X-ray (WDX) and Energy dispersive X-ray (EDX) spectroscopy, Transmission electron microscope (TEM), selected area diffraction, techniques of specimen preparation, Scanning-Tunneling Microscope (STM) and Atomic Force Microscope (AFM); Thermal analysis:- TGA, DTA/DSC, Dilatometer; UTM, Impact test, Fatigue test, Hardness, Creep, and Fracture Toughness.

Unit 2 : Advanced Powder Metallurgy

Conventional and modern methods, Blending techniques. Powder characterization techniques, Powder compaction processes, Theories of sintering and its mechanism, Sintering furnaces and atmospheres, applications of P/M processes for tools, creep resistant alloys and bearing materials.

Unit 3 :Nanomaterials & Nanotechnology

Top down and bottom up approaches, classification of nanomaterials, carbon nanotube (CNT), particulate reinforced metal/ceramic/polymer nanocomposites, Characterization of nanomaterials, Applications of nanotechnology in medicine, automobile sector, metallurgical, civil, computer and electronics field; Pros and cons of nanotechnology.

Unit 4: Electronic Materials

Dielectric properties, Polarization mechanism, Frequency and Temperature effects, Electrical breakdown, Classification of ferroelectric materials, Piezoelectricity, Capacitor dielectric materials, Insulating materials and Pyroelectric materials, ceramic composites as capacitors and sensors.

Unit 5: Diffusion and Kinetics

Introduction, Fick's Law of diffusion, factors affecting diffusion, Mechanism of diffusion, methods of evaluation of diffusion coefficient, Kirkendall effect, diffusion in thin films and multilayers. Problems related to diffusions. Order of reactions, absolute reaction rate theory, nucleation and growth in homogeneous and heterogeneous reactions, nucleation problems in solid phases.

Unit 6: Advanced Composites

Introduction to advanced composites, Classifications of composites, role of interfaces, types of reinforcements, methods of fabricating metal matrix composite (MMC), polymer matrix composite (PMC) and ceramic matrix composite (CMC), Their properties and applications.

Unit 7 : Iron and Steel Making

Iron making, Blast furnace, Raw materials, Pig iron, Reduction reaction, Steel making, Refractories, Scrap, Fluxes, Sponge Iron production, Electric Furnace, Ladle Metallurgy, Principle of Steel making and Refining Technology, Gases removal, De-oxidation of Steel and Non-Metallic inclusions, Role of Slag Composition on Quality of Steel, Processes-AOD, VOD& VD. Continuous Casting processes, Defects in Cast Product, Electromagnetic Stirring (EMS) for Quality improvement.

Unit 8 : High Temperature Corrosion

Introduction to high Temperature corrosion & oxidation of Metals and Alloys, Thermodynamics & Ellingham diagram, vapour species diagram, Isothermal stability diagram, Rate Laws, Kinetics and Mechanics. Wagner's parabolic law of Oxidation. Role of Diffusion and Defect structure of oxides in Oxidation, multiple scale formation & cracking. Hot Corrosion, Corrosion in Mixed Gaseous Environment. Prevention of Corrosion, Inhibition, Metallic and Ceramic Paints, Coatings, Special Treatment. High temperature materials.

Unit 9 : Casting and Materials Joining

Casting processes, Solidification medium, Constitutional super cooling, Feeder design and performance, Defects in castings and remedial measures, Fusion welding, Solid-liquid joining, Solid state joining, Heat flow analysis, Weld metal microstructure, Heat Affected Zone, Properties of welded zones, Defects and remedies in welded zones, Dissimilar metal joining, Joining processes selection, applications of joining processes.

Unit 10 : Advanced Thermodynamics of Materials

First law and second law of thermodynamics, Heat capacity, Enthalpy, Heat of reactions, Hess's law, Kirchoff's equation, Third law of thermodynamics, Temperature dependence of heat capacity. Concept of equilibrium, Free energy as criterion for equilibrium and its applications to processing of materials. Gibbs-Duhem equations. Free energy-temperature diagrams, oxygen potential. Binary phase diagrams, Free energy versus compositions in binary systems.

Reference Books:

1. William F. Smith - Foundation of Materials Science and Engineering, Mc Graw-Hill International Edition, 2nd Edition, 1993.
2. S. O. Kasap - Principles of Electronic Materials and Devices, Tata Mc Graw-Hill Publication, 2nd Edition, 2002.
3. Buschow K.H.J. (Ed.), Handbook of Magnetic Materials, Amsterdam : Elsevier
4. Electronic Materials Handbook, ASM International, Materials Park, 1989
5. High Temperature Oxidation of Metals and Alloys –by N.Birks and Meir
6. Fundamentals of Corrosion- Scully
7. W.D.kingery, H.A.Bowen and D.R.Uhlman-Introduction to ceramics –2nd Edition, John Wiley, New York1976
8. R.C.Buchanan –Ceramic materials for Electronics, Marcel Dekker Inc.1986
9. Steel Making –V. Kudrin, Mir. Publisher
10. Introduction to Modern Steel Making- Dr.R.H.Tupkari, Khanna Publishers
11. Electrometallurgy-I - By Edneral
12. Continuous Casting of Steel – By Irving W.R.,
13. B.D. Cullity, Elements of X-ray Diffraction (For X-rays), 3rd ed., Prentice-Hall, Upper Saddle River 2001
14. L.E. Murr, Electron and Ion Microscopy and Microanalysis, Marcel Dekker, 1991.
15. K.K. Chawla, Composite Materials- Science & Engg., Springer-Verlag, NY, 1987.
16. Clyne & Withers, An Introduction to Metal matrix composites, Cambridge Uni. Press, 1993.
17. Suresh S., Martensen, Needleman, Fundamentals of Metal Matrix Composites, Butterworth-Heinmann, 1993.
18. Nanomaterials: An introduction to synthesis, properties and applications, Editor-Dieter Vollath, Wiley-CVH.
19. Nanoscale Materials in Chemistry, Editor: Kenneth J. Klabunde, Publisher-Wiley-Interscience.

700003-B6: Advances in Instrumentation and Control

Note: Each Unit is of 2 credits. A candidate has to take any *three* units (6 credits)

Unit 1: Process Optimization
Multivariable optimization, linear programming, quadratic programming, integer programming, sequential quadratic programming, global optimization, geometric programming and dynamic programming.

Unit 2: Dynamical System Design and Analysis
Development of system models using lumped and distributed parameter techniques, numerical analysis and simulation, experiment design, case studies.

Unit 3: Instrument and System Design
Need analysis, shielding, cabling, electromagnetic interference (EMI), electromagnetic compatibility, electrostatic discharge, different kind of noise and their reduction techniques.

Unit 4: Biomedical Instrumentation
Physiological measurements, non-invasive measurement techniques, biomedical signal analysis, modeling of physiological systems.

Unit 5: Intelligent Sensors
Consideration for sensor design, smart materials and their characterisation, features of intelligent sensors, testing and validation, case studies.

Unit 6: Digital Control
Digital systems and signal analysis, control system design, stability improvement by state feed- back, digital controller tuning.

Unit 7: Advanced Process Control
System identification, multivariable control system design of linear, bilinear, mixed-integer and nonlinear systems, optimal control, model-based predictive control, adaptive control.

Unit 8: Soft Computing
Fuzzy logic, neural network, support vector machines, genetic algorithms.

Unit 9: Embedded System Design
Embedded system design concepts, memory management, I/O management, analog and digital sensors interfacing, actuator interfacing, final state machine design, design tools.

Unit 10:Photonic instrumentation
Laser instrumentation, Fiber Optic instrumentation, Advanced optical sensors.

Unit 11: Advanced analytical instrumentation
Advanced techniques in analytical instrumentation.

Reference Books:

1. Vaidyeswaran Rajaraman; Computer oriented numerical methods, Prentice-Hall of India, 2nd edition, (1980)
2. Jorge Nocedal and Stephen Wright; Numerical Optimization, Springer, 2nd edition, (2006)
3. S. S. Rao; Engineering Optimization: Theory and Practice, Wiley, 4th edition, (2009)
4. Ian T. Cameron, Katalin Hangos, John Perkins, George Stephanopoulos; Process Modelling and Model Analysis, Academic Press, 1st edition, (2001) Sabrie Soloman; Sensors handbook, McGraw Hill, (1999) J. Fraden; Handbook of modern sensors; physics, design and application, Springer, 3rd edition, (2004)
5. R. Frank; Understanding smart sensors, Artech house, (1996)
6. Frank Vahid and Tony D. Givargis; Embedded System Design: A Unified Hard-ware/Software Introduction, Wiley, (2001)
7. Joseph D. Bronzino; The Biomedical Engineering Handbook, CRC Press, 3rd edition,(2006)
8. Henry Ott; Electromagnetic Compatibility Engineering, Wiley, 1st Edition, (2009)
9. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, Francis J. Doyle III; Process Dynamics and Control, John Wiley and Sons, 3rd edition, (2010)
10. F. Gregg Shinskey; Process Control Systems: Application, Design, and Tuning, McGraw-Hill Professional, 4th Edition, (1996)
11. B. Wayne Bequette; Process Control: Modeling, Design and Simulation, Prentice Hall, (2003) 2

700003-B7: Advances in Printing Engineering

Note: Each Unit is of 2 credits. A candidate has to take any *three* units (6 credits)

Instructions:

- **Select one unit from first five units**

Unit 1. Flexography:
Anilox generation and Cell Geometry; Parameters affecting ink transfer; Doctor Blades

Unit 2. Gravure:
Cylinder engraving techniques; Parameters affecting printability; Cell Geometry

Unit 3. Offset Lithography:
Ink and water emulsification; Parameters affecting dot reproduction; Coating materials for plate

Unit 4. Screen Printing:
Mesh Geometry; Parameters affecting Ink transfer, Ink metering technique

Unit 5. Non-impact Printing:
Piezo crystals; Electrostatic forces; Acoustic pulse generation; Magnetic forces

Unit 6. Surface Properties:
Surface tension and energy; Surface physical properties and treatments; Stresses in substrate, coatings and ink film

Unit 7. Physical and Chemical Interactions:
Chemical interactions required for printing inks and image carriers; Chemical and surface interaction

Unit 8. Liquid Properties:
Colloidal Systems; Newtonian and Non-Newtonian Liquids; Polar nature of liquids; Rheology

Unit 9. Liquids:
Wetting liquids and non-wetting liquids; Contact, wetting and equilibrium dynamics of printing inks on porous and non-porous substrates with 2D and 3D approach

Unit 10. Physical Properties:
Particle size; Phase separation of polymers; Pigment aspect ratio; Color shifting properties of particles

Unit 11. Materials 1:
Solvents; Biodegradable polymers; Nano pigments for ink and substrate

Unit 12. Materials 2:
Elastomers in printing; Printing process metallurgy; Material strength

Unit 13. Color:
N-colors; Color Inconstancy; Metamerism; Color Vision

Unit 14. Substrate:
Water absorption rate; Substrate and ink interaction; Di-electric and electric properties, Surface Imperfections

Unit 15. Chemicals:
Oxidizers and Reducers; Catalysts; Thermo and photo sensitive chemicals and reactions in printing

Unit 16. Light and Heat:
Photochemical reaction; Laser systems and their designing parameters for imaging and engraving

Unit 17. Drying:
Ink drying/curing and related calculations; Calculating dryer temperatures; Solvent absorption, evaporation and calculating rate; Effect of pH on drying of ink

Unit 18. Screening:
Screening, dot forming and color separation; Physical and Chemical factors governing line resolution; Relation between angular resolution, dot and viewing conditions

References:

1. Shlomo Magdassi (Ed.), The Chemistry of Inkjet Inks, World Scientific Publishing Co. Pte. Ltd., 2010

2. Eric R.Lee, Microdrop Generation, CRC Press, 2003

3. Herbert Holik (Ed.), Handbook of Paper and Board, WILEY-VCH GmbH & Co. KGaA

4. D. H. Everett, F. R. S., Basic Principles of Colloid Science, Royal Society of Chemistry

5. Gravure Process and Technology, Gravure Education Foundation and Gravure Association of America, 2003.

6. Flexography-Principles and Practices, Volume 1-6, FFTA, 5th Edition, 1999.

7. H. Kipphan, Handbook of Print Media, ISBN: 3-540-67326-1 Springer-Verlag Berlin Heidelberg, 2001

8. E. A. Apps, Printing Ink Technology, Leonard Hill Ltd., 1958.

9. A. S. Athayle, Plastics in Packaging, Tata McGrawHill Publication, 1992.

10. A. S. Athayle, Plastics in Flexible Packaging, Multi-Tech Publishing, 1992.

11. James P. Cassey, Pulp and Paper-Chemistry & Chemical Technology, Inter Science Publication, 1960.

12. Brett, G, Digital Prepress Technologies, Leatherhead: Pira International, 2001.

13. Martin, G., Non-impact Printing, Leatherhead: Pira International, 1993.

14. Dr. Abhay Sharma, Understanding Color Management, Thomson Delmar Learning, 2003.

15. Aaron L. Brody, Kenneth S. Marsh, Encyclopedia of Packaging Technology, A Wiley-Interscience Publication, 2nd Edition, 1997.

16. Dr. Nelson R. Eldered, What Printer Should Know About Ink, GATF Press Pittsburgh, 2001.

17. Laden P. O, Chemistry & Technology of Water based Inks, Blackie Academic & Professional - Imprint of Chapmall Hall, 1st Edition, 1997.

18. Chris H. Williams; Printing Ink Technology, Pira International, 2001.

19. Hans Kuhn, Horst-Dieter Försterling, David Hennessey Waldeck, Principles of Physical Chemistry, Wiley Publications, 2009.

20. Orazio Svelto, Principles of Lasers 5th Edition, Spinger, 2009.

21. Nicholas P. Cheremisinoff, Elastomer Technology Handbook

22. Anil K. Bhowmick, Howard L. Stephens, Handbook of Elastomers 2nd Edition, 2001.

700003-B8: Advances in Chemical Engineering

Note: Each Unit is of 2 credits. A candidate has to take any *three* units (6 credits)

Unit 1: **Advance Biochemical Engineering**
Various Applications Use of Microbes modeling of biochemical reaction and applications to scale up. Metabolic pathways and Bioreactor models

Reference Books:

1. Biochemical Engineering fundamentals, by James, E.Bailey and David F Ollis, II Edition, 1986. McGraw-Hill Internal Edition.
2. Fogler, H. Scott. Elements of Chemical Reaction Engineering, 3rd Ed. Prentice Hall (1999).

Unit 2: Advance Polymer Engineering
Metallocene catalysis, Ziegler Natta Catalysis Mechanism and Products, Polymerization reactors.

Reference Books:

1. Handbook of Polymer reaction Engineering"**,** Thierry Meyer (Editor), Jos Keurentjes (Editor), Wiley, New York, April 2005.
2. George Odian Principles of Polymerization Wiley-Interscience; 4 edition 2004

Unit 3: Nanotechnology
Recent Approaches for synthesis, characterization of nanomaterials and Applications

Reference Books:

1. Introduction to NanoScience, CRC Press G. Louis Hornyak, Joydeep Dutta, Harry F. Tibbals and Anil K. Rao,
2. R. Kelsall, I. Hamley and M. Geoghegan (Eds.), "Nanoscale Science and Technology",
3. Wiley, 2005

Unit 4 : Separation Technology
Separation techniques using LEM, Ionic liquids, extractive separation reactive crystallization reactive separation and modeling

Reference Books:

1. Phillip C. Wankat, "Separation Process Engineering", Prentice Hall PTR, 2006.
2. Roger G. Harrison, Paul W. Todd, Scott R., "Bioseparations Science and Engineering",
3. Oxford University Press,

Unit 5 : Environmental Engineering
Advance Oxidation processes, Water treatment and analysis, Emphasis on advance treatment techniques and reactors etc

Reference Books:

1. S.J.Arceivala, wastewater treatment and disposal, marcel dekker 1981.

2. Metcalf and Eddy, wastewater engineering, treatment, disposal and Reuse, Inc. Third
3. edition McGraw – hill 1991.

Unit 6 : Advance Modeling and Simulation

Multiscale simulations in materials, Industrial flow modeling, Data driven modeling, Non-linear system dynamics

Reference Books:

1. C. L. Smith, R. N. Pike & P. W. Murill, Formulation optimization of Mathematical
   International text, Pensylvania (1970) 2)W. L. Luyben, Process Modeling Simulation and Controls for Chemical Engineers, Mc.Graw Hill Book Co.

Unit 7 : Catalysis, reactor and reaction engineering

Heterogeneous reactor analysis and design Special reactors, Molecular catalysis, Solid catalyst, supported catalyst

Reference Books:

1. Fogler, H. Scott. Elements of Chemical Reaction Engineering, 3rd Ed. Prentice Hall (1999). 2) Froment, Gilbert F. and Bischoff, Kenneth B. Chemical Reactor Analysis and Design, 2nd Ed.Wiley (1990).

Unit 8 : Advance Transport Phenomena

Boundary conditions. Macroscopic balances. Governing equations of heat transfer: Energy balance, Governing equations of mass transfer: Species mass balance, Constitutive equations, Simultaneous heat and mass transfer

Reference Books:

1. Bird, R.B., Stewart, W.E. and Lightfoot E.N., Transport Phenomena, Second edition, John Wiley and Sons, 2002.
2. Deen W. M., Analysis of transport phenomena, Oxford University Press, 1998.

Unit 9 : Mass Transfer with Multiphase System

Diffusional mass transfer: Mass transfer with reaction in Fluid-Fluid- Solid system Simultaneous absorption and Desorption with reaction Mass transfer accompanied by General order irreversible and reversible reaction in gas – liquid and liquid- Liquid System.

Reference Books:

1. Gas liquid relation by Danckwerts P.V..
2. Heterogeneous Relation Analysis example and Relation design Vol: 2 John Wiley and
3. Sons by Doraiswamy L.K. and M.M. Sharma

Unit 10 Advanced Process Control

Modeling of a few complicated systems, State space and transfer function matrix models, Stability criterion of transferfunction matrix models, Development of empirical model from process data, Identifying Discrete-Time models from experimental data.

Reference Books:

1. Seborg, Edgar, Mellichamp, Process Dynamics and control John Willey, 2nd Edn., 2004.
2. Willis Harmon Ray, Babatunde Ayodeji Ogunnaike. "Process Dynamics, Modeling, and Control", Oxford University Press, 1994.

Unit 11 Advance Heat transfer

Forced convection Inside Tubes & Ducts**,**Forced Convection over Exterior Surfaces,Heat transfer coefficients in laminar and turbulent flow, Heat Transfer with phase change Heat transfer in Two and three phase system Heat transfer by combined conduction, convection and Radiation

Reference Books:

1. Frank Kreith & Mark S. Bohn Principles of Heat Transfer, 6th Edition, Asian Books Private Limited, 2001
2. Ghoshdastidar, P. S. Heat Transfer, Oxford University Press, 2004.

700003-B9: Advances in Computer Engineering

Note: Each Unit is of 2 credits. A candidate has to take any *three* units (6 credits)

Unit 1: Natural Language Processing

Introduction to Natural Language Understanding, An Outline of English Syntax, Grammars and Parsing, Grammars for Natural Language, Toward Efficient Parsing, Ambiguity Resolution: Statistical Methods, Linking Syntax and Semantics, Ambiguity Resolution, Scoping and the Interpretation of Noun Phrases.

References

1. James Allen, "Natural Language Understanding", Pearson Education, 2nd Edition
2. Akshar Bharati, Vineet Chaitanya, Rajiv Sangal, "Natural Language Processing- A Paninian Perspective", PHI
3. Christopher D. Manning and Hinrich Schütze. 1999. Foundations of Statistical Natural Language Processing. MIT Press.

Unit-2: Compilers

Introduction, types of Parsers, LL (k) and LALR (k) parsers, three address codes. Introduction to code generation, simple code generation algorithm, DAGs Introduction to Code Optimization, basic blocks and flow graphs, common subexpression elimination, loop optimization, loop invariant computations, dead code elimination, code movement

Reference

1. Alfred V. Aho, Ravi Shethi, Jeffrey D Ullman,"Compilers- principle, techniques and tools", Pearson Education, 2006
2. V Raghvan,"Principles of Compiler Design",Tata McGraw Hill,,2010

Unit-3: Digital Image Processing

Digital image fundamentals: image digitization, sampling and quantization, image resolution, color perception & processing, image processing: pixel based transformation, geometric transformation, local processing restoration, binary image processing: thresholding, runlength encoding, distance transforms, medial axis transforms, morphological operations, region segmentation & representation: split & merge algorithm, region growing, image filtering histogram modification, linear and Gaussian filters, contours , digital curves, polyline splitting, Hop_ Along algorithm, Conic & Splines Hough transform, Fourier description, textures: statistical syntactic and model based methods, Texture image analysis, image transforms :Fourier, Hadamard, discrete cosine, wavelets and other orthogonal transforms, compression image (predictive compression methods, vector quantization, hierarchical & progressive methods, JPEG & MPEG), Motion picture analysis.

References:

1. Rafael C Gonzalez, Richard E Woods, "Digital Image Processing", Prentice Hall Publisher, 2008, 3rd Edition
2. William K Pratt, "Digital Image Processing", John Willey (2001)
3. Millman Sonka, Vaclav hlavac, Roger Boyle, Broos/colic,"Image Processing Analysis and Machine Vision", Thompson Learning (1999).
4. A.K. Jain, "Fundamentals of Digital Image Processing", PHI, New Delhi (1995)

5. Chanda Dutta Magundar,"Digital Image Processing and Applications", PHI, 2000

Unit-4: Wireless Technology.

WSN: Design issues, System Architecture, Sensor Network OS Tiny OS, Nes C Language, Distributed data processing, Synchronization and localization, Communication and routing, Security issues , services and applications

Mobile Ad-hoc Networks: Location Management Schemes, Routing.

GSM and satellite Communication: Architecture, hand-off and power management.

Wireless Network Standards & Protocols: 802.11.X, 802.16.x, 802.15.X, Comparison 802.11a, 11b, 11g, Challenges for MAC, DCF and PCF, WEP& EAP

QoS in wireless Network: Parameters Throughput or bandwidth, Delay or latency Delay variation (delay jitter), Loss or error rate

References

1. Holger Kars," Protocols and architectures for WSN" , Wiely publication.
2. M Jochen Schiller, "Mobile communication", Person Publication.
3. Mathew Gast, "802.11 wireless Networks the definitive guide", O'Reilly.

Unit-5: Network Security

Network threats and attacks, Security Services, Number Theory Concepts, Cryptographic algorithms, Network Security Protocols, System Security, Security research in wired, wireless and ubiquitous networks, Security Standards and RFCs

References

1. William Stallings, "Cryptography and Network Security", Fourth Edition,Pearson Education 2007.
2. Behrouz A. Forouzan, "Cryptography & Network Security", TMH 2007.
3. Robert Bragg, Mark Rhodes, "Network Security: The complete reference", TMH

Unit-6: Artificial Intelligence

AI problems, AI intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation. Searching: Searching for solutions, uniformed search strategies, Heuristic functions. Constrain satisfaction problems: Game Playing Alpha-Beta pruning, Evaluation functions, cutting of search, Knowledge Representation & Reasons logical Agents, logic, propositional logic, Resolution patterns in propositional logic, Resolution, Forward & Backward Chaining, Planning – Classical planning problem, Language of planning problems, Expressiveness and extension, planning with state.

References

1. Stuart Russel,Peter Norvig, "Artificial Intelligence – A Modern Approach", Second Edition, PHI/Pearson Education.
2. Patrick Henry Winston, "Artificial Intelligence", 3rd Edition, Pearson Education.

Unit-7: Language Translation

Language Processing: applications and key issues; lexicon and morphology; Phrase structure grammars and English syntax; Part of speech tagging; Syntactic parsing, top-down and bottom-up parsing strategies; Semantics, Word Sense Disambiguation, Semantic parsing; Information retrieval and Question answering; knowledge representation and reasoning, local discourse context and reference

References

1. Christopher D. Manning and Hinrich Schütze, "Foundations of Statistical Natural Language Processing", MIT Press,1999.
2. James Allen, "Natural Language Understanding", Pearson Education, 2nd Edition

Unit-8: Machine Learning

Designing a Learning system, Learning Process, Learning methods, Forms of learning, Induction learning, Learning with complex data, learning with Hidden variables, Parametric-Nonparametric methods, Multivariate methods, Feature extraction, clustering, Decision tree, Artificial Neural networks, Self Organization Map, Regression, Radial Basis Function networks, Function Approximation, Hopfield models Evaluating Hypotheses, Computational Learning theory, Instance based learning, rule based learning, Analytical Learning, Reinforcement learning, Hidden Markov Models, Probability, classification, Linear Discrimination.

References

1. Simon Hhaykin, "Neural networks - A comprehensive foundations", Pearson Education 2nd Edition 2004.
2. Ethem Alpaydin, "Introduction to Machine Learning", PHI
3. Tom Mitchell, "Machine Learning", MGH

Unit-9: Graphics & Visualization

Picture analysis, Modeling: 2D, 3D Geometric modeling and transformations, projections, Clipping, curves and fractals. Illumination models and Rendering: Light, Ambient Light, Diffuse reflection, Specular reflection, Shading algorithms, Color models, Ray tracing, Texture mapping. Scientific Visualization: Methods of Scientific Exploration, Data Aspects and Transformations, Time-Tested Principles for Good Visual Plots, Tone Mapping, Matters of Perception, Visualizing Multidimensional Data, Scalar Data Visualization, Vector Data Visualization. Graphics User Interfaces, image manipulation and storage, advanced modeling techniques.

References

1. Peter Shirley, Ashikhmin Gleicher et. al.,"Fundamentals of Computer Graphics", A. K. Peters Ltd., 2005
2. Hearn and Baker,"Computer Graphics", PHI
3. Van Dan Feiner, Hughes, Foley, "Computer Graphics: Principles and Practice", PHI

Unit-10: Advanced Algorithms and Applications

Problem solving, Probabilistic analysis and randomized algorithms, Perfect Hashing, The Floyd-Warshall algorithm, Johnson's algorithm for sparse graphs, NP-hard problems, Approximation algorithms, Online algorithms and competitive analysis. Linear-Programming Algorithms: Structure of Optima, Interior Point. Computational geometry: convex hull. Random Walks and Markov chains

References

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein**,** "Introduction to Algorithms," Third Edition PHI 2010.

Unit-11: Data warehousing and Mining

Data Mining Tasks, Data Warehouse (Multidimensional Data Model, Data Warehouse Architecture, Implementation), Data Warehousing to Data Mining, Data Preprocessing: Why Preprocessing, Cleaning, Integration, Transformation, Reduction, Discretization, Concept Hierarchy Generation, Descriptive Statistical Measures, Classification: Decision Trees, Model Over fitting, Bayesian Classification, Rule-based classification, Nearest Neighbor Classifier, Classification by Back-propagation, Support vector machines, Association Rule Based, Other Classification Methods, Prediction, Classifier Accuracy, Cluster Analysis: K-means, Agglomerative Hierarchical Clustering, DBSCAN, Association Rules: Apriori algorithm, FP-growth algorithm, Advanced techniques, Data Mining software and applications: Text mining (extracting attributes/keywords, structural approaches - parsing, soft parsing, Bayesian approach to classifying text), Web mining (classifying web pages, extracting knowledge from the web), Data Mining software and applications

Reference

1. J. Han and M. Kamber, "Data Mining- Concepts and Techniques", 2nd Edition, Morgan Kaufmann, 2006.
2. M argaret H. Dunham," Data Mining Introductory and Advanced Topics", Prentice Hall
3. P. Tan, M. Steinbach and V.,Kumar, "Introduction to Data Mining", Addison Wesley, 2006.

Unit-12: Parallel and Distributed Systems

Terminology of Parallel and Distributed Computing, Parallel and Distributed Architectures, Parallel Performance, Shared Memory and Threads, Parallel Algorithms, Message Passing, Distributed Systems, Distributed Coordination, Distributed File Systems, Distributed Shared Memory, Cloud Computing, Computational Grids and Applications

References

1. G Coulouris, J Dollimore and T Kindberg, "Distributed Systems Concepts and Design", Third Edition, Pearson Education.
2. Kai Hwang, Faye A.Brigs, "Computer Architecture and Parallel Processing", Mc Graw Hill

700003-B10: Advances in Production & Industrial Engineering

Note: Each Unit is of 2 credits. A candidate has to take any *three* units (6 credits)

Unit 1 : Quantitative techniques

Optimization techniques, Simulation Using Software, Non-linear Programming, Goal Programming, Inventory Management , Supply Chain Management, Project Management, Resource Optimization.

Reference Books

1. Gupta P. K. and Hira D. S. : Operations Research, S Chand & Company Ltd.
2. Sharma J. K. : Mathematical Models in Operations Research, Tata McGraw – Hill Publishing Company Limited.
3. Sharma S. D., Kedar Nath : Operations Research, Ram Nath & Co.
4. R. Panneerselvam : Operations Research, Prentice Hall of India Pvt. Ltd

Unit 2 : Robotics And Automation

CAD / CAM, Rapid Prototyping, Flexible Manufacturing Systems And Group Technology (MICLASS, OPTIZ), Cell Formation in GT. Analysis of Vision System, online Inspection through Vision System, Design of Grippers, various sensors in robotics, Robot kinematics and dynamics, Trajectory Planning in robotics, Avoiding obstacles by robot.

Reference Books

1. Robotics Technology and Flexible Automation – S.R. Deb Tata McGraw Hill.
2. Robotics for Engineers – Yoram Koren, Tata McGraw Hill.
3. Industrial Robotics – Groover, Weiss, Tata McGraw Hill.
4. Robotics – Control, Sensing, Vision and Intelligence – K. S. Fu, R. C. Gonzalez, C. S. G. Lee, McGraw Hill Int.
5. Robotics and Image Processing by P.A. Janakiraman, Tata McGraw Hill 1995

Unit 3 :Facility planning

Site selection theories, Physical facilities – Algorithm, Automated Guided Vehicles (AGV's), Material handling systems – Conveyor design., Deterministic models - single and multi facility location models, Job Allocation problems - quadratic assignment problems, Warehouse layout models, plant location problems

Reference Books

1. Facilities Planning, Thompkins, J A and White, J. A.
2. Facility layout and Location. Francies, R.L. and White, J. A
3. Plant Layout and Material handling James M Apple,2"d Edition., John, Wiely and Sail.

Unit 4 :Production Systems

Markov chain analysis, Discrete Time Markov Chain, Assembly line balancing, Petri Nets, Generalized Stochastic PetriNets, Stochastic of manufacturing Systems, Economic analysis, Materials Management, Operations Management.

Reference Books

1. Production Flow Analysis for Planning Group Technology – John L. Burbridge
2. Just in Time – David Hutchins-Gower Publishing ISBN-0566077981
3. Handbook of MRP II and JIT-John Petroff-Prentice hall

Unit 5 : Reliability / Maintenance

Fault Tree Analysis & Event Tree Analysis, Accelerated reliability testing, Nonparametric reliability evaluation, Failure Modes Effects Analysis & Failure Modes Effects and Criticality Analysis, HASS, HALT, reliability evaluation of complex system, Evaluation of system reliability, maintainability and availability, AGREE, ARINC, Mean & Median statistical methods, Fair & Kim's Algorithm.

Reference Books

1. Concepts in Reliability in Engineering – L. S. Srinath, Affiliated East West Press.
2. Reliability in Engineering Design – K. C. Kapur and L. R. Lumbersome, Willey.
3. System reliability-Modelling and Evaluation – C. Singh and R. Billinton, Hutchinson.
4. Terotechnology: Reliability Engineering and Maintenance Management - B Bhadury and S.K. Basu, Asian Reference Books , New Delhi 2002.
5. A.K. Gupta: Reliability Engineering & Terotechnology Mc Millan (I) Ltd.
6. Terotechnology & Reliability Engineering: A. K. Gupta, McMillan Co.
7. Maintenance, Replacement & Reliability: A. K. S. Jardine, HMSO, London.

Unit 6 :Work Study & Ergonomics

Time & Motion Study, PMTS, Anthropometry, Critical analysis of work design criteria, Man - machine learning phenomenon, Bio – dynamics analysis, Job evaluation and merit rating.

Reference Books

1. Human Factors in Design and Manufacturing-Mark S.Sanders, Ernest. J. McCORMICK.
2. Works Organisation and Management: Basu S.K., Sahoo K.C., and Datta N.K., Oxford-IBH, 3rd Edn., 1997.
3. Human Engineering- Guide to Equipment design C.T.Morgan, J.S.Cook, A. Chapnis and M.W.Land: McGraw Hill, N.Y, 1963.
4. Barnes, "Motion and Time Study", Wiley International.

Unit 7: Advanced Machine Tool Design

Design of elements like Bed, Columns, Guideways, Design of Guides using FEA, Lumped parametric method, Design of spindles based on deformation and rigidity, Reliability based design, static and dynamic rigidity, stability analysis, Vibrational study - Microdisplacement and error analysis Modular Concept in Machine tool structure.

Reference Books

1. Design of Machine Tools – Latest Edn. – S. K. Basu and D. K. Pal, Oxford – IBH.
2. Computer Numerical Control Machines – B. Leatham and Jones.
3. Computer Control in Manufacturing – Yoram Koren, Tata McGrew Hill.
4. Numerical Control and Computer Aided Manufacturing – Kundra, Rao and Tiwari, Tata McGraw Hill.
5. NC Machine tools – S.J. Martin, ELBS.
6. Principles of Machine Tools – A. Bhattacharya and G.C. Sen, New Central Book Agency, Calcutta.
7. Machine Tool Design – N. K. Mehta, Tata McGraw Hill.

Unit 8 : Advanced Machining / Non conventional Machining

Theory and Numerical analysis of abrasive jet machine, Abrasive flow machining, Ultrasonic machining, Electrical Discharge Machining(EDM), Electro Chemical Machining, Electro Chemical Discharge Machining(ECDM) , Vibro ECDM, Dry and Near dry EDM, thermal Energy Methods material pressing, LASER machining, Electron Beam Machining, Plasma arc machining, Physical vapour deposition and chemical vapour deposition, high energy rate forming and Electroforming.

Reference Books

1. MEMS & Microsystem: Design & Manufacture by Tai ran Hsu, Tata McGraw Hill Publisher, 2002.
2. The MEMS handbook, CRC Press, 2001
3. Microsensors, MEMS and smart Devices by Julian W. Gardner & Vijay K. Varadan, John Wiley & Sons, 2001.
4. 'Nanotechnology' by Nario Taniguchi, , Oxford University Press, 1996.

Unit 9 : Metrology and Quality Control

Error due to Numerical Interpolation, displacement measurement technique, Error types and their evaluation, Image processing and its applications in metrology, Laser trackers, micro and nanometrology, Process capability- Process Capability Index. Advanced dimensional chain and tolerance stacking , Global management or six sigma management, methods of improving accuracy and surface finish. Quality Control, Statistical Quality Control, Quality assurance systems

Reference Books

1. Precision Engineering in Manufacturing , R.L. Murthy
2. Metrology, R.K. Jain
3. Engineering Metrology, I.C. Gupta

Unit 10 :Theory of plasticity, Metal forming

Analysis in drawing and extrusion of metals, theory and practice of Bulk forming processes, Plastic deformation in forging, rolling, Extrusion and Drawing process, Sheet

metal forming. Theory of plastic deformation – Yield criteria - Work of plastic deformation

Analysis of forming processes - Energy slab method- open die forging, plate drawing, Flat rolling ,- Other methods of analysis like FEM, Upper and lower bound solution methods – slip line field.

Review of stress –strain relations, Yield criteria, plastic anisotropy, forming limits and material models , Viscoplasticity, Solutions to metal forming problems.

Reference Books

1. Theory of Metal Forming Plasticity - Classical and Advanced Topics by Sluzalec, Andrzej , Springer Publications
2. Metal Forming - Process and analysis – by B. Avitzur, Tata Mcgraw Hill
3. Metal working science and Engineering by E.M. Mielnik , McGraw Hill. Inc.
4. Theory of plasticity "-Chakrabarthy J.,- McGraw Hill Co, 1987.
5. Metal forming Mechanics and Metallurgy – Hofsord W.F. and Caddell R.M. – Prentice Hall, Eaglewood, cliffs, 1993
6. Theory of Metal Forming Plasticity - Classical and Advanced Topics by Sluzalec, Andrzej , Springer Publications

Unit 11: Tribology

Triboenvironment, contact theory of surface, Ergodicity and Stationarity of surface, Contact phenomenon & contact deformation of the surface, Parameters affecting friction and wear, Adhesive, Abrasive, Erosive wear, Dry friction, boundary friction, semi liquid and liquid friction under lubrication, Use of solid lubricants in extrusion and metal cutting, method of testing and Characterization of lubrication.

Reference Books

1. Fundamentals of Tribology – S.K.Basu, B.B. Ahuja and S.N. Sengupta, PHI
2. Friction, lubrication, wear- vol I,II and III-Kragelsky.
3. Tribology of bearings – B.C. Mujumdar.
4. Tribology – A System Approach – H.Czichos and Elsevies.
5. Friction and Wear of Materials –E. Rabinowics, Wiley N.Y.

700003-B11: Advances in Petroleum and Petrochemical Engineering

Note: Each Unit is of 2 credits. A candidate has to take any *three* units (6 credits)

Unit 1: Advanced Transport Phenomena

Navier Stokes equations in Heat, Mass and Momentum Transport. Modeling of heterogeneous systems of practical interest in Navier Stokes framework. Solution of model equations.

Unit 2: Reservoir simulation

Generalized approach, model formulation, history matching, up scaling, streamline simulation, simulation of geomechanics, Pressure/Volume/Temperature (PVT) Treatment, high performance computing, well modeling, thermodynamic characterization.

Unit 3: Production optimization

Integrated production systems, reservoir inflow characterization and modeling tools, multiphase flow modeling in wellbore, risers and flow lines, Diagnosis of systems performance. Production Allocation, Linking the reservoir; the near-wellbore, the wellbore and the surface facilities. Planning short, medium and long-term optimization of field management

Unit 4: Emerging Drilling Technologies

Materials, Microsystems, real time drilling and communications, advanced designs in bit technology and mud motors, advances in mud and solids control technology, advances in measurement while drilling (MWD) and other drilling technology, drilling optimization methods

Unit 5: Enhanced Oil Recovery

Fluid flow in permeable media, mass conservation, energy equations, and momentum equations. Phase behavior, fluid properties, displacement efficiencies, volumetric sweep efficiency. Principal secondary and tertiary recovery mechanisms and Advances.

Unit 6: Unconventional Hydrocarbon Energy sources

Heavy and extra heavy oil, tight gas reservoirs, CBM, GTL, Shale gas and Gas Hydrates

Unit 7: Intelligent systems in oilfield development

Real options theory, decision support methods, fuzzy logic, Real Option Value Calculation by Monte Carlo Simulation and , Approximation by Fuzzy Numbers and Genetic Algorithms, Analysis of Alternatives for Oil Field Development under Uncertainty, high performance processing

Unit 8 Carbon capture and sequestration

Greenhouse gas effect, Carbon Sequestration and management, Global and fossil fuel carbon cycles, sequestration of carbon dioxide in geological formations, advanced biological processes, materials, advanced chemical approaches to sequestration, system

technology platforms and technologies, engineering system components, science and technology capabilities.

Unit 9: Artificial Intelligence Techniques
Artificial Neural Network, Fuzzy Logic, Evolutionary Algorithm, Their applications in petroleum and petrochemical engineering

Unit 10: Numerical Methods
Numerical Solution of system of stiff / non-stiff Ordinary Differential Equations and Partial Differential Equations with boundary conditions

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PRINCIPAL

T.E. (Information Technology) 2015 Course to be implemented from June 2017

SYLLABUS STRUCTURE

SEMESTER – I

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Tutorial	Practical	In-Sem. Paper	End-Sem. Paper	TW	PR	OR		
314441	Theory of Computation	4	--	--	30	70	--	--	--	100	4
314442	Database Management Systems	4	--	--	30	70				100	4
314443	Software Engineering & Project Management	3	--	--	30	70	--	--	--	100	3
314444	Operating System	4	--	--	30	70	--	--	--	100	4
314445	Human-Computer Interaction	3	--	--	30	70	--	--	--	100	3
314446	Software laboratory-I	--	--	4	--	--	25	50	50	125	2
314447	Software laboratory-II	--	--	4	--	--	25	50	--	75	2
314448	Software laboratory-III	--	--	2	--	--	50	--	--	50	1
314449	Audit Course II	--	--		--	--	--	--	--	Grade	
	Total	18	--	10	150	350	100	100	50	750	23
	Total of Part-I	28 Hours				750					

SEMESTER – II

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Tutorial	Practical	In-Sem. Paper	End-Sem. Paper	TW	PR	OR		
314450	Computer Network Technology	3	-	--	30	70	--	--	--	100	3
314451	Systems Programming	4	-	--	30	70	--	--	--	100	4
314452	Design and Analysis of Algorithms	4	-	-	30	70	--	--	--	100	4
314453	Cloud Computing	3	-	-	30	70	--	--	--	100	3
314454	Data Science & Big Data Analytics	4	-	-	30	70	--	--	--	100	4
314455	Software Laboratory-IV	--	--	2	--	--	25	--	25	50	1
314456	Software Laboratory-V	--	--	4	--	--	50	50	--	100	2
314457	Software Laboratory-VI	--	--	2	--	--	25	25	--	50	1
314458	Project Based Seminar	--	01	--	--	--	--	--	50	50	1
314459	Audit Course-II	--	--	--	--	--	--	--	--	Grade	
	Total	18	01	08	150	350	100	75	75	750	23
	Total of Part-II	27 Hours				750					

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SEMESTER – I

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		Lecture	Tutorial	Practical	In-Sem. Paper	End-Sem. Paper	TW	PR	OR		
314441	Theory of Computation	4	--	--	30	70	--	--	--	100	4
314442	Database Management Systems	4	--	--	30	70				100	4
314443	Software Engineering & Project Management	3	--	--	30	70	--	--	--	100	3
314444	Operating System	4	--	--	30	70	--	--	--	100	4
314445	Human-Computer interaction	3	--	--	30	70	--	--	--	100	3
314446	Software Laboratory-I		--	4	--	--	25	50	50	125	2
314447	Software Laboratory-II	--	--	4	--	--	25	50	--	75	2
314448	Software Laboratory-III	--	--	2	--	--	50	--	--	50	1
314449	Audit Course 3	--	--		--	--	--	--	--	Grade	
	Total	18	--	10	150	350	100	100	50	750	23
	Total of Part-I	28 Hours				750					

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SEMESTER – II

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Tutorial	Practical	In-Sem. Paper	End-Sem. Paper	TW	PR	OR		
314450	Computer Netwcrk Technology	3			30	70				100	3
314451	Systems Programming	4	-	--	30	70	--	--	--	100	4
314452	Design and Analysis of Algorithms	4			30	70				100	4
314453	Cloud Computing	3	-	-	30	70	--	--	--	100	3
314454	Data Science & Big Data Analytics	4	-	-	30	70	--	--	--	100	4
314455	Software Laboratory-IV	--	--	2	--	--	25	--	25	50	1
314456	Software Laboratory-V	--	--	4	--	--	50	50	--	100	2
314457	Software Laboratory-VI	--	--	2	--	--	25	25	--	50	1
314458	Project Based Seminar	--	01	--	--	--	--	--	50	50	1
314459	Audit Course 4	--	--	--	--	--	--	--	--	Grade	
	Total	18	01	08	150	350	100	75	75	750	23
	Total of Part-II	27 Hours			750						

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B.E. (Information Technology) 2015 Course to be implemented from Academic Year 2018-19

SEMESTER-I

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Practical	Tutorial	In-Sem	TW	PR	OR	End-Sem		
414453	Information and Cyber Security	3	--	--	30	--	--	--	70	100	3
414454	Machine Learning and Applications	4	--	--	30	--	--	--	70	100	4
414455	Software Design and Modeling	3	--	--	30	--	--	--	70	100	3
414456	Elective-I	3	--	--	30	--	--	--	70	100	3
414457	Elective -II	3	--	--	30	--	--	--	70	100	3
414458	Computer Laboratory-VII	--	4	--	--	50	50	--	--	100	2
414459	Computer Laboratory-VIII	--	4	--	--	50	--	50	--	100	2
414460	Project Phase-I	--	--	2	--	--	--	50	--	50	2
414461	Audit Course-V	--	--	--	--	--	--	--	--	Grade	
Total		16	8	2	150	100	50	100	350	750	22
Total of Part-I		26				750					

Abbreviations: TW: Term Work TH: Theory OR: Oral PR: Practical Sem: Semester
Computer Laboratory-VII (Information and Cyber Security+ Machine Learning and Application)
Computer Laboratory-VIII (Software Design and Modeling)

Elective I		Elective II	
414456 A	1. Wireless Communications	414457A	1. Software Defined Networks
414456B	2. Natural Language Processing	414457B	2. Soft Computing
414456C	3. Usability Engineering	414457C	3. Software Testing and Quality Assurance
414456D	4. Multicore and Concurrent Systems	414457D	4. Compiler Construction
414456E	5. Business Analytics and Intelligence	414457E	5. Gamification

Audit Course-V	
414461A	1. Emotional Intelligence
414461B	2. Green Computing
414461C	3. Critical Thinking
414461D	4. Statistical Learning model using R.

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SEMESTER –II

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Practical	Tutorial	In-Sem	TW	PR	OR	End-Sem		
414462	Distributed Computing System	3	–	–	30	--	–	–	70	100	3
414463	Ubiquitous Computing	3	–	–	30	--	–	–	70	100	3
414464	Elective-III	3	2	–	30	25	–	25	70	150	4
414465	Elective-IV	3	–	–	30	--	–	–	70	100	3
414466	Computer Laboratory-IX	--	4	–	--	50	50	–	--	100	2
414467	Computer Laboratory-X	--	2	–	--	25	–	25	--	50	1
414468	Project Work	--	–	6	--	50	–	100	--	150	6
414469	Audit Course-VI	--	–	–	--	--	–	–	--	Grade	
Total		12	8	6	120	150	50	150	280	750	22
Total of Part-II		26			750						

Abbreviations: TW: Term Work TH: Theory OR: Oral PR: Practical Sem: Semester
Computer Laboratory-IX (Distributed Computing System)
Computer Laboratory-X (Ubiquitous Computing)

Elective III		Elective IV	
414464A	1. Internet of Things (IoT)	414465A	1. Rural Technologies and Community Development
414464B	2. Information storage and retrieval	414465B	2. Parallel Computing
414464C	3. Multimedia Techniques	414465C	3. Computer Vision
414464D	4. Internet and Web Programming	414464D	4. Social Media Analytics
414464E	5. Computational Optimization	414465E	5. Open Elective

Audit Course-VI	
414469A	1. IoT – Application in Engineering field
414469B	2. Entrepreneurship
414469C	3. Cognitive Computing
414469D	4. AI and Robotics

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Savitribai Phule Pune University
Second Year of Information Technology Engineering(2019 Course)
(With effect from Academic Year 2020-21)
Semester-III

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	IN-Sem	End-Sem	TW	PR	OR	Total	TH	PR	TUT	Total
214441	Discrete Mathematics	03	-	01	30	70	25	-	-	125	03	—	01	04
214442	Logic Design and Computer Organization	03	-	-	30	70	-	-	-	100	03	-	-	03
214443	Data Structures and Algorithms	03	-	-	30	70	-	-	-	100	03	-	-	03
214444	Object Oriented Programming	03	-	-	30	70	-	-	-	100	03	-	-	03
214445	Basics of Computer Network	03	-	-	30	70	-	-	-	100	03	-	-	03
214446	Logic Design Computer Organization Lab	-	02	-	-	-	25	25	-	50	-	01	-	01
214447	Data Structures and Algorithms Lab	-	04	-	-	-	25	25	-	50	-	02	-	02
214448	Object Oriented Programming Lab	-	04	-	-	-	25	25	-	50	-	02	-	02
214449	Soft Skill Lab	-	02	-	-	-	25	-	-	25	-	01	-	01
214450	Mandatory Audit Course 3	-	-	-	-	-	-	-	-	-	Non Credit			-
Total		15	12	01	150	350	125	75	—	700	15	06	01	22

Abbreviations:
TH: Theory TW: Term Work PR: Practical
OR: Oral TUT: Tutorial

Note: Students of S.E. (Information Technology) can opt any one of the audit course from the list of audit courses prescribed by BoS (Information Technology)

#Mandatory Audit Course 3:
214450A- Ethics and values in IT
214450B - Quantitative Aptitude and Logical Reasoning
214450C- Language Study- Japanese- Module
214450D-Cyber Security and Law

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Savitribai Phule Pune University, Pune
Second Year of Information Technology Engineering (2019 Course)
(With effect from Academic Year 2020-21)

Semester-IV

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	IN-Sem	End-Sem	TW	PR	OR	Total	TH	PR	TUT	Total
207003	Engineering Mathematics- III	03	-	01	30	70	25	-	-	125	03	—	01	04
214451	Processor Architecture	03	-	-	30	70	-	-	-	100	03	-	-	03
214452	Database Management System	03	-	-	30	70	-	-	-	100	03	-	-	03
214453	Computer Graphics	03	-	-	30	70	-	-	-	100	03	-	-	03
214454	Software Engineering	03	-	-	30	70	-	-	-	100	03	-	-	03
214455	Programming Skill Development Lab	-	02	-	-	-	25	25	-	50	-	01	-	01
214456	Database Management System Lab	-	04	-	-	-	25	25		50	-	02	-	02
214457	Computer Graphics Lab	-	02	-	-	-	-	25	-	25	-	01	-	01
214458	Project Based Learning	-	04	-	-	-	50	-	-	50	-	02	-	02
214459	Mandatory Audit Course 4	-	-	-	-	-	-	-	-	-	Non Credit			-
Total		15	12	01	150	350	125	75	-	700	15	06	01	22

Abbreviations:
TH: Theory TW: Term Work PR: Practical
OR: Oral TUT: Tutorial
Note: Students of S.E. (Information Technology) can opt any one of the audit course from the list of audit courses prescribed by BoS (Information Technology)

#Mandatory Audit Course 4:
214459A - Water Supply and Treatment
214459B - Language Study- Japanese- Module II
214459C - Waste Management and Pollution Control
214459D - Intellectual Property Rights

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TE Information Technology (2019 Course) Syllabus Structure

Savitribai Phule Pune University
Third Year of Information Technology (2019Course)
(With effect from Academic Year2021-22)

SemesterV

Course Code	CourseName	TeachingScheme(Hours/week)			ExaminationSchemeandMarks						CreditScheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Termwork	Practical	Oral	Total	Lecture	Practical	Tutorial	Total
	Theory of Computation	03	-	-	30	70	-	-	-	100	3	-	-	3
	Operating Systems	03	-	-	30	70	-	-	-	100	3	-	-	3
	Machine Learning	03	-	-	30	70	-	-	-	100	3	-	-	3
	Human Computer Interaction	03	-	-	30	70	-	-	-	100	3	-	-	3
	Elective-I	03	-	-	30	70	-	-	-	100	3	-	-	3
	Operating Systems Lab	-	04	-	-	-	25	25	-	50	-	2	-	2
	Human Computer Interaction- Lab	-	02	-	-	-		-	50	50	-	1		1
	Laboratory Practice-I	-	04	-	-	-	25	25		50	-	2	-	2
	Seminar	-	01	-	-	-	50	-	-	50	-	1	-	1
	Audit Course 5													
										TotalCredit	15	06	-	21
	Total	**15**	**10**	**-**	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**06**	**-**	**21**

Elective-I:
- Design and Analysis of Algorithm
- Advanced Database and Management System
- Design Thinking
- Internet of Things

Audit Course5:
- Banking and Insurance
- Startup Ecosystems
- Foreign Language–I (German / French)

LaboratoryPracticeI:
Assignment from **Machine Learning and Elective I**

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Savitribai Phule Pune University
Third Year of Information Technology (2019 Course)
(With effect from Academic Year 2021-22)
Semester-VI

Course Code	CourseName	TeachingScheme(Hours/week)			ExaminationSchemeandMarks						CreditScheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Term work	Practical	Oral	Total	Lecture	Practical	Tutorial	Total
	Computer Networks & Security	03	-	-	30	70	-	-	-	100	03			03
	Data Science and Big Data Analytics	03	-	-	30	70	-	-	-	100	03			03
	Web Application Development	03	-	-	30	70	-	-	-	100	03			03
	Elective-II	03	-	-	30	70	-	-	-	100	03			03
	Internship	-	04	-	-	-	100	-	-	100		04		04
	Computer Networks & Security-Lab	-	04	-	-	-	25	-	50	75		02		02
	DS & BDA-Lab	-	02	-	-	-	25	25	-	50		01		01
	Laboratory Practice-II	-	04	-	-	-	50	25	-	75		02		02
	Audit Course 6													
										Total	12	09	-	21
	Total	**12**	**14**	**-**	**120**	**280**	**200**	**50**	**50**	**700**	**12**	**09**	**-**	**21**

Elective-II:
- Artificial Intelligence
- Cyber Security
- Cloud Computing
- Software Modeling and Design

Audit Course6:
- Green and Unconventional Energy
- Leadership and Personality Development
- ForeignLanguage-II German / French)

LaboratoryPracticeII:
Assignments from Web Application Development and Elective-II.

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Savitribai Phule Pune University

Honours* in Data Science

With effect from 2020-21

Year & Semester	Course Code	Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks						Credit Scheme		
			Theory	Tutorial	Practical	Mid-Semester	End-Semester	Term work	Practical	Presentation	Total Marks	Theory / Tutorial	Practical	Total Credit
TE & V	310501	Data Science and Visualization	04	--	--	30	70	--	--	--	100	04	--	04
	310502	Data Science and Visualization Laboratory	--	--	02	--	--	50	--	--	50	--	01	01
		Total	04	-	02	100		50	-	-	150	04	01	05
Total Credits = 05														
TE & VI	310503	Statistics and Machine Learning	04	--	--	30	70	--	--	--	100	04	--	04
		Total	04	-	-	100		-	-	-	100	04	-	04
Total Credits = 04														
BE & VII	410501	Machine Learning and Data Science	04	--	--	30	70	--	--	--	100	04	--	04
	410502	Machine Learning and Data Science Laboratory	--	--	02	--	--	50	--	--	50	--	01	01
		Total	04	-	02	100		50	-	-	150	04	01	05
Total Credits = 05														
BE & VIII	410503	Artificial Intelligence for Big Data Analytics	04	-	--	30	70	--	--	--	100	04	--	04
	410504	Seminar	--	02	--	--	--	-	--	50	50	02	--	02
		Total	04	-	02	100		-	--	50	150	06	-	06
Total Credits = 06														

Total Credit for Semester V+VI+VII+VIII = 20

*** To be offered as Honours for Major Disciplines as–**

1. Computer Engineering
2. Electronics and Telecommunication Engineering
3. Electronics Engineering
4. Information Technology

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TE Information Technology (2019 Course) Syllabus Structure

Savitribai Phule Pune University
Third Year of Information Technology (2019Course)
(With effect from Academic Year2021-22)

SemesterV

Course Code	CourseName	TeachingScheme(Hours/week)			ExaminationSchemeandMarks						CreditScheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Termwork	Practical	Oral	Total	Lecture	Practical	Tutorial	Total
	Theory of Computation	03	-	-	30	70	-	-	-	100	3	-	-	3
	Operating Systems	03	-	-	30	70	-	-	-	100	3	-	-	3
	Machine Learning	03	-	-	30	70	-	-	-	100	3	-	-	3
	Human Computer Interaction	03	-	-	30	70	-	-	-	100	3	-	-	3
	Elective-I	03	-	-	30	70	-	-	-	100	3	-	-	3
	Operating Systems Lab	-	04	-	-	-	25	25	-	50	-	2	-	2
	Human Computer Interaction- Lab	-	02	-	-	-		-	50	50	-	1		1
	Laboratory Practice-I	-	04	-	-	-	25	25		50	-	2	-	2
	Seminar	-	01	-	-	-	50	-	-	50	-	1	-	1
	Audit Course 5													
										TotalCredit	**15**	**06**	-	**21**
	Total	**15**	**10**	-	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**06**	-	**21**

Elective-I:
- Design and Analysis of Algorithm
- Advanced Database and Management System
- Design Thinking
- Internet of Things

Audit Course5:
- Banking and Insurance
- Startup Ecosystems
- Foreign Language–I (German / French)

LaboratoryPracticeI:
Assignment from **Machine Learning and ElectiveI**

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Savitribai Phule Pune University
Third Year of Information Technology (2019 Course)
(With effect from Academic Year 2021-22)
Semester-VI

Course Code	CourseName	TeachingScheme(Hours/week)			ExaminationSchemeandMarks						CreditScheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Term work	Practical	Oral	Total	Lecture	Practical	Tutorial	Total
	Computer Networks & Security	03	-	-	30	70	-	-	-	100	03			03
	Data Science and Big Data Analytics	03	-	-	30	70	-	-	-	100	03			03
	Web Application Development	03	-	-	30	70	-	-	-	100	03			03
	Elective-II	03	-	-	30	70	-	-	-	100	03			03
	Internship	-	04	-	-	-	100	-	-	100		04		04
	Computer Networks & Security-Lab	-	04	-	-	-	25	-	50	75		02		02
	DS & BDA-Lab	-	02	-	-	-	25	25	-	50		01		01
	Laboratory Practice-II	-	04	-	-	-	50	25	-	75		02		02
	Audit Course 6													
										Total	**12**	**09**	**-**	**21**
	Total	**12**	**14**	**-**	**120**	**280**	**200**	**50**	**50**	**700**	**12**	**09**	**-**	**21**

Elective-II:
- Artificial Intelligence
- Cyber Security
- Cloud Computing
- Software Modeling and Design

Audit Course6:
- Green and Unconventional Energy
- Leadership and Personality Development
- ForeignLanguage-II German / French)

LaboratoryPracticeII:
Assignments from Web Application Development and Elective-II.

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B.E. (Information Technology) 2015 Course to be implemented from Academic Year 2018-19

SEMESTER-I

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Practical	Tutorial	In-Sem	TW	PR	OR	End-Sem		
414453	Information and Cyber Security	3	--	--	30	--	--	--	70	100	3
414454	Machine Learning and Applications	4	--	--	30	--	--	--	70	100	4
414455	Software Design and Modeling	3	--	--	30	--	--	--	70	100	3
414456	Elective-I	3	--	--	30	--	--	--	70	100	3
414457	Elective -II	3	--	--	30	--	--	--	70	100	3
414458	Computer Laboratory-VII	--	4	--	--	50	50	--	--	100	2
414459	Computer Laboratory-VIII	--	4	--	--	50	--	50	--	100	2
414460	Project Phase-I	--	--	2	--	--	--	50	--	50	2
414461	Audit Course-V	--	--	--	--	--	--	--	--	Grade	
Total		16	8	2	150	100	50	100	350	750	22
Total of Part-I		26			750						

Abbreviations: TW: Term Work TH: Theory OR: Oral PR: Practical Sem: Semester
Computer Laboratory-VII (Information and Cyber Security+ Machine Learning and Application)
Computer Laboratory-VIII (Software Design and Modeling)

Elective I		Elective II	
414456A	1. Wireless Communications	414457A	1. Software Defined Networks
414456B	2. Natural Language Processing	414457B	2. Soft Computing
414456C	3. Usability Engineering	414457C	3. Software Testing and Quality Assurance
414456D	4. Multicore and Concurrent Systems	414457D	4. Compiler Construction
414456E	5. Business Analytics and Intelligence	414457E	5. Gamification

Audit Course-V	
414461A	1. Emotional Intelligence
414461B	2. Green Computing
414461C	3. Critical Thinking
414461D	4. Statistical Learning model using R.

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SEMESTER –II

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Practical	Tutorial	In-Sem	TW	PR	OR	End-Sem		
414462	Distributed Computing System	3	–	–	30	--	–	–	70	100	3
414463	Ubiquitous Computing	3	–	–	30	--	–	–	70	100	3
414464	Elective-III	3	2	–	30	25	–	25	70	150	4
414465	Elective-IV	3	–	–	30	--	–	–	70	100	3
414466	Computer Laboratory-IX	–	4	–	--	50	50	–	--	100	2
414467	Computer Laboratory-X	–	2	–	--	25	–	25	--	50	1
414468	Project Work	–	–	6	--	50	–	100	--	150	6
414469	Audit Course-VI	--	–	–	--	--	–	–	--	Grade	
Total		12	8	6	120	150	50	150	280	750	22
Total of Part-II		26			750						

Abbreviations: TW: Term Work TH: Theory OR: Oral PR: Practical Sem: Semester
Computer Laboratory-IX (Distributed Computing System)
Computer Laboratory-X (Ubiquitous Computing)

Elective III		Elective IV	
414464A	1. Internet of Things (IoT)	414465A	1. Rural Technologies and Community Development
414464B	2. Information storage and retrieval	414465B	2. Parallel Computing
414464C	3. Multimedia Techniques	414465C	3. Computer Vision
414464D	4. Internet and Web Programming	414464D	4. Social Media Analytics
414464E	5. Computational Optimization	414465E	5. Open Elective

Audit Course-VI	
414469A	1. IoT – Application in Engineering field
414469B	2. Entrepreneurship
414469C	3. Cognitive Computing
414469D	4. AI and Robotics

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TE Information Technology (2019 Course) Syllabus Structure

Savitribai Phule Pune University
Third Year of Information Technology (2019Course)
(With effect from Academic Year2021-22)

SemesterV

Course Code	CourseName	TeachingScheme(Hours/week)			ExaminationSchemeandMarks						CreditScheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Termwork	Practical	Oral	Total	Lecture	Practical	Tutorial	Total
	Theory of Computation	03	-	-	30	70	-	-	-	100	3	-	-	3
	Operating Systems	03	-	-	30	70	-	-	-	100	3	-	-	3
	Machine Learning	03	-	-	30	70	-	-	-	100	3	-	-	3
	Human Computer Interaction	03	-	-	30	70	-	-	-	100	3	-	-	3
	Elective-I	03	-	-	30	70	-	-	-	100	3	-	-	3
	Operating Systems Lab	-	04	-	-	-	25	25	-	50	-	2	-	2
	Human Computer Interaction- Lab	-	02	-	-	-		-	50	50	-	1		1
	Laboratory Practice-I	-	04	-	-	-	25	25		50	-	2	-	2
	Seminar	-	01	-	-	-	50	-	-	50	-	1	-	1
	Audit Course 5													
										TotalCredit	**15**	**06**	-	**21**
	Total	**15**	**10**	-	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**06**	-	**21**

Elective-I:
- Design and Analysis of Algorithm
- Advanced Database and Management System
- Design Thinking
- Internet of Things

Audit Course5:
- Banking and Insurance
- Startup Ecosystems
- Foreign Language–I (German / French)

LaboratoryPracticeI:
Assignment from **Machine Learning and Elective I**

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Savitribai Phule Pune University
Third Year of Information Technology (2019 Course)
(With effect from Academic Year 2021-22)
Semester-VI

Course Code	CourseName	TeachingScheme(Hours/week)			ExaminationSchemeandMarks						CreditScheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Term work	Practical	Oral	Total	Lecture	Practical	Tutorial	Total
	Computer Networks & Security	03	-	-	30	70	-	-	-	100	03			03
	Data Science and Big Data Analytics	03	-	-	30	70	-	-	-	100	03			03
	Web Application Development	03	-	-	30	70	-	-	-	100	03			03
	Elective-II	03	-	-	30	70	-	-	-	100	03			03
	Internship	-	04	-	-	-	100	-	-	100		04		04
	Computer Networks & Security-Lab	-	04	-	-	-	25	-	50	75		02		02
	DS & BDA-Lab	-	02	-	-	-	25	25	-	50		01		01
	Laboratory Practice-II	-	04	-	-	-	50	25	-	75		02		02
	Audit Course 6													
										Total	**12**	**09**	-	**21**
	Total	**12**	**14**	-	**120**	**280**	**200**	**50**	**50**	**700**	**12**	**09**	-	**21**

Elective-II:
- Artificial Intelligence
- Cyber Security
- Cloud Computing
- Software Modeling and Design

Audit Course6:
- Green and Unconventional Energy
- Leadership and Personality Development
- ForeignLanguage-II German / French)

LaboratoryPracticeII:
Assignments from Web Application Development and Elective-II.

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Savitribai Phule Pune University
Second Year of Information Technology Engineering(2019 Course)
(With effect from Academic Year 2020-21)
Semester-III

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	IN-Sem	End-Sem	TW	PR	OR	Total	TH	PR	TUT	Total
214441	Discrete Mathematics	03	-	01	30	70	25	-	-	125	03	–	01	04
214442	Logic Design and Computer Organization	03	-	-	30	70	-	-	-	100	03	-	-	03
214443	Data Structures and Algorithms	03	-	-	30	70	-	-	-	100	03	-	-	03
214444	Object Oriented Programming	03	-	-	30	70	-	-	-	100	03	-	-	03
214445	Basics of Computer Network	03	-	-	30	70	-	-	-	100	03	-	-	03
214446	Logic Design Computer Organization Lab	-	02	-	-	-	25	25	-	50	-	01	-	01
214447	Data Structures and Algorithms Lab	-	04	-	-	-	25	25	-	50	-	02	-	02
214448	Object Oriented Programming Lab	-	04	-	-	-	25	25	-	50	-	02	-	02
214449	Soft Skill Lab	-	02	-	-	-	25	-	-	25	-	01	-	01
214450	Mandatory Audit Course 3	-	-	-	-	-	-	-	-	-	Non Credit			-
Total		15	12	01	150	350	125	75	–	700	15	06	01	22

Abbreviations:
TH: Theory TW: Term Work PR: Practical
OR: Oral TUT: Tutorial

Note: Students of S.E. (Information Technology) can opt any one of the audit course from the list of audit courses prescribed by BoS (Information Technology)

#Mandatory Audit Course 3:
214450A- Ethics and values in IT
214450B - Quantitative Aptitude and Logical Reasoning
214450C- Language Study- Japanese- Module
214450D-Cyber Security and Law

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Savitribai Phule Pune University, Pune
Second Year of Information Technology Engineering (2019 Course)
(With effect from Academic Year 2020-21)
Semester-IV

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	IN-Sem	End-Sem	TW	PR	OR	Total	TH	PR	TUT	Total
207003	Engineering Mathematics- III	03	-	01	30	70	25	-	-	125	03	—	01	04
214451	Processor Architecture	03	-	-	30	70	-	-	-	100	03	-	-	03
214452	Database Management System	03	-	-	30	70	-	-	-	100	03	-	-	03
214453	Computer Graphics	03	-	-	30	70	-	-	-	100	03	-	-	03
214454	Software Engineering	03	-	-	30	70	-	-	-	100	03	-	-	03
214455	Programming Skill Development Lab	-	02	-	-	-	25	25	-	50	-	01	-	01
214456	Database Management System Lab	-	04	-	-	-	25	25		50	-	02	-	02
214457	Computer Graphics Lab	-	02	-	-	-	-	25	-	25	-	01	-	01
214458	Project Based Learning	-	04	-	-	-	50	-	-	50	-	02	-	02
214459	Mandatory Audit Course 4	-	-	-	-	-	-	-	-	-	Non Credit			-
Total		15	12	01	150	350	125	75	-	700	15	06	01	22

Abbreviations:
TH: Theory TW: Term Work PR: Practical
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Note: Students of S.E. (Information Technology) can opt any one of the audit course from the list of audit courses prescribed by BoS (Information Technology)

#Mandatory Audit Course 4:
214459A - Water Supply and Treatment
214459B - Language Study- Japanese- Module II
214459C - Waste Management and Pollution Control
214459D - Intellectual Property Rights

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SEMESTER – I

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Tutorial	Practical	Theory Paper	Theory Online	TW	PR	OR		
214441	Discrete Structures	4	--	--	30	30	--	--	--	100	4
214442	Computer Organization & Architecture	4	--	--	30	30				100	4
214443	Digital Electronics and Logic Design	4	--	--	30	30	--	--	--	100	4
214444	Fundamentals of Data Structures	4	--	--	30	30	--	--	--	100	4
214445	Problem Solving and Object Oriented programming	4	--	--	30	30	--	--	--	100	4
214446	Digital Laboratory	--	--	2	--	--	25	50	--	75	1
214447	Programming Laboratory	--	--	4	--	--	25	50	--	75	2
214448	Object Oriented programming Lab.	--	--	2	--	--	25	50		75	1
214449	Communication Skills	--	--	2	--		25	--	--	25	1
	Audit Course	--	--	--	--	--	--	--	--	Grade	
	Total	20	--	10	250	250	100	150	--	750	25
	Total of Part-II	30 Hours				750					

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SEMESTER – II

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Tutorial	Practical	Theory Paper	Theory Online	TW	PR	OR		
207003	Engineering Mathematics -III	4	1	--	50	50	25	--	--	125	5
214450	Computer Graphics	3	-	--	50	50	--	--	--	100	3
214451	Processor Architecture and Interfacing	4	-	-	50	50	--	--	--	100	4
214452	Data Structures & Files	4	-	-	50	50	--	--	--	100	4
214453	Foundations of Communication and Computer Network	4	-	-	50	50	--	--	--	100	4
214454	Processor Interfacing Laboratory	--	--	4	--	--	25	50	--	75	2
214455	Data Structure and Files Laboratory	--	--	4	--	--	25	50	--	75	2
214456	Computer Graphics Laboratory	--	--	2	--	--	25	50	--	75	1
	Audit Course	--	--	--	--	--	--	--	--	Grade	
	Total	19	01	10	250	250	100	150	--	750	25
	Total of Part-II	30 Hours			750						

TW: Term Work PR: Practical OR: Oral

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SYLLABUS STRUCTURE

SEMESTER – I

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Tutorial	Practical	In-Sem. Paper	End-Sem. Paper	TW	PR	OR		
314441	Theory of Computation	4	--	--	30	70	--	--	--	100	4
314442	Database Management Systems	4	--	--	30	70				100	4
314443	Software Engineering & Project Management	3	--	--	30	70	--	--	--	100	3
314444	Operating System	4	--	--	30	70	--	--	--	100	4
314445	Human-Computer Interaction	3	--	--	30	70	--	--	--	100	3
314446	Software Laboratory-I		--	4	--	--	25	50	50	125	2
314447	Software Laboratory-II	--	--	4	--	--	25	50	--	75	2
314448	Software Laboratory-III	--	--	2	--	--	50	--	--	50	1
314449	Audit Course 5	--	--		--	--	--	--	--	Grade	
	Total	18	--	10	150	350	100	100	50	750	23
	Total of Part-I	28 Hours				750					

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SEMESTER – II

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Tutorial	Practical	In-Sem. Paper	End-Sem. Paper	TW	PR	OR		
314450	Computer Netwcrk Technology	3			30	70				100	3
314451	Systems Programming	4	-	--	30	70	--	--	--	100	4
314452	Design and Analysis of Algorithms	4			30	70				100	4
314453	Cloud Computing	3	-	-	30	70	--	--	--	100	3
314454	Data Science & Big Data Analytics	4	-	-	30	70	--	--	--	100	4
314455	Software Laboratory-IV	--	--	2	--	--	25	--	25	50	1
314456	Software Laboratory-V	--	--	4	--	--	50	50	--	100	2
314457	Software Laboratory-VI	--	--	2	--	--	25	25	--	50	1
314458	Project Based Seminar	--	01	--	--	--	--	--	50	50	1
314459	Audit Course 4	--	--	--	--	--	--	--	--	Grade	
	Total	18	01	08	150	350	100	75	75	750	23
	Total of Part-II	27 Hours			750						

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SEMESTER I

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Practical	Tutorial	In-Sem	TW	PR	OR	End-Sem		
414453	Information and Cyber Security	3	--	--	30	--	--	--	70	100	3
414454	Machine Learning and Applications	4			30				70	100	4
414455	Software Design and Modeling	3	--	--	30	--	--	--	70	100	3
414456	Elective-I	3	--	--	30	--	--	--	70	100	3
414457	Elective -II	3	--	--	30	--	--	--	70	100	3
414458	Computer Laboratory-VII	--	4	--	--	50	50	--	--	100	2
414459	Computer Laboratory-VIII	--	4	--	--	50	--	50	--	100	2
414460	Project Phase-I	--	--	2	--	--	--	50	--	50	2
414461	Audit Course-V	--	--	--	--	--	--	--	--	Grade	
Total		16	8	2	150	100	50	100	350	750	22
Total of Part-I		26				750					

Abbreviations: TW: Term Work TH: Theory OR: Oral PR: Practical Sem: Semester
Computer Laboratory-VII (Information and Cyber Security+ Machine Learning and Application)
Computer Laboratory-VIII (Software Design and Modeling)

Elective I		Elective II	
414456 A	1. Wireless Communications	414457A	1. Software Defined Networks
414456B	2. Natural Language Processing	414457B	2. Soft Computing
414456C	3. Usability Engineering	414457C	3. Software Testing and Quality Assurance
414456D	4. Multicore and Concurrent Systems	414457D	4. Compiler Construction
414456E	5. Business Analytics and Intelligence	414457E	5. Gamification

Audit Course-V	
414461A	1. Emotional Intelligence
414461B	2. Green Computing
414461C	3. Critical Thinking
414461D	4. Statistical Learning model using R.

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SEMESTER –II

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Practical	Tutorial	In-Sem	TW	PR	OR	End-Sem		
414462	Distributed Computing System	3	--	--	30	--	--	--	70	100	3
414463	Ubiquitous Computing	3	--	--	30	--	--	--	70	100	3
414464	Elective-III	3	2	--	30	25	--	25	70	150	4
414465	Elective-IV	3	--	--	30	--	--	--	70	100	3
414466	Computer Laboratory-IX	--	4	--	--	50	50	--	--	100	2
414467	Computer Laboratory-X	--	2	--	--	25	--	25	--	50	1
414468	Project Work	--	--	6	--	50	--	100	--	150	6
414469	Audit Course-VI	--	--	--	--	--	--	--	--	Grade	
Total		12	8	6	120	150	50	150	280	750	22
Total of Part-II		26				750					

Abbreviations: TW: Term Work TH: Theory OR: Oral PR: Practical Sem: Semester
Computer Laboratory-IX (Distributed Computing System)
Computer Laboratory-X (Ubiquitous Computing)

Elective III		Elective IV	
414464A	1. Internet of Things (IoT)	414465A	1. Rural Technologies and Community Development
414464B	2. Information storage and retrieval	414465B	2. Parallel Computing
414464C	3. Multimedia Techniques	414465C	3. Computer Vision
414464D	4. Internet and Web Programming	414464D	4. Social Media Analytics
414464E	5. Computational Optimization	414465E	5. Open Elective

Audit Course-VI	
414469A	1. IoT – Application in Engineering field
414469B	2. Entrepreneurship
414469C	3. Cognitive Computing
414469D	4. AI and Robotics

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M.E. (Information Technology) 2013 syllabus to be implemented from

July-2013

Semester – I

Subject Code	Subject Title	Teaching Scheme	Examination Scheme					
		Lecture / Practical	Paper		TW	Oral / Presentation	Marks	Credits
			In-Sem. Assessment	End-Sem. Assessment				
514401	Mathematical Foundation of Information Technology	04	50	50	-	-	100	04
514402	Applied Algorithms	04	50	50	-	-	100	04
514403	Advance Operating System	04	50	50			100	04
514404	Research Methodology	04	50	50	-	-	100	04
514405	Elective – I	05	50	50#	-	-	100	05
514406	Laboratory Practice - I	04 (PR)	-	-	50	50	100	04
	Total	25	250	250	50	50	600	25

Semester – II

Subject Code	Subject Title	Teaching Scheme	Examination Scheme					
		Lecture / Practical	Paper		TW	Oral / Presentation	Marks	Credits
			In-Sem. Assessment	End-Sem. Assessment				
514407	Wireless Communication Technologies	04	50	50	--	--	100	04
514408	Advanced Database Systems	04	50	50	--	--	100	04
514409	Advance Computer Architecture	04	50	50			100	04
514410	Elective-II	05	50	50#	--	--	100	04
514411	Lab. Practice-II	04(PR)	--	--	50	50	100	05
514412	Seminar-I	04(PR)	--	--	50	50	100	04
	Total	25	200	200	100	100	600	25

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SEMESTER – I

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Tutorial	Practical	Theory Paper	Theory Online	TW	PR	OR		
214441	Discrete Structures	4	--	--	50	50	--	--	--	100	4
214442	Computer Organization & Architecture	4	--	--	50	50				100	4
214443	Digital Electronics and Logic Design	4	--	--	50	50	--	--	--	100	4
214444	Fundamentals of Data Structures	4	--	--	50	50	--	--	--	100	4
214445	Problem Solving and Object Oriented programming	4	--	--	50	50	--	--	--	100	4
214446	Digital Laboratory	--	--	2	--	--	25	50	--	75	1
214447	Programming Laboratory	--	--	4	--	--	25	50	--	75	2
214448	Object Oriented programming Lab.	--	--	2	--	--	25	50		75	1
214449	Communication Skills	--	--	2	--		25	--	--	25	1
	Audit Course	--	--	--	--	--	--	--	--	Grade	
	Total	20	--	10	250	250	100	150	--	750	25
	Total of Part-II	30 Hours				750					

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SEMESTER – II

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits
		Lecture	Tutorial	Practical	Theory Paper	Theory Online	TW	PR	OR		
207003	Engineering Mathematics -III	4	1	--	50	50	25	--	--	125	5
214430	Computer Graphics	3	-	--	50	50	--	--	--	100	3
214431	Processor Architecture and Interfacing	4	-	-	50	50	--	--	--	100	4
214432	Data Structures & Files	4	-	-	50	50	--	--	--	100	4
214433	Foundations of Communication and Computer Network	4	-	-	50	50	--	--	--	100	4
214434	Processor Interfacing Laboratory	--	--	4	--	--	25	50	--	75	2
214435	Data Structure and Files Laboratory	--	--	4	--	--	25	50	--	75	2
214436	Computer Graphics Laboratory	--	--	2	--	--	25	50	--	75	1
	Audit Course	--	--	--	--	--	--	--	--	Grade	
	Total	19	01	10	250	250	100	150	--	750	
	Total of Part-II	30 Hours			750						25

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SEMESTER – I

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks
		Lecture	Practical	Tutorial	In-Semester Assessment Phase - I	TW	PR	OR	End Semester Examination Phase - II	
314441	Computer Network Technology	3			30				70	100
314442	Theory of Computation	4			30				70	100
314443	Database Management Systems	4			30				70	100
314444	Software Engineering	3			30				70	100
314445	Web Engineering and Technology	3			30				70	100
314446	Software Laboratory - I		4			50	50			100
314447	Database Management Systems Laboratory		4				50	50		100
314448	Employability Skill Development Laboratory	1	2			50				50
Total		18	10		150	100	100	50	350	750

Software Lab.-I Part – I : Assignments on Computer Network Technology and
Part – II : Assignments on Web Engineering and Technology

SEMESTER – II

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks
		Lecture	Practical	Tutorial	In-Semester Assessment Phase - I	TW	PR	OR	End Semester Examination Phase - II	
314449	Design and Analysis of Algorithms	4			30				70	100
314450	Systems Programming	4			30				70	100
314451	Operating System	4			30				70	100
314452	Multimedia Technologies	3			30				70	100
314453	Information Tech Project Management	3			30				70	100
314454	Operating System Laboratory		4			50	50			100
314455	Software Laboratory - II		4				50	50		100
314456	Seminar & Technical Communication Lab.		2			50				50
Total		18	10		150	100	100	50	350	750

Software Lab.-II Part – I : Assignments on Design and Analysis of Algorithms and
Part – II : Assignments on Systems Programming

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Course Structure for T.E.\B.E. (Electronics/Electronics & Telecommunication Engineering) Honours Course (With effect from Academic Year 2020-21)

Savitribai Phule Pune University															
Honours* in Data Science **With effect from 2020-21**															
Year & Semester	**Course Code and Course Title**		**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**						**Credit Scheme**		
			Theory	**Tutorial**	**Practical**	**Mid-Semester**	**End-Semester**	**Term work**	**Practical**	**Presentation**	**Total Marks**	**Theory / Tutorial**	**Practical**	**Total Credit**
TE & V	310501	Data Science and Visualization	04	--	--	30	70	--	--	--	100	04	--	04
	310502	Data Science and Visualization Laboratory	--	--	02	--	--	50	--	--	50	--	01	01
		Total	04	-	02	100		50	-	-	150	04	01	05
Total Credits = 05														
TE & VI	310503	Statistics and Machine Learning	04	--	--	30	70	--	--	--	100	04	--	04
		Total	04	-	-	100		-	-	-	100	04	-	04
Total Credits = 04														
BE & VII	410501	Machine Learning and Data Science	04	--	--	30	70	--	--	--	100	04	--	04
	410502	Machine Learning and Data Science Laboratory	--	--	02	--	--	50	--	--	50	--	01	01
		Total	04	-	02	100		50	-	-	150	04	01	05

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Total Credits = 05														
BE & VIII	410503	Artificial Intelligence for Big Data Analytics	04	-	--	30	70	--	--	--	100	04	--	04
	410504	Seminar	--	02	--	--	--	-	--	50	50	02	--	02
		Total	04	-	02	100		-	--	50	150	06	-	06
Total Credits = 06														
Total Credit for Semester V+VI+VII+VIII = 20														

*** To be offered as Honours for Major Disciplines as–**

1. Computer Engineering
2. Electronics and Telecommunication Engineering
3. Electronics Engineering
4. Information Technology

For any other Major Disciplines which is not mentioned above, it may be offered as Minor Degree.

Reference: https://www.aicte-india.org/sites/default/files/APH%202020_21.pdf / page 99-100

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Course Structure for T.E.\B.E. (Electronics/Electronics & Telecommunication Engineering) Honours Course (With effect from Academic Year 2020-21)

Savitribai Phule Pune University

Honours* in Cyber Security
With effect from 2020-21

Year & Semester	Course Code	Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks						Credit Scheme		
			Theory	Tutorial	Practical	Mid-Semester	End-Semester	Term work	Practical	Presentation	Total Marks	Theory / Tutorial	Practical	Total Credit
TE & V	310401	Information and Cyber Security	04	--	--	30	70	--	--	--	100	04	--	04
	310402	Information and Cyber Security Laboratory	--	--	02	--	--	50	--	--	50	--	01	01
		Total	04	-	02	100		50	-	-	150	04	01	05
Total Credits = 05														
TE & VI	310403	Enterprise Architecture and Components	04	--	--	30	70	--	--	--	100	04	--	04
		Total	04	-	-	100		-	-	-	100	04	-	04
Total Credits = 04														
BE & VII	410401	Internet of Things and Embedded Security	04	--	--	30	70	--	--	--	100	04	--	04
	410402	Risk Assessment Laboratory	--	--	02	--	--	50	--	--	50	--	01	01
		Total	04	-	02	100		50	-	-	150	04	01	05

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Total Credits = 05														
BE & VIII	410403	Information Systems Management	04	-	--	30	70	--	--	--	100	04	--	04
	410404	Seminar	--	02	--	--	--	-	--	50	50	02	--	02
		Total	04	-	02	100		-	--	50	150	06	-	06
Total Credits = 06														

Total Credit for Semester V+VI+VII+VIII = 20

*** To be offered as Honours for Major Disciplines as–**

1. Computer Engineering
2. Electronics and Telecommunication Engineering
3. Electronics Engineering
4. Information Technology

For any other Major Disciplines which is not mentioned above, it may be offered as Minor Degree.

Reference: https://www.aicte-india.org/sites/default/files/APH%202020_21.pdf / page99-100

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S.E. (Electronics / E&TC Engineering) 2019 Course
(With effect from Academic Year 2020-21)
Semester-III

Course Code	CourseName	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	In-Sem	nd-Sem	TW	PR	OR	Total	TH	PR	TUT	Total
207005	Engineering Mathematics III	04	-	01	30	70	25	-	-	125	04	-	01	05
204181	Electronic Circuits	03	-	-	30	70	-	-	-	100	03	-	-	03
204182	Digital Circuits	03	-	-	30	70	-	-	-	100	03	-	-	03
204183	Electrical Circuits	03	-	-	30	70	-	-	-	100	03	-	-	03
204184	Data structures	03	-	-	30	70	-	-	-	100	03	-	-	03
204185	Electronic Circuit Lab	-	02	-	-	-	-	50	-	50	-	01	-	01
204186	Digital circuits Lab		02					50		50		01		01
204187	Electrical Circuit Lab	-	02	-	-	-	25	-	-	25	-	01	-	01
204188	Data Structures Lab	-	02	-	-	-	-	-	25	25	-	01	-	01
204189	Electronic Skill Development	-	02	-	-	-	25	-	-	25	-	01	-	01
204190	Mandatory Audit Course 3	-	-	-					-	-	-	-	-	-
Total		**16**	**10**	**01**	**150**	**350**	**75**	**100**	**25**	**700**	**16**	**05**	**01**	**22**

Mandatory Audit Course 3

1. Technical English For Engineers
2. Ecology and Environment
3. Ecology and Society
4. German I
5. Science, Technology and Society
6. Introduction to Japanese Language and Culture

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Semester-IV

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	In-Sem	End-Sem	TW	PR	OR	Total	TH	PR	TUT	Total
204191	Signals & Systems	03	-	01	30	70	25	-	-	125	03	-	01	04
204192	Control Systems	03	-		30	70		-	-	100	03	-	-	03
204193	Principles of Communication Systems	03	-	-	30	70	-	-	-	100	03	-	-	03
204194	Object Oriented Programming	03	-	-	30	70	-	-	-	100	03	-	-	03
204195	Signals & Control System Lab		02				50			50		01		01
204196	Principle of Communication SystemsLab	-	02	-	-	-	-	50	-	50	-	01	-	01
204197	Object Oriented Programming Lab	-	02	-	-	-	-	-	50	50	-	01	-	01
204198	Data Analytics Lab		02				-		25	25		01		01
204199	Employability Skill Development	02	02	-	-	-	50	-	-	50	02	01	-	03
204200	Project Based Learning ηl	-	04				50		-	50		02		02
204201	Mandatory Audit Course 4	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		14	14	01	120	280	175	50	75	700	14	07	01	22

Mandatory Audit Course 4

1. Enhancing Soft Skills and Personality
2. Language & Mind
3. Emotional Intelligence
4. German II
5. Human Behaviour
6. Speaking Effectively

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Course Structure for S.E. (Electronics & Telecommunication Engineering) 2015 Course (With effect from Academic Year 2016-17)

SEMESTER I

Course Code	Course	Teaching SchemeHours/ Week			SemesterExaminationSchemeofMarks						Credit	
		Theory	Tutorials	Practical	In-Sem(Online)	End-Sem(Theory)	TW	PR	OR	Total	TH/ TUT	PR+ OR
204181	Signals &Systems	3	1	-	50	50	25	-	-	125	4	-
204182	ElectronicDevices &Circuits	4	-	2	50	50	-	50	-	150	4	1
204183	ElectricalCircuits And Machines	3	-	2	50	50	25	-	-	125	3	1
204184	Data Structures and Algorithms	4	-	2	50	50	-	-	50	150	4	1
204185	DigitalElectronics	4	-	2	50	50	-	50	-	150	4	1
204186	Electronic Measuring Instruments &Tools	1	-	2	-	-	50	-	-	50	1	1
204192	**AuditCourse1**	--	--	--	--	--	--	--	--	--		
	Total	**19**	**1**	**10**	**250**	**250**	**100**	**100**	**50**	**750**	**20**	**05**
	TotalCredits										**25**	

Audit Course 1

1. Japanese Language module-I
2. Road Safety Management

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(With effect from Academic Year 2016-17)

SEMESTER II

Course Code	Course	Teaching Scheme Hours / Week			Semester Examination Scheme of Marks						Credit	
		Theory	Tutorials	Practicals	In-Sem(on line)	End-Sem(Theory)	TW	PR	OR	Total	TH/TUT	PR+OR
207005	Engineering Mathematics III	4	1	-	50	50	25	-	-	125	5	-
204187	Integrated Circuits	4	-	2	50	50	25	50	-	175	4	1
204188	Control Systems	3	-	-	50	50	-	-	-	100	3	-
204189	Analog Communication	3	-	2	50	50	-	50	-	150	3	1
204190	Object Oriented Programming	3	-	4	50	50	-	-	50	150	3	2
204191	Employability Skill Development	2	-	2	-	-	50	-	-	50	2	1
204193	**Audit Course 2**	--	--	--	--	--	--	--	--	--		
Total		**19**	**1**	**10**	**250**	**250**	**100**	**100**	**50**	**750**	**20**	**05**
Total Credits											**25**	

Audit Course 2

1. Japanese Language module II
2. Cyber Crime and law

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Course Structure for B. E. (Electronics/Electronics & Telecommunication Engineering) 2015 Course
(With effect from Academic Year 2018-19)
SEMESTER I

Course Code	Course	Teaching Scheme Hours / Week			Semester Examination Scheme of Marks						Credits	
		Theory	Tut	Pract	In-Sem	End-Sem	TW	PR	OR	Total	TH/TW	PR+OR
404181	VLSI Design& Technology	3	--	--	30	70	--	--	--	100	3	--
404182	Computer Networks & Security	4	--	--	30	70	--	--	--	100	4	--
404183	Radiation&Microwave Techniques	3	--	--	30	70	--	--	--	100	3	--
404184	Elective I	3	--	--	30	70	--	--	--	100	3	--
404185	Elective II	3			30	70	--	--	--	100	3	--
404186	Lab Practice -I (CNS+ RMT)	--	--	4	--	--	50	--	50	100	--	TW 01 + OR 01
404187	Lab Practice -II (VLSI + Elective I)	--	--	4	--	--	50	50		100	--	TW01 + PR 01
404188	Project Stage I	-	2	--	--	--	-	--	50	50	--	2
	Audit Course 5	--	--	--	--	--	--	--	--	--	----	
Total		**16**	**2**	**8**	**150**	**350**	**100**	**50**	**100**	**750**	**16**	**6**
Total Credits											**22**	

Elective I
1 Digital Image and Video Processing
2. Industrial Drives andControl
3. Embedded Systems &RTOS
4. Internet ofThings

Elective II
1. Wavelets
2. Electronics ProductDesign
3. OptimizationTechniques
4. ArtificialIntelligence
5. Electronics inagriculture

Audit Course 5
1. GreenEnergy
2. HumanBehavior

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Course Structure for B. E . (Electronics/Electronics & Telecommunication Engineering) 2015 Course
(With effect from Academic Year 2018-19)
SEMESTER II

Course Code	Course	Teaching Scheme Hours / Week			Semester Examination Scheme of Marks						Credit	
		Theory	Tut	Pract	In Sem	End-Sem	TW	PR	OR	Total	TH/TW	PR+OR
404189	Mobile Communication	3	--	--	30	70	--	--	--	100	3	--
404190	Broadband Communication Systems	4	--	--	30	70	--	--	--	100	4	--
404191	Elective III	3	--	--	30	70	--	--	--	100	3	--
404192	Elective IV	3	--	--	30	70	--	--	--	100	3	--
404193	Lab Practice –III (MC+BCS)	--	--	4	--	--	50	50	--	100	--	TW 01 + PR 01
404194	Lab Practice –IV (Elective III)	--	--	2	--	--	--	--	50	50	--	1
404195	Project Stage II	--	6	-	--	--		150	50	200	--	TW 04 + OR 02
	Audit Course 6	--	--	--	--	--	--	--	--	--		
Total		**13**	**6**	**6**	**120**	**280**	**200**	**50**	**100**	**750**	**13**	**9**
Total Credits											**22**	

Elective III	Elective-IV	Audit Course 6
1. Machine Learning 2. PLC s andAutomation 3. Audio and SpeechProcessing 4. Software DefinedRadio 5. Audio VideoEngineering	1. Robotics 2. BiomedicalElectronics 3. Wireless SensorNetworks 4. Renewable EnergySystems 5. OpenElective*	1. Team Building, Leadership and Fitness 2. Environmental issues and DisasterManagement

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2012 Course (With effect from Academic Year 2015-16)

SEMESTER I

Subject Code	Subject	Teaching Scheme			Examination Scheme					Marks
		LECT	TUT	PR	In Semester Assessment Phase I	PR	OR	TW	End Semester Examination Phase II	Total
404181	VLSI Design & Technology	3			30				70	100
404182	Computer Networks	3			30				70	100
404183	Microwave Engineering	4			30				70	100
404184	Elective I	3			30				70	100
404185	Elective II	3			30				70	100
404186	Lab Practice I (CN & MWE)			4			50	50		100
404187	Lab Practice II (VLSI &Elective I)			4		50		50		100
404188	Project Phase I		2				50			50
	Total	**16**	**2**	**8**	**150**	**50**	**100**	**100**	**350**	**750**

Elective I
1. Digital Image Processing
2. Embedded Systems & RTOS
3. Software Defined Radio
4. Industrial Drives and Control

Elective II
1. Multi rate & Adaptive Signal Processing
2. Electronic Product Design
3. PLCs and Automation
4. Artificial Intelligence

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Course Structure for B.E . (Electronics/Electronics & Telecommunication Engineering)
2012 Course (With effect from Academic Year 2015-16)

SEMESTER II

Subject Code	Subject	Teaching Scheme			Examination Scheme					Marks
		LECT	TUT	PR	InSemester Assessment Phase I	PR	OR	TW	End Semester Examination Phase II	Total
404189	Mobile Communication	4			30				70	100
404190	Broadband Communication Systems	4			30				70	100
404191	Elective III	3			30				70	100
404192	Elective IV	3			30				70	100
404193	Lab Practice III(MC & BCS)			4			50	50		100
404194	Lab Practice IV (Elective III)			2		50		50		100
404195	Project Phase II		6			50		100		150
	Total	**14**	**6**	**6**	**120**	**100**	**50**	**200**	**280**	**750**

Elective III
1. Speech & Audio Signal Processing
2. RF Circuit Design
3. Audio Video Engineering
4. Soft Computing

Elective IV
1. Biomedical Signal Processing
2. Nano Electronics & MEMS
3. Detection & Estimation Theory
4. Wireless Networks
5. Open Elective*

***Any one subject from the list of Elective IV of computer/IT/Electrical/Instrumentation or Institute can offer elective IV based on any industry need with prior approval from BoS(Electronics). Repetition of subjects or topics is to be avoided.**

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SavitribaiPhule Pune University, Pune
T.E. (Electronics& Telecommunication Engineering) 2019 Course
(With effect from Academic Year 2021-22)

Semester-V

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	In-Sem	End-Sem	TW	PR	OR	Total	TH	PR	TUT	Total
304181	Digital Communication	03	-	-	30	70	-	-	-	100	03	-	-	03
304182	Electromagnetic Field Theory	03	-	01	30	70	25	-	-	125	03	-	01	04
304183	Database Management	03	-	-	30	70	-	-	-	100	03	-	-	03
304184	Microcontrollers	03	-	-	30	70	-	-	-	100	03	-	-	03
304185	Elective - I	03	-	-	30	70	-	-	-	100	03	-	-	03
304186	Digital Communication Lab	-	02	-	-	-	-	50	-	50	-	01	-	01
304187	Database Management Lab	-	02	-	-	-	-	-	25	25	-	01	-	01
304188	Microcontroller Lab	-	02	-	-	-	-	50	-	50	-	01	-	01
304189	Elective I Lab	-	02	-	-	-	-	25	-	25	-	01	-	01
304190	Skill Development	-	02	-	-	-	25	-	-	25	-	01	-	01
304191A	Mandatory Audit Course[5] &	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**10**	**01**	**150**	**350**	**50**	**125**	**25**	**700**	-		-	-
										Total Credit	**15**	**05**	**01**	**21**

Elective -I	Mandatory Audit Course
1.Digital Signal Processing 2.Electronic Measurement 3.Fundamentals of JAVA Programming 4.Computer Networks	1.Developing Soft skills and Personality 2.Entrepreneurship and IP Strategy 3.Urbanization and Environment 4.Environmental & Resource Economics 5.Environment and Development 6.Globalization and Culture

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SavitribaiPhule Pune University, Pune
T.E. (Electronics& Telecommunication Engineering) 2019 Course
(With effect from Academic Year 2021-22)

Semester-VI

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	In-Sem	End-Sem	TW	PR	OR	Total	TH	PR	TUT	Total
304192	Cellular Networks	03	-	-	30	70	-	-	-	100	03	-	-	03
304193	Project Management	03	-	-	30	70	-	-	-	100	03	-	-	03
304194	Power Devices & Circuits	03	-	-	30	70	-	-	-	100	03	-	-	03
304195	Elective-II	03	-	-	30	70	-	-	-	100	03	-	-	03
304196	Cellular Networks Lab	-	02	-	-	-	-	-	50	50	-	01	-	01
304197	Power Devices & Circuits Lab	-	02	-	-	-	-	50	-	50		01		01
304198	Elective-II Lab	-	02	-	-	-	-	25	-	25	-	01	-	01
304199	Internship**	-	-	-	-	-	100	-	-	100	-	-	04	04
304200	Mini Project	-	04	-	-	-	25	-	50	75	-	02	-	02
304191 B	Mandatory Audit Course 6 &	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tota	12	10	00	120	280	125	75	100	700				
										Total Credit	12	05	04	21

Elective -II
1. Digital Image Processing
2. Sensors in Automation
3. Advanced JAVA Programming
4. Embedded Processors
5. Network Security

Mandatory Audit Course6
1. Patent Law for Engineers and Scientists
2. English language for competitive exams
3. Energy Resources, Economics and Environment Principles of Human Resource Management
4. Six Sigma
5. Non-Conventional Energy Resources

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Course Structure for T.E. (Electronics & Telecommunication Engineering) 2015 Course
(With effect from Academic Year 2017-18)
SEMESTER- I

Course Code	Course	Teaching Scheme Hours / Week			Semester Examination Scheme of Marks						Credits	
		Theory	Tutorials	Practicals	In-Sem	End-Sem	TW	PR	OR	Total	Th+ Tut	PR/OR/ TW
304181	Digital Communication	3	--	--	30	70	--	-	--	100	3	--
304182	Digital Signal Processing	3	--	--	30	70	--	--	--	100	3	--
304183	Electromagnetics	3	1	--	30	70	--	--	--	100	4	--
304184	Microcontrollers	3	--	--	30	70	--	--	--	100	3	--
304185	Mechatronics	3	--	--	30	70	--	--	--	100	3	--
304191	Signal Processing andCommunicationsLab (DC/DSP)	--	--	4	--	--	50	50		100	--	2
304192	Microcontrollers and Mechatronics Lab	--	--	4	--	--	50	50		100	--	2
304193	Electronics System Design	2	--	2	--	--	--	--	50	50	2	1
	Audit Course 3	--	--	--	--	--	--	--	--	--	-	
Total		**17**	**01**	**10**	**150**	**350**	**100**	**100**	**50**	**750**	**18**	**5**
										Total Credits	**23**	

Audit Course 3

1. Japanese Language Audit Course
2. Cyber and Information Security

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Course Structure for T.E. (Electronics & Telecommunication Engineering) 2015 Course
(With effect from Academic Year 2017-18)
Semester II

Course Code	Course	Teaching Scheme Hours /Week			Semester Examination Scheme of Marks						Credit	
		Theory	Tutorials	Practical's	In-Sem	End-Sem	TW	PR	OR	Total	Th+Tut	PR/OR/TW
304186	Power Electronics	3	--	--	30	70	--	--	--	100	3	--
304187	Information Theory, Coding and Communication Networks	4	--	--	30	70	--	--	--	100	4	--
304188	Business Management	3	--	--	30	70	--	--	--	100	3	--
306189	Advanced Processors	3	--	--	30	70	--	--	--	100	3	--
304190	System Programming and Operating Systems	3	--	--	30	70		--	--	100	3	--
304194	Power and ITCT Lab	--	--	4	--	--	50	50	--	100	--	2
304195	Advanced Processors and System Programming Lab	--	--	4	--	--	50	50	--	100	--	2
304196	Employability Skills and Mini Project	2	--	2	--	--	--	--	50	50	2	1
	Audit Course 4	--	--	--	--	--	--	--	--	--		
	Total	**18**	**---**	**10**	**150**	**350**	**100**	**100**	**50**	**750**	**18**	**5**
										Total Credits	**23**	

Audit Course 4
1. Japanese Language Audit Course
2. Embedded System Design using MSP430

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Course Structure for T.E. (Electronics & Telecommunication Engineering) 2012 Course (With effect from Academic Year 2014-15)

SEMESTER I

Subject Code	Subject	Teaching Scheme			Examination Scheme					Marks
		Lect	Tut	Pr	Pr	Oral	TW	In Semester Assessment	End Semester Examination	Total
								Phase I	Phase II	
304181	Digital Communication	4						30	70	100
304182	Digital Signal Processing	4						30	70	100
304183	Micro Controller and Applications	3						30	70	100
304184	Electromagnetics and Transmission Lines	3	1					30	70	100
304185	System Programming and Operating System	3						30	70	100
304186	Digital Communication and Signal Processing Lab			4	50		50			100
304187	System Programming And Microcontroler Applications Lab			4	50		50			100
304188	Employability Skills in Electronics Design	2		2		50				50
	Total	**19**	**1**	**10**	**100**	**50**	**100**	**150**	**350**	**750**

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Course Structure for T.E. (Electronics & Telecommunication Engineering) 2012 Course
(With effect from Academic Year 2014-15)

SEMESTER II

Subject Code	Subject	Teaching Scheme			Examination Scheme					Marks
		Lect	Tut	Pr	Pr	Oral	TW	InSemester Assessment	End Semester Examination	Total
								Phase I	Phase II	
304189	Information Theory and Coding Techniques	4						30	70	100
304190	Antenna and Wave Propagation	4						30	70	100
304191	EmbeddedProcessors	4						30	70	100
304192	Industrial Management	3						30	70	100
304193	Power Electronics	3						30	70	100
304194	Communication Lab			4	50		50			100
304195	Power Electronics and Embedded Lab			4	50		50			100
304196	Mini project and Seminar			4		50				50
	Total	**18**		**12**	**100**	**50**	**100**	**150**	**350**	**750**

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Course Structure for S.E. (Electronics & Telecommunication Engineering) 2012 Course
(With effect from Academic Year 2013-14)

SEMESTER-I										
Subject Code	Subject	Teaching Scheme Hrs/Week			Examination Scheme					Marks
		Lect	Tut	Pr	Theory Online	Tw	Pr	Or	Theory Paper	Total
204181	Signals & Systems	4	1	-	50	25	-	-	50	125
204182	Electronic Devices & Circuits	4	-	2	50	-	50	-	50	150
204183	Network Theory	3	1	-	50	25	-	-	50	125
204184	Data structures & Algorithms	4	-	2	50	-	-	50	50	150
204185	Digital Electronics	4	-	2	50	-	50	-	50	150
204186	Electronic Measuring Instruments & Tools	1	-	2	-	50	-	-	-	50
	Total	**20**	**2**	**8**	**250**	**100**	**100**	**50**	**250**	**750**

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Course Structure for S.E. (Electronics & Telecommunication Engineering) 2012 Course
(With effect from Academic Year 2013-14)

SEMESTER-II										
Subject Code	Subject	Teaching Scheme Hrs/Week			Examination Scheme					Marks
		Lect	Tut	Pr	Theory Online	Tw	Pr	Or	Theory Paper	Total
207005	Engineering Maths-III	4	1	-	50	25	-	-	50	125
204187	IntegratedCircuits	3	-	2	50	-	50	-	50	150
204188	Control Systems	3	1	-	50	25	-	-	50	125
204189	Analog Communication	4	-	2	50	-	50	-	50	150
204190	Computer Organization	3	-	-	50	-	-	-	50	100
204191	Object Oriented Programming	2	-	2	-	25	-	50	-	75
204192	Soft Skills	1	-	2	-	25	-	-	-	25
	Total	**20**	**2**	**8**	**250**	**100**	**100**	**50**	**250**	**750**

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BE Mechanical 2015 Pattern

Savitribai Phule Pune University

B.E. (Mechanical) (2015 Course) Semester – I

Code	Subject	Teaching Scheme Hrs / week			Examination Scheme					Total Marks	Credits	
		Lecture	Tut	Pract	In Sem	End Sem	TW	PR	OR		Theory	TW/ Pr/OR
402041	Hydraulics and Pneumatics	3	-	2	30	70	25	-	25	150	3	1
402042	CAD CAM Automation	3	-	2	30	70	25	50	-	175	3	1
402043	Dynamics of Machinery	4	-	2	30	70	25	-	25	150	4	1
402044	Elective-I	3	-	2	30	70	25	-	-	125	3	1
402045	Elective-II	3	-	-	30	70	-	-	-	100	3	-
402046	Project-I	-	-	4	-	-	25	-	25	50	-	2
Total		16	-	12	150	350	125	50	75	750	16	6
											22	

B.E. (Mechanical) (2015 Course) Semester – II

Code	Subject	Teaching Scheme Hrs / week			Examination Scheme					Total Marks	Credits	
		Lecture	Tut	Pract	In Sem	End Sem	TW	PR	OR		Theory	TW/ Pr/OR
402047	Energy Engineering	3	-	2	30	70	25	-	25	150	3	1
402048	Mechanical System Design	4	-	2	30 (1.5 Hrs)	70 (3 Hrs)	25	-	50	175	4	1
402049	Elective-III	3	-	2	30	70	25	-	-	125	3	1
402050	Elective-IV	3	-	-	30	70	-	-	-	100	3	-
402051	Project-II	-	-	12	-	-	100	-	100	200	-	6
Total		13	-	18	120	280	175	-	175	750	13	9
											22	

Elective – I		Elective – II	
Code	Subject	Code	Subject
402044 A	Finite Element Analysis	402045 A	Automobile Engineering
402044 B	Computational Fluid Dynamics	402045 B	Operation Research
402044 C	Heating Ventilation and Air Conditioning	402045 C	Energy Audit and Management
		402045 D	Open Elective**

Elective – III		Elective – IV	
402049 A	Tribology	402050 A	Advanced Manufacturing Processes
402049 B	Industrial Engineering	402050 B	Solar & Wind Energy
402049 C	Robotics	402050 C	Product Design and Development
		402050 D	Open Elective**

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TE Mechanical 2015 Pattern

Savitribai Phule Pune University
T.E. Mechanical Engineering 2015 – Course
T. E. (Mechanical) (2015 Course) Semester – I

Code	Subject	Teaching Scheme Hrs / week			Examination Scheme					Total Marks	Credits	
		Lecture	Tut	Pract	In-Sem	ESE	TW	PR	OR		Th	TW / PR / OR
302041	Design of Machine Elements-I	4	-	2	30@	70@	50	-		150	4	1
302042	Heat Transfer*	4	-	2	30	70		50	-	150	4	1
302043	Theory of Machines-II$	3	1		30	70	25	-	25	150	3	1
302044	Turbo Machines	3	-	2	30	70	-	-	25	125	3	1
302045	Metrology and Quality Control$	3	-	2	30	70	-	-	25	125	3	1
302046	Skill Development	-	-	2	-	-	25	25	-	50	-	1
Total		17	1	10	150	350	100	75	75	750	17	6
											23	

T. E. (Mechanical) (2015 Course) Semester – II

Code	Subject	Teaching Scheme Hrs / week			Examination Scheme					Total Marks	Credits	
		Lecture	Tut	Pract	In-Sem	ESE	TW	PR	OR		Th	TW / PR / OR
302047	Numerical Methods and Optimization*	4	-	2	30	70	-	50	-	150	4	1
302048	Design of Machine Elements-II	4	-	2	30@	70@	25	-	25	150	4	1
302049	Refrigeration and Air Conditioning	3	-	2	30	70	-	-	25	125	3	1
302050	Mechatronics*^	3	1		30	70	-	-	25	125	3	1
302051	Manufacturing - Process-II$	3	-	-	30	70	-	-	-	100	3	-
302052	Machine Shop-II$	-	-	2	-	-	50	-	-	50	-	1
302053	Seminar$	-	-	2	-	-	25	-	25#	50	-	1
302054	Audit Course*	—	—	—	—	—	-	-	-	-	-	-
Total		17	1	10	150	350	100	50	100	750	17	6
											23	

Though it is under Oral head Internal Panel to be appointed by Principal and HOD. Examination schedule will not be prepared at University level.
* Marked subjects are common with TE (Auto. Engg.) and TE Mech. Sandwich
$ Marked subjects are common with TE (Auto. Engg.) only
^ Marked subjects are common with TE Mech. Sandwich only
@ Examination time for Insem examination 1 Hr 30 Min. and Endsem examination 3Hrs.

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SE Mechanical 2015 Pattern

Structure of S.E. (Mechanical Engineering/ Automobile Engineering)
2015 Course

Semester-I

Subject Code	Subject	Teaching Scheme Hours/Week			Examination Scheme					Total Marks	Credits	
		L	Tut.	PR	In-Sem (online)	End-Sem	TW	PR	Oral		Lect/Tut	PR/OR
207002	Engineering Mathematics – III	04	01	-	50	50	25	-	-	125	05	-
202041	Manufacturing Process-I	03		02	50	50	50			150	03	01
202042	Computer Aided Machine Drawing	01	-	02	--	--		50	-	50	01	01
202043	Thermodynamics	04	-	02	50	50	-	-	50	150	04	01
202044	Material Science	03	01	-	50	50	25	-	-	125	03	01
202051	Strength of Materials	04	-	02	50	50	-	-	50	150	04	01
202055	Audit course				--	--						
	Total	19	02	08	250	250	100	50	100	750	20	05
	Total of Part-I	29 Hrs				750					25	

Note: Material Science and Engineering Mathematics-III practical may be carried out fortnightly for two hours so that the tutorial hours may be used as practical.

Semester-II

Subject Code	Subject	Teaching Scheme Hours/Week			Examination Scheme					Total Marks	Credits	
		L	Tut.	PR	In Sem (online)	End Sem	TW	PR	Oral		Lect/Tut	PR/OR
202045	Fluid Mechanics	04	-	02	50	50	-	50	-	150	04	01
202047	Soft Skills	-	-	02	--	--	25	-	-	25	-	01
202048	Theory of Machines – I	04	01	-	50	50	25	-	25	150	04	01
202049	Engineering Metallurgy	03	01	-	50	50	-	-	25	125	03	01
202050	Applied Thermodynamics	04	-	02	50	50	-	50	-	150	04	01
203152	Electrical and Electronics Engineering	03	-	02	50	50	25	-	-	125	03	01
203053	Machine Shop – I	-	-	02	--	--	25	-	-	25	-	01
	Total	18	02	10	250	250	100	100	50	750	18	07
	Total of Part-II	30 Hrs				750					25	

Note: Theory of Machine-I and Engineering Metallurgy practical may be carried out fortnightly for two hours, so that the tutorial hours may be used as practical.

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TE Mechanical 2019 Pattern

Savitribai Phule Pune University
Board of Studies - Automobile and Mechanical Engineering
Undergraduate Program - Mechanical Engineering (2019 pattern)

Course Code	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
Semester-V														
302041	Numerical & Statistical Methods	3	-	1	30	70	25	-	-	125	3	-	1	4
302042	Heat & Mass Transfer	3	2	-	30	70	-	50	-	150	3	1	-	4
302043	Design of Machine Elements	3	2	-	30	70	-	-	25	125	3	1	-	4
302044	Mechatronics	3	2	-	30	70	-	-	25	125	3	1	-	4
302045	Elective I	3	-	-	30	70	-	-	-	100	3	-	-	3
302046	Digital Manufacturing Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302047	Skill Development	-	2	-	-	-	25	-	-	25	-	1	-	1
302048	Audit course - V$^{\$}$	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**10**	**1**	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**5**	**1**	**21**
Semester-VI														
302049	Artificial Intelligence &Machine Learning	3	2	-	30	70	-	-	25	125	3	1	-	4
302050	Computer Aided Engineering	3	2	-	30	70	-	50	-	150	3	1	-	4
302051	Design of Transmission Systems	3	2	-	30	70	-	-	25	125	3	1	-	4
302052	Elective II	3	-	-	30	70	-	-	-	100	3	-	-	3
302053	Measurement Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302054	Fluid Power &Control Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302055	Internship/Mini project *	-	4	-	-	-	100	-	-	100	-	4	-	4
302056	Audit course - VI$^{\$}$	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**12**	**14**	**-**	**120**	**280**	**200**	**50**	**50**	**700**	**12**	**9**	**-**	**21**

Elective-I		Elective-II	
302045-A	Advanced Forming & Joining Processes	302052-A	Composite Materials
302045-B	Machining Science & Technology	302052-B	Surface Engineering

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SE Mechanical 2019 Pattern

Savitribai Phule Pune University
Board of Studies - Automobile and Mechanical Engineering
Undergraduate Program - Automobile Engineering & Mechanical Engineering (2019 pattern)

Course Code	Course Name	Teaching Scheme (Hours/ Week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	TOTAL	TH	PR	TUT	TOTAL
Semester-III														
202041	Solid Mechanics	4	2	-	30	70	-	50	-	150	4	1	-	5
202042	Solid Modeling and Drafting	3	2	-	30	70	-	50	-	150	3	1	-	4
202043	Engineering Thermodynamics	3	2	-	30	70	-	-	25	125	3	1	-	4
202044	Engineering Materials and Metallurgy	3	2	-	30	70	25	-	-	125	3	1	-	4
203156	Electrical and Electronics Engineering	3	2	-	30	70	25	-	-	125	3	1	-	4
202045	Geometric Dimensioning and Tolerancing Lab	-	2	-	-	-	25	-	-	25	-	1	-	1
202046	Audit Course - III	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**16**	**12**	**-**	**150**	**350**	**75**	**100**	**25**	**700**	**16**	**6**	**-**	**22**
Semester-IV														
207002	Engineering Mathematics III	3		1	30	70	25			125	3		1	4
202047	Kinematics of Machinery	3	2	-	30	70	-	-	25	125	3	1	-	4
202048	Applied Thermodynamics	3	2	-	30	70	-	-	25	125	3	1	-	4
202049	Fluid Mechanics	3	2	-	30	70	-	-	25	125	3	1	-	4
202050	Manufacturing Processes	3	-	-	30	70	-	-	-	100	3	-	-	3
202051	Machine Shop	-	2	-	-	-	50	-	-	50	-	1	-	1
202052	Project Based Learning - II	-	4	-	-	-	50	-	-	50	-	2		2
202053	Audit Course - IV	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**12**	**1**	**150**	**350**	**125**	**-**	**75**	**700**	**15**	**6**	**1**	**22**

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Board of Studies - Automobile and Mechanical Engineering
Undergraduate Program - Mechanical Engineering (2019 pattern)
Honors in "3D Printing"

Course Code	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
Semester-V														
302011MJ	Additive Manufacturing Technology	4	-	-	30	70	-	-	-	100	4	-	-	4
302012MJ	Modelling Lab	-	2	-	-	-	50	-	-	50	-	1	-	1
	Total	4	2	-	30	70	50	-	-	150	4	1	-	5
Semester-VI														
302013MJ	Design for Additive Manufacturing	4	-	-	30	70	-	-	-	100	4	-	-	4
	Total	4	-	-	30	70	-	-	-	100	4	-	-	4
Semester-VII														
402014MJ	Additive Manufacturing System Design	4	-	-	30	70	-	-	-	100	4	-	-	4
402015MJ	3D Printing Lab	-	2	-	-	-	50	-	-	50	-	1	-	1
	Total	4	2	-	30	70	50	-	-	150	4	1	-	5
Semester-VIII														
402016MJ	3D Printing Applications & Entrepreneurship	4	-	-	30	70	-	-	-	100	4	-	-	4
402017MJ	Seminar	-	-	2	-	-	50	-	-	50	-	-	2	2
	Total	4	-	2	30	70	50	-	-	150	4	-	2	6

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Board of Studies - Automobile and Mechanical Engineering
Undergraduate Program - Mechanical Engineering (2019 pattern)
Honors in "Electric Vehicles"

Course Code	Course Name	Teaching Scheme (Hrs/Week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	TOTAL	TH	PR	TUT	TOTAL
Semester-V														
302031MJ	e-Vehicle Technology	4	-	-	30	70	-	-	-	100	4	-	-	4
302032MJ	EV Lab	-	2	-	-	-	50	-	-	50	-	1	-	1
	Total	4	2	-	30	70	50	-	-	150	4	1	-	5
Semester-VI														
302033MJ	e-Vehicle System Design	4	-	-	30	70	-	-	-	100	4	-	-	4
	Total	4	-	-	30	70	-	-	-	100	4	-	-	4
Semester-VII														
302034MJ	Modelling and Simulation of EHV	4	-	-	30	70	-	-	-	100	4	-	-	4
302035MJ	EV Simulation Lab	-	2	-	-	-	50	-	-	50	-	1	-	1
	Total	4	2	-	30	70	50	-	-	150	4	1	-	5
Semester-VIII														
302036MJ	e-Vehicle Standards, Charging & Safety	4	-	-	30	70	-	-	-	100	4	-	-	4
302037MJ	Seminar	-	-	2	-	-	50	-	-	50	-	-	2	2
	Total	4	-	2	30	70	50	-	-	150	4	-	2	6

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Board of Studies - Electronics & Telecommunication Engineering

Undergraduate Program - (2019 pattern)

Honors in 'Robotics'

Course Code	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	TOTAL	TH	PR	TUT	TOTAL
Semester-V														
304051MJ	Principles of Industrial Robotics	4	-	-	30	70	-	-	-	100	4	-	-	4
304052MJ	Industrial Robotics Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
	Total	**4**	**2**	**-**	**30**	**70**	**50**	**-**	**-**	**150**	**4**	**1**	**-**	**5**
Semester-VI														
304053MJ	Robot Programming & Simulation	4	-	-	30	70	-	-	-	100	4	-	-	4
	Total	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**-**	**100**	**4**	**-**	**-**	**4**
Semester-VII														
404054MJ	Automation System Design	4	-	-	30	70	-	-	-	100	4	-	-	4
404055MJ	Design of Robotic Systems Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
	Total	**4**	**2**	**-**	**30**	**70**	**50**	**-**	**-**	**150**	**4**	**1**	**-**	**5**
Semester-VIII														
404056MJ	Artificial Intelligence in Robotics	4	-	-	30	70	-	-	-	100	4	-	-	4
404057MJ	Seminar	-	-	2	-	-	50	-	-	50	-	-	2	2
	Total	**4**	**-**	**2**	**30**	**70**	**50**	**-**	**-**	**150**	**4**	**-**	**2**	**6**

Abbreviations: TH: Theory, PR: Practical, TUT: Tutorial, ISE: In-Semester Exam, ESE: End-Semester Exam, TW: Term Work, OR: Oral

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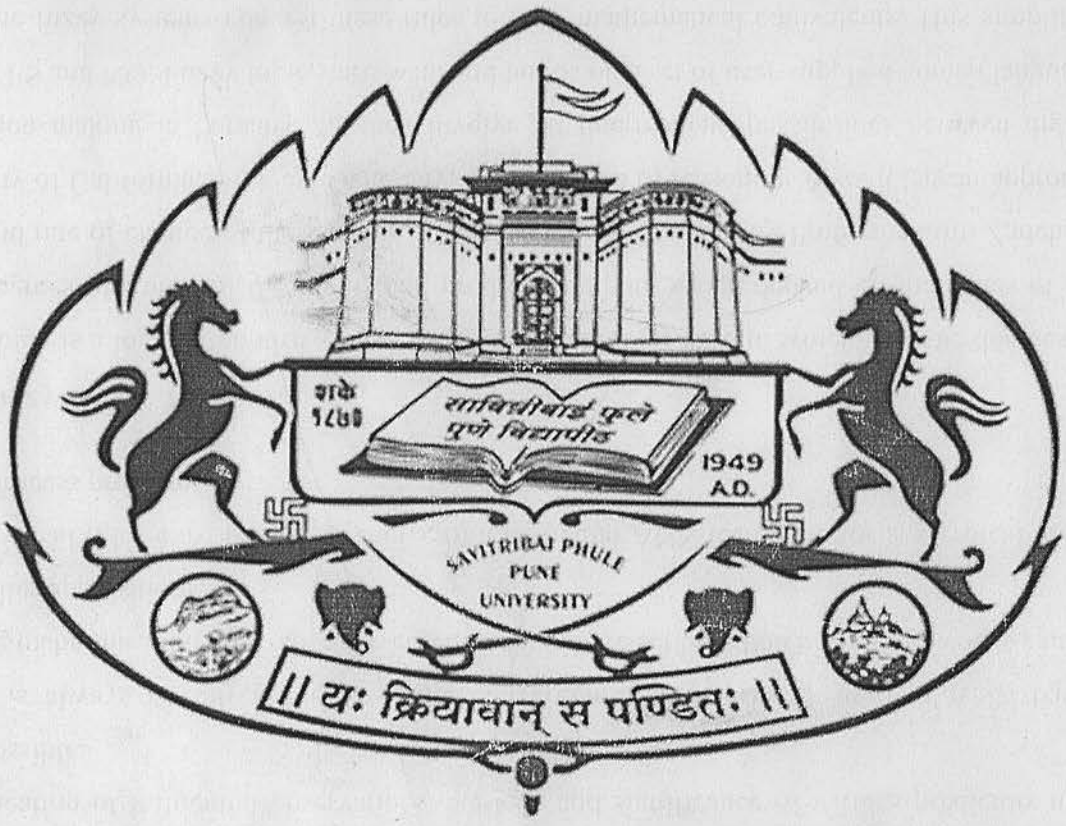
SE MECH 2020-21
& 2021-22

Savitribai Phule Pune University
Faculty of Science & Technology



Curriculum/Syllabus
for
Second Year
Bachelor of Engineering
(Choice Based Credit System)
Mechanical Engineering and Automobile Engineering
(2019 Course)

Board of Studies - Automobile and Mechanical Engineering
(With Effect from Academic Year 2020-21)

Savitribai Phule Pune University

Board of Studies - Automobile and Mechanical Engineering

Undergraduate Program - Automobile Engineering & Mechanical Engineering (2019 pattern)

Course Code	Course Name	Teaching Scheme (Hours/ Week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	TOTAL	TH	PR	TUT	TOTAL
Semester-III														
202041	Solid Mechanics	4	2	-	30	70	-	50	-	150	4	1	-	5
202042	Solid Modeling and Drafting	3	2	-	30	70	-	50	-	150	3	1	-	4
202043	Engineering Thermodynamics	3	2	-	30	70	-	-	25	125	3	1	-	4
202044	Engineering Materials and Metallurgy	3	2	-	30	70	25	-	-	125	3	1	-	4
203156	Electrical and Electronics Engineering	3	2	-	30	70	25	-	-	125	3	1	-	4
202045	Geometric Dimensioning and Tolerancing Lab	-	2	-	-	-	25	-	-	25	-	1	-	1
202046	Audit Course - III	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**16**	**12**	**-**	**150**	**350**	**75**	**100**	**25**	**700**	**16**	**6**	**-**	**22**
Semester-IV														
207002	Engineering Mathematics - III	3	-	1	30	70	25	-	-	125	3	-	1	4
202047	Kinematics of Machinery	3	2	-	30	70	-	-	25	125	3	1	-	4
202048	Applied Thermodynamics	3	2	-	30	70	-	-	25	125	3	1	-	4
202049	Fluid Mechanics	3	2	-	30	70	-	-	25	125	3	1	-	4
202050	Manufacturing Processes	3	-	-	30	70	-	-	-	100	3	-	-	3
202051	Machine Shop	-	2	-	-	-	50	-	-	50	-	1	-	1
202052	Project Based Learning - II	-	4	-	-	-	50	-	-	50	-	2		2
202053	Audit Course - IV	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**12**	**1**	**150**	**350**	**125**	**-**	**75**	**700**	**15**	**6**	**1**	**22**

Abbreviations: TH: Theory, **PR**: Practical, **TUT**: Tutorial, **ISE**: In-Semester Exam, **ESE**: End-Semester Exam,**TW**: Term Work, OR: Oral

Note: Interested students of SE (Automobile Engineering and Mechanical Engineering) can opt for any one of the audit course from the list of audit courses prescribed by BoS (Automobile and Mechanical Engineering)

Instructions

- Practical/Tutorial must be conducted in three batches per division only.
- Minimum number of required Experiments/Assignments in PR/ Tutorial shall be carried out as mentioned in the syllabi of respective subjects.
- Assessment of tutorial work has to be carried out as a term-work examination. Term-work Examination at second year of engineering course shall be internal continuous assessment only.
- Project based learning (PBL) requires continuous mentoring by faculty throughout the semester for successful completion of the tasks selected by the students per batch. While assigning the teaching workload of 2 Hrs/week/batch needs to be considered for the faculty involved. The Batch needs to be divided into sub-groups of 5 to 6 students. Assignments / activities / models/ projects etc. under project based learning is carried throughout semester and Credit for PBL has to be awarded on the basis of internal continuous assessment and evaluation at the end of semester.
- Audit course is mandatory but non-credit course. Examination has to be conducted at the end of Semesters for award of grade at institute level. Grade awarded for audit course shall not be calculated for grade point & CGPA.

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202041 - Solid Mechanics

Teaching Scheme	Credits	Examination Scheme
Theory : 04 Hr./Week Practical : 02 Hr./Week	05 Theory : 04 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Practical : 50 Marks

Prerequisite Courses

Engineering Mathematics- I and II, Systems in Mechanical Engineering, Engineering Mechanics

Course Objectives

1. To acquire basic knowledge of stress, strain due to various types of loading.
2. To draw Shear Force and Bending Moment Diagram for transverse loading.
3. To determine Bending, Shear stress, Slope and Deflection on Beam.
4. To solve problems of Torsional shear stress for shaft and Buckling for the column.
5. To apply the concept of Principal Stresses and Theories of Failure.
6. To utilize the concepts of Solid Mechanics on application based combined mode of loading.

Course Outcomes

On completion of the course, learner will be able to

CO1. DEFINE various types of stresses and strain developed on determinate and indeterminate members.

CO2. DRAW Shear force and bending moment diagram for various types of transverse loading and support.

CO3. COMPUTE the slope & deflection, bending stresses and shear stresses on a beam.

CO4. CALCULATE torsional shear stress in shaft and buckling on the column.

CO5. APPLY the concept of principal stresses and theories of failure to determine stresses on a 2-D element.

CO6. UTILIZE the concepts of SFD & BMD, torsion and principal stresses to solve combined loading application based problems.

Course Contents

Unit I **Simple stresses & strains** **[10 Hr.]**

Simple Stress & Strain: Introduction to types of loads (Static, Dynamic & Impact Loading) and various types of stresses with applications, Hooke's law, Poisson's ratio, Modulus of Elasticity, Modulus of Rigidity, Bulk Modulus. Interrelation between elastic constants, Stress-strain diagram for ductile and brittle materials, factor of safety, Stresses and strains in determinate and indeterminate beam, homogeneous and composite bars under concentrated loads and self-weight, Thermal stresses in plain and composite members

Unit II **Shear Force & Bending Moment Diagrams** **[08 Hr.]**

SFD & BMD: Introduction to SFD, BMD with application, SFD & BMD for statically determinate beam due to concentrated load, uniformly distributed load, uniformly varying load, couple and combined loading, Relationship between rate of loading, shear force and bending moment, Concept of zero shear force, Maximum bending moment, point of contra-flexure

Unit III **Stresses, Slope & Deflection on Beams** **[12 Hr.]**

Bending Stress on a Beam: Introduction to bending stress on a beam with application, Theory of Simple bending, assumptions in pure bending, derivation of flexural formula, Moment of inertia of common cross section (Circular, Hollow circular, Rectangular, I & T), Bending stress distribution along the same cross-section

Shear Stress on a Beam: Introduction to transverse shear stress on a beam with application, shear stress distribution diagram along the Circular, Hollow circular, Rectangular, I & T cross-section

Slope & Deflection on a Beam: Introduction to slope & deflection on a beam with application, slope, deflection and Radius of Curvature, Macaulay's Method, Slope and Deflection for all standard beams

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Unit IV	Torsion, Buckling	[08 Hr.]

Torsion of circular shafts: Introduction to torsion on a shaft with application, Basic torsion formulae and assumption in torsion theory, Torsion in stepped and composite shafts, Torque transmission on strength and rigidity basis, Torsional Resilience

Torsion on Thin-Walled Tubes: Introduction of Torsion on Thin-Walled Tubes Shaft and its application

Buckling of columns: Introduction to buckling of column with its application, Different column conditions and critical, safe load determination by Euler's theory. Limitations of Euler's Theory

Unit V	Principal Stresses, Theories of Failure	[08 Hr.]

Principal Stresses: Introduction to principal stresses with application, Transformation of Plane Stress, Principal Stresses and planes (Analytical method and Mohr's Circle), Stresses due to combined Normal and Shear stresses

Theories of Elastic failure: Introduction to theories of failure with application, Maximum principal stress theory, Maximum shear stress theory, Maximum distortion energy theory, Maximum principal strain theory, Maximum strain energy theory

Unit VI	Application based combined loading & stresses (Based on load and stress condition studied in Unit I to Unit V)	[08 Hr.]

Introduction to the Combined Loading and various stresses with application, Free Body Diagram and condition of Equilibrium for determining internal reaction forces, couples for 2-D system, Combined stresses at any cross-section or at any particular point for Industrial and Real life example for the following cases: Combined problem of Normal type of Stresses (Tensile, Compressive and Bending stress), Combined problem of Shear type of stresses (Direct and Torsional Shear stresses), Combined problem of Normal and Shear type of Stresses

Books & Other Resources

Text Books

1. R. K. Bansal, "Strength of Materials", Laxmi Publication
2. S. Ramamurtham, "Strength of material", Dhanpat Rai Publication
3. S.S. Rattan, "Strength of Material", Tata McGraw Hill Publication Co. Ltd.
4. B.K. Sarkar, "Strength of Material", McGraw Hill New Delhi
5. Singer and Pytel, "Strength of materials", Harper and row Publication
6. R. C. Hibbeler, "Mechanics of Materials", Prentice Hall Publication

Reference Books

1. Egor. P. Popov, "Introduction to Mechanics of Solids",Prentice Hall Publication
2. G. H. Ryder, "Strength of Materials", Macmillan Publication
3. Beer and Johnston, "Strength of materials", CBS Publication
4. James M. Gere, "Mechanics of Materials", CL Engineering
5. Timoshenko and Young, "Strength of Materials", CBS Publication, Singapore
6. Prof. S.K. Bhattacharyya, IIT Kharagpur , "NPTEL Web course material" https://drive.google.com/file/d/1N2Eyv9ofPimIT2OSMZeMrSxe68Ulclei/view?usp=sharing

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

The Termwork shall consist of completion of Practicals, Self-learning Study Assignments and Presentations. Practical examination shall be based on the Termwork undertaken during the semester.

Practical *(Any 6 experiments out of experiment no 1 to 8 from the following list whereas experiment no. 9 and 10 are mandatory. Minimum One experiment must be performed on IoT platform- Virtual Lab)*:

1. Tension test for Ductile material using extensometer on Universal Testing Machine.
2. Compression test for Brittle material on Universal Testing Machine.
3. Shear test of ductile material on Universal Testing Machine.
4. Tension test of Plastic/Composite material on low load capacity Tensile Testing Machine.
5. Measurement of stresses and strains using strain gauges.

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6. Experimental verification of flexural formula in bending for cantilever, Simple supported beam.
7. Study and interpretations of stress distribution pattern using Polariscope for Plastic/Acrylic.
8. Experimental verification of torsion formula for circular bar.
9. Verification of results of any two from experiments no 1-8 using any FEA software tools.
10. **Self-learning study practical**: *Following topics are distributed among the group of 3-5 Students and groups need to present and also submit the slides/poster on TW file.*
    a. Experimental stress analysis, Strain Gauges rosette with case study.
    b. Residual stresses and Fatigue life with case study.
    c. Effect of heat treatment on the mechanical properties of a metal with case study.
    d. Mechanical properties of materials, Stresses and Design of components with case study.
    e. Failure Mode Analysis and Stresses with case study.

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202042 - Solid Modeling and Drafting		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week Practical : 02 Hr./Week	**04** Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Practical : 50 Marks

Prerequisite Courses

Systems in Mechanical Engineering, Engineering Graphics, Engineering Mathematics - I and II

Course Objectives

1. To understand basic structure of CAD systems and their use to create geometric models of simple engineering parts
2. To introduce the curves and surfaces and their implement in geometric modeling
3. To apply basic concepts of 3D modeling, viewing and evaluate mass properties of components and assemblies
4. To apply geometrical transformations in CAD models
5. To understand data exchange standards and translators for various applications
6. To create engineering drawings, design documentation and use in manufacturing activities

Course Outcomes

On completion of the course, learner will be able to

CO1. UNDERSTAND basic concepts of CAD system, need and scope in Product Lifecycle Management

CO2. UTILIZE knowledge of curves and surfacing features and methods to create complex solid geometry

CO3. CONSTRUCT solid models, assemblies using various modeling techniques & PERFORM mass property analysis, including creating and using a coordinate system

CO4. APPLY geometric transformations to simple 2D geometries

CO5. USE CAD model data for various CAD based engineering applications viz. production drawings, 3D printing, FEA, CFD, MBD, CAE, CAM, etc.

CO6. USE PMI & MBD approach for communication

Course Contents

Unit I **Fundamentals of 3D Modeling** **[08 Hr.]**

Introduction, Product Life Cycle, CAD tools in the design process of Product Cycle, Scope of CAD, Software Modules - Operating System (OS) module, Geometric module, application module, programming module, communication module, Computer Aided Design - Features, requirements and applications

3D Modeling approach - Primitive, Features and Sketching, Types of Geometric models - 2½ extrusions, axisymmetric, composite, 3D objects, difference between wireframe, surface & solid modeling, Modeling strategies

Model viewing: VRML web-based viewing

Unit II **Curves & Surfaces** **[08 Hr.]**

Curves: Methods of defining Point, Line and Circle, Curve representation - Cartesian and Parametric space, Analytical and Synthetic curves, Parametric equation of line, circle, ellipse, Continuity (C^0, C^1 & C^2), Synthetic Curves - Hermit Cubic Spline, Bezier, B-Spline Curve, Non-Uniform Rational B-Spline curves (NURBS)

Surfaces: Surface representation, Types of Surfaces, Bezier, B-Spline, NURBS Surface, Coons patch surface, Surface Modeling

Reverse Engineering: Introduction, Point Cloud Data (PCD), PCD file formats, Quality issues in PCD, Requirements for conversion of surface models into solid models, Applications of PCD

Unit III **Solid Modeling** **[08 Hr.]**

Introduction, Geometry and Topology, Solid entities, Solid representation, Fundamentals of Solid modeling, Half spaces, Boundary representation (B-Rep), Constructive Solid Geometry (CSG), Sweep representation, Analytical solid modeling, Parametric solid modeling, feature based modeling,

etc., Euler Equation (Validity of 3D solids), Mass Property Calculations

Introduction to Assembly Modeling, Assemblies (Top-down and Bottom-up approach), Design for Manufacturing [DFM], Design for Easy Assembly & Disassembly [DFA], Design for Safety

Unit IV **Geometric Transformation** **[08 Hr.]**

Introduction, Geometric Transformations, Translation, Scaling, Rotation, Reflection/Mirror, Shear, Homogeneous Transformation, Inverse Transformation, Concatenated Transformation (limited to 2D objects with maximum 3 points only), Coordinate systems - Model (MCS), Working (WCS), Screen (SCS) coordinate system, Mapping of coordinate systems

Projections of geometric models - Orthographic and Perspective projections, Design and Engineering applications

Unit V **CAD Data Exchange** **[08 Hr.]**

Introduction, CAD Kernels, CAD Data File, Data interoperability, CAD Data Conversions, challenges in CAD data conversions/remedies, Direct Data Translators, Neutral 3D CAD file formats (DXF, IGES, PDES, STEP, ACIS, Parasolid, STL, etc.), Data Quality

Requirements of CAD file format for 3D Printing (Additive Manufacturing), CAE, FEA, CFD, CAM (Subtractive Manufacturing), Multi-Body Dynamics (Motion Simulations), Computer Aided Inspection (CAI), Computer Aided Technologies (CAx), AR/VR applications, etc., Introduction to CAD Geometry Clean-up for different applications

Unit VI **CAD Customization & Automation** **[08 Hr.]**

Introduction, Limitations of 2D drawings, Introduction to Product and Manufacturing Information (PMI), Model Based Definitions (MBD), Applications of PMI & MBD

CAD Customization: Introduction, advantages and disadvantages, Applications of Customization Interfaces, Product Customization Approaches - Part Modeling Customization, Assembly Modeling Customization, Drawing sheets & PMI Customization, CAD Automation

Introduction to Application Programming Interface (API), Structures of APIs, Coding/Scripting for customization, Introduction to CAD API Development, CAD Files & application handling

Books & Other Resources

Text Books

1. Zeid, I and Sivasubramania, R., (2009), "CAD/CAM : Theory and Practice", 2nd edition, McGraw Hill Education, ISBN-13: 978-0070151345
2. Rao, P. N., (2017), "CAD/CAM: Principles and Applications", 3rd edition, McGraw Hill Education, ISBN-13: 978-0070681934
3. Chang, Kuang-Hua, (2015), "e-Design: Computer-Aided Engineering Design", Academic Press, ISBN-13: 978-0123820389

Reference Books

1. Lee, Kunwoo, (1999), "Principles of CAD/CAM/CAE Systems", Pearson/Addison-Wesley, ISBN-13: 978-0201380361
2. Bordegoni, Monica and Rizzi, Caterina, (2011), "Innovation in Product Design: From CAD to Virtual Prototyping", Springer, ISBN-13: 978-1447161875
3. Vukašinovic, Nikola and Duhovnik, Jože, (2019), "Advanced CAD Modeling: Explicit, Parametric, Free-Form CAD and Re-engineering", Springer, ISBN-13: 978-3030023980
4. Um, Dugan, (2018), "Solid Modeling and Applications: Rapid Prototyping, CAD and CAE Theory", 2nd edition, Springer, ISBN-13: 978-3319745930
5. Rogers, D. and Adams, J. A., (2017), "Mathematical Elements for Computer Graphics", 2nd edition, McGraw Hill Education, ISBN-13: 978-0070486775
6. Hearn, D. D. and Baker, M. P., (2013), "Computer Graphics with OpenGL", 4th edition, Pearson Education India, ISBN-13: 978-9332518711
7. Gokhale, N. S., Deshpande, S. S., Bedekar, S. V. and Thite, A. N., (2008), "Practical Finite Element Analysis", Finite to Infinite, Pune, India, ISBN-13: 978-8190619509
8. Lee Ambrosius, (2015), "AutoCAD® Platform Customization: User Interface, AutoLISP®, VBA, and Beyond", John Wiley & Sons, Inc., IN, ISBN-13: 978-1118798904

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9. Bucalo, Joe and Bucalo, Neil, (2007), "Customizing SolidWorks for Greater Productivity", Sheet Metal Guy, LLC, ISBN-13: 978-0979566608
10. Ziethen, Dieter R. (2012), "CATIA V5: Macro Programming with Visual Basic Script", McGraw-Hill Companies, Inc./Carl Hanser Verlag München, ISBN-13: 978-0071800020, ISBN: 978-007180003-7
11. Programming Manuals of Softwares

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work Journal

Practical

The student shall complete the following Practical in laboratory using suitable CAD modeling software. Learner will demonstrate skills to communicate drawings as per industry standards.

1. 2-D sketching with geometrical and dimensional constraints
2. Solid & Surface modeling for simple mechanical components (Output file as Production drawing and Model Based Definition (MBD)
   (a) Sheet-Metal (b) Machining
   (c) Fabrication (d) Casting
   (e) Forgings (f) Plastic Molding
3. Assembly modeling (Output file as Assembly drawing and detailing) of the parts modeled in Practical assignment-2 using proper assembly constraint conditions and generation of exploded view for assemblies like Couplings, Clutches, Gear Assemblies, Engine/Pump/Turbine Components, Valves, Machine Tools, Automobile Components, Gear-Box, Pressure Vessels, etc.
4. Reverse Engineering of surface/solid modeling using Point Cloud Data.
5. Assembly Modeling by importing parts/components from free online resources like CAD and Product development software websites, forums, blogs, etc.
6. Demonstration on CAD Customization (with introduction to programming languages, interfacing)

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202043 - Engineering Thermodynamics

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Oral : 25 Marks

Prerequisite Courses

Higher Secondary Science courses, Engineering Mathematics - I and II, Engineering Physics, Engineering Chemistry

Course Objectives

1. To introduce the fundamentals of thermodynamics.
2. To understand the concepts of laws of thermodynamics.
3. To apply the concepts of thermodynamics towards open and closed systems.
4. To be acquainted with Entropy generation and Exergy Analysis.
5. To understand the behaviour of a Pure substance and to analyze Vapour power cycles.
6. To undertake the performance analysis of a steam generator.

Course Outcomes

On completion of the course, learner will be able to

CO1. DESCRIBE the basics of thermodynamics with heat and work interactions.
CO2. APPLY laws of thermodynamics to steady flow and non-flow processes.
CO3. APPLY entropy, available and non available energy for an Open and Closed System,
CO4. DETERMINE the properties of steam and their effect on performance of vapour power cycle.
CO5. ANALYSE the fuel combustion process and products of combustion.
CO6. SELECT various instrumentations required for safe and efficient operation of steam generator.

Course Contents

Unit I **Fundamentals of Thermodynamics** **[07 Hr.]**

Introduction, Review of basic definitions, Zeroth law of Thermodynamics, Macro and Microscopic Approach, State Postulate, State, Path, Process and Cycles, Point function and Path function, quasi static process, Equilibrium, **Temperature** (concepts, scales, international fixed points and measurement of temperature), Constant volume gas thermometer and constant pressure gas thermometer, mercury in glass thermometer.

First Law of Thermodynamics: Concept of heat and work, Sign convention and its conversion. First law of thermodynamics, Joules experiments, Equivalence of heat and work. Application of first law to flow and non-flow Processes and Cycles. Steady flow energy equation (SFEE), Applications of SFEE to various devices such as Nozzle, Turbine, Compressors, Boilers etc. PMM-I kind.

Unit II **Ideal Gas and Second law of Thermodynamics** **[08 Hr.]**

Properties and Processes of Ideal Gas: Ideal Gas definition, Gas Laws: Boyle's law, Charle's law, Avagadro's Law, Equation of State, Ideal Gas constant and Universal Gas constant, Ideal gas Processes- on P-v and T-s diagrams, Constant Pressure, Constant Volume, Isothermal, Adiabatic, Polytropic, Throttling Processes (Open and Closed systems), Calculations of Heat transfer, Work done, Internal Energy.

Second Law of Thermodynamics: Limitations of first law of thermodynamics, Thermal reservoir, Heat Engine, Refrigerator and Heat pump: Schematic representation, Efficiency and Coefficient of Performance (COP), Kelvin-Planck & Clausius Statement of the Second law of Thermodynamics; PMM-II kind, Equivalence of the two statements; Clausius Inequality, Concept of Reversibility and Irreversibility, Carnot Theorem/Principles, Carnot Cycle.

Unit III **Entropy and Availability** **[08 Hr.]**

Entropy: Entropy as a property, Clausius Inequality, Principle of increase of Entropy Principle, Entropy changes for an Open and Closed System, Change of Entropy for an ideal gas and Pure Substance, Concept of Entropy generation. Entropy - a measure of Disorder.

Availability: Available and Unavailable Energy, Concept of Availability, Availability of heat source at constant temperature and variable temperature, Availability of non-flow and steady-flow Systems.

Unit IV **Properties of Pure substances & Thermodynamics of Vapour Cycle** **[07 Hr.]**

Properties of Pure substances: Formation of steam, Phase changes, Properties of steam, Use of Steam Tables, Study of P-v, T-s and h-s plots (Mollier Chart) for steam, Dryness fraction and its determination, Study of steam calorimeters (Barrel, Separating, Throttling and combined) Non-flow and Steady flow Vapour Processes, Change of Properties, Work and Heat transfer.

Thermodynamics of Vapour Cycle: Rankine Cycle, Comparison of Carnot cycle and Rankine cycle, Introduction to Steam power Plant, Efficiency of Rankine Cycle, Relative Efficiency, Effect of Varying operating parameters like Superheat, Boiler and Condenser Pressure on performance of Rankine cycle, Modified Rankine Cycle.

Unit V **Fuels and Combustion** **[07 Hr.]**

Types of fuels, Proximate and ultimate analysis of fuel, Combustion theory, Combustion Equations, Theoretical and Excess air requirements, Equivalence ratio, Analysis of products of combustion, Calorific value - HCV & LCV. Bomb and Boys gas Calorimeters. Flue Gas Analysis using Orsat Apparatus, Exhaust Gas analyser, Enthalpy of formation, Adiabatic flame temperature.

Unit VI **Steam Generators & Boiler Draught** **[08 Hr.]**

Steam Generators: Classification, Constructional details of low pressure boilers, Primary Features of high pressure (Power) boilers, Location, Construction and working principle of boiler, Boiler mountings and accessories, Instrumentations required for safe and efficient operation, Introduction to IBR Act, Boiler performance Calculations-Equivalent Evaporation, Boiler efficiency, Heat balance Sheet.

Boiler Draught: Classification, Necessity of Draught, Natural draught, Determination of Height of chimney, Diameter of chimney, condition for maximum discharge, Forced draught, Induced draught, Balanced draught, Draught losses.

Books & Other Resources

Text Books

1. P. K. Nag, "Engineering Thermodynamics", Tata McGraw Hill Publications
2. R. K. Rajput, "Engineering Thermodynamics", EVSS Thermo, Laxmi Publications
3. P. L Ballaney, "Thermal Engineering", Khanna Publishers
4. C.P. Arora, "Thermodynamics", Tata McGraw Hill
5. Domkundwar, Kothandaraman and Domkundwar,"Thermal Engineering",Dhanpat Rai Publishers
6. M M Rathore, "Thermal Engineering", Tata McGraw-Hill

Reference Books

1. Rayner Joel, "Basic Engineering Thermodynamics", AWL-Addison Wesley
2. Cengel and Boles, "Thermodynamics an Engineering Approach", McGraw Hill
3. G.VanWylen, R.Sonntag and C.Borgnakke, "Fundamentals of Classical Thermodynamics", John Wiley & Sons
4. Holman J.P, "Thermodynamics", McGraw Hill
5. M Achuthan, "Engineering Thermodynamics", PHI
6. Steam Tables/Data book

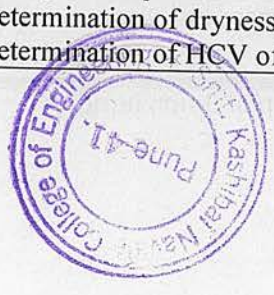
Guidelines for Laboratory Conduction

The student shall complete the following activity as Term Work

The Term work shall consist of successful completion of Practicals, and Industrial Visits. Oral Examination shall be based on the term work.

Practical

1. Joule's experiment to validate, first law of thermodynamics.
2. Survey of temperature sensors used in various thermal systems.
3. Determination of dryness fraction of steam using combined separating and throttling calorimeter.
4. Determination of HCV of solid or gaseous fuel using Bomb or Junker's calorimeter respectively.



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of Engineering, Pune - 41.

5. Demonstration on Orsat Apparatus.
6. Trial on boiler to determine boiler efficiency, equivalent evaporation and Energy Balance.
7. Thermodynamic Analysis of any System / Model by using any Computer Software.
8. Energy and Exergy analysis of contemporary steam generator.

Industrial Visits

Visit to any Process Industry/Plant having Boiler equipped with Accessories.

The visit report consists of

- Details about the Industry/Process Plant.
- Operational description of the Equipment with specification, its use, capacity, application etc.

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202044 - Engineering Materials and Metallurgy

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Term Work : 25 Marks

Prerequisite Courses

Higher Secondary Science courses, Engineering Physics, Engineering Chemistry, Systems in Mechanical Engineering

Course Objectives

1. To impart fundamental knowledge of material science and engineering.
2. To establish significance of structure property relationship.
3. To explain various characterization techniques.
4. To indicate the importance of heat treatment on structure and properties of materials.
5. To explain the material selection process.

Course Outcomes

On completion of the course, learner will be able to

CO1. COMPARE crystal structures and ASSESS different lattice parameters.

CO2. CORRELATE crystal structures and imperfections in crystals with mechanical behaviour of materials.

CO3. DIFFERENTIATE and DETERMINE mechanical properties using destructive and non-destructive testing of materials.

CO4. IDENTIFY & ESTIMATE different parameters of the system viz., phases, variables, component, grains, grain boundary, and degree of freedom. etc.

CO5. ANALYSE effect of alloying element & heat treatment on properties of ferrous & nonferrous alloy.

CO6. SELECT appropriate materials for various applications.

Course Contents

Unit I **Crystal Structures and Deformation of Materials** **[08 Hr.]**

Crystal Structures: Study of Crystal structures BCC, FCC, HCP and lattice parameters & properties, Miller indices, Crystal imperfections, and Diffusion Mechanisms

Material Properties: Mechanical (Impact, hardness, etc.), Electrical, optical and Magnetic properties

Deformation of Materials: Elastic deformation, Plastic deformation: slip, twinning, work hardening, baushinger effect, recovery, re-crystallization and grain growth, Fracture: Types of fractures (brittle, ductile), Creep & Fatigue failures

Unit II **Material Testing and Characterization Techniques** **[06 Hr.]**

Destructive Testing: Impact test, Cupping test and Hardness test

Non-Destructive Testing: Eddy current test, Sonic & Ultrasonic testing, X-ray Radiography testing (Principle and Applications only)

Microscopic Techniques: Sample Preparation and etching procedure, optical microscopy, Electronic microscopy - only SEM, TEM and X-ray diffraction (Principle and Applications only)

Macroscopy: Sulphur printing, flow line observation, spark test

Unit III **Phase Diagrams and Iron-Carbon Diagram** **[09 Hr.]**

Solid solutions: Introduction, Types, Humerothery rule for substitutional solid solutions

Solidification: Nucleation & crystal growth, solidification of pure metals, solidification of alloys.

Phase Diagrams: Cooling curves, types of phase diagrams, Gibbs phase rules

Iron-Carbon Diagram: Iron-carbon equilibrium diagrams in detail with emphasis in the invariant reactions

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Unit IV	Heat Treatments	[08 Hr.]

Austenite transformation in steel: Time temperature transformation diagrams, continuous cooling transformation diagrams. Retained austenite and its effect

Steps in Heat treatment and Cooling Medium

Heat Treatment Processes: Introduction, Annealing (Full annealing, Process annealing, Spheroidise annealing, isothermal annealing, stress relief annealing), Normalising, Hardening, Tempering, Austempering, Martempering, Sub-Zero Treatment, Hardenability

Surface Hardening: Classification, Flame hardening, Induction hardening, Carburising, Nitriding, Carbonitriding

Unit V	Ferrous Materials	[07 Hr.]

Carbon Steel: Classification, types & their composition, properties and Industrial application

Alloy Steels: Classification of alloy steels & Effect of alloying elements, examples of alloy steels, (Stainless steel, Tool steel) sensitization of stainless steel

Designation of carbon steel and alloy steels as per IS, AISI, SAE Standards

Cast Iron: Classification, types & their composition, properties and Industrial application of (White CI, Gray CI, SG CI, Malleable Cast and alloy Cast Iron)

Microstructure and property relationship of various ferrous Materials

Unit VI	Non-Ferrous Materials	[07 Hr.]

Classification of Non-Ferrous Metals: Study of Non-ferrous alloys with Designation, Composition, Microstructure

Mechanical & other properties for Industrial Applications: Copper and its Alloys (Gilding Metal, Cartridge Brass, Muntz Metal, Tin Bronze, Beryllium Bronze), Aluminium and its Alloy (LM5, Duralumin, Y-Alloy, Hinduminum), Nickel and its Alloys (Invar, Inconel), Titanium and its Alloys (α Alloys, α-β Alloys), Cobalt and its Alloys (Stellite Alloys, Alnico), Bearing Alloys (Classification, lead based alloys, tin based alloys), Age Hardening

Microstructure and Property relationship of various Non-ferrous Materials

Recent Material used in Additive Manufacturing: Properties, Composition and Application only

Books & Other Resources

Text Books

1. Dr. V. D. Kodgire & S. V. Kodgire, "Material Science & Metallurgy For Engineers", Everest Publication.
2. William D. Callister, "Materials Science and Engineering an Introduction", Jr, John Wiley & Sons, Inc.

Reference Books

1. A. K. Bhargava, C.P. Sharma, "Mechanical Behaviour & Testing of Materials", P H I Learning Private Ltd.
2. Raghvan V., "Material Science & Engineering",Prentice Hall of India, New Delhi. 2003
3. Avner, S.H., "Introduction to Physical Metallurgy", Tata McGraw-Hill, 1997.
4. Higgins R. A., "Engineering Metallurgy", Viva books Pvt. Ltd.
5. George Ellwood Dieter, "Mechanical Metallurgy", McGraw-Hill 1988
6. Smith, W.F, Hashemi, J., and Prakash, R., "Materials Science and Engineering in SI Units", Tata McGraw Hill Education Pvt. Ltd.

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work Journal

Total 10 experiments from the following list must be performed. Term Work of the Student is evaluated based on the completion of Practical, Assignments, and Industrial Visits.

Practical *(Any Seven)*

1. Destructive testing - Hardness testing (Rockwell/Vickers) Hardness conversion number
2. Brinell and Poldi hardness Test

3. Impact Test for Steel, Aluminum, Brass and Copper (Charpy/Izod)
4. Non Destructive testing - Dye Penetrant Test/ Magnetic Particle test/ Ultrasonic Test
5. Steps for Specimen Preparation for microscopic examination & Demonstration of Optical Metallurgical microscope
6. Observation and Drawing of Microstructure of Steels, Cast Iron of various compositions
7. Observation and Drawing of Microstructure of Non Ferrous Metals of various compositions
8. Heat Treatment of steels based on relative hardness
9. Jominy End Quench Test for hardenability

Miniature commitment or Assignments *(Any Two)*

1. Exploration of engineering Alloy (Name, composition, properties, microstructure, Heat treatment, Designation & specific applications)- One student one Alloy or material
2. Examine aspects of component form material and manufacturing process point of view (Name, Material, Drawing, Manufacturing Process, properties, microstructure, Heat treatment, & specific applications) - For example spur gear, Needle etc. One student one component
3. Creep and Fatigue Test (Virtual Lab IIT Bombay)
4. Fluorescence Microscope (Virtual Lab IIT Bombay)

Industrial Visits

To provide awareness and understanding of the course, Compulsory Industrial Visit must be arranged for the students.

The Industrial Visit must be preferably to

- Material & Metallurgy related like Engineering Cluster, NDT Lab, and Nearby NABL lab or
- Any manufacturing unit with material orientation

Student must submit a properly documented Industrial Visit Report.

Guidelines for Instructor's Manual

The Instructor's Manual should contain following related to every experiment:

1. Brief theory related to the experiment
2. Apparatus with their detailed specifications
3. Standard ASME/ IS numbers of test procedure
4. Schematic, Layout/diagram
5. Observation table/graphs.
6. Sample calculations for one/two reading
7. Result table, Graph and Conclusions.
8. 3/4 questions related to the experiment
9. Relevance of practical in industry with recent software of image analysis

Guidelines for Student's Lab Journal

The Student's Lab Journal should contain following related to every experiment:

1. Theory related to the experiment
2. Apparatus with their detailed specifications
3. Schematic, Layout/diagram
4. Observation table/simulation plots/graphs
5. Sample calculations for one/two reading
6. Result table. Graph and Conclusions
7. 3/4 questions related to the experiment
8. Attach Photo of experiment or image related to Experiment

Guidelines for Lab/TW Assessment

1. There should be continuous assessment for the TW
2. Assessment must be based on understanding of theory, attentiveness during practical, and understanding
3. Session, how efficiently the student is able to do connections and get the results
4. Online evolutions of practical with objective type of Questions
5. Timely submission of journal

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203156 - Electrical and Electronics Engineering

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Term Work : 25 Marks

Prerequisite Courses

Basic Electrical Engineering, Basic Electronics Engineering, Systems in Mechanical Engineering

Course Objectives

1. To understand Arduino IDE; an open source platform and its basic programming features
2. To interface Atmega328 based Arduino board with different devices and sensors
3. To study principle of operation of DC machines and speed control of DC motors
4. To know about three phase induction motor working and its applications
5. To get acquainted with Electric Vehicle (EV) technology and subsystems
6. To get familiar with various energy storage devices and electrical drives

Course Outcomes

On completion of the course, learner will be able to

CO1. APPLY programming concepts to UNDERSTAND role of Microprocessor and Microcontroller in embedded systems

CO2. DEVELOP interfacing of different types of sensors and other hardware devices with Atmega328 based Arduino Board

CO3. UNDERSTAND the operation of DC motor, its speed control methods and braking

CO4. DISTINGUISH between types of three phase induction motor and its characteristic features

CO5. EXPLAIN about emerging technology of Electric Vehicle (EV) and its modular subsystems

CO6. CHOOSE energy storage devices and electrical drives for EVs

Course Contents

Unit I **Introduction to Arduino** **[08 Hr.]**

Introduction to microcontroller and microprocessors, role of embedded systems, open source embedded platforms, Introduction to Arduino IDE- features, IDE overview, Programming concepts: variables, functions, conditional statements, Concept of GPIO in Atmega328 based Arduino board, digital input and output

Unit II **Peripheral Interface** **[07 Hr.]**

Interfacing of Atmega328 based Arduino board with LED and LCD/serial monitor, serial communication using Arduino IDE, Concept of ADC in Atmega328 based Arduino board, interfacing of Atmega328 based Arduino board with temperature sensor (LM35), LVDT, strain gauge

Unit III **DC Machines** **[08 Hr.]**

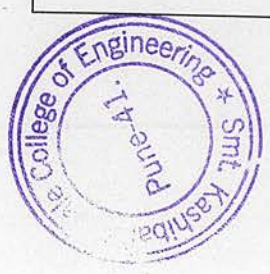
Generating and motoring action, Constructional features of a DC machine, EMF equation of DC machine and its significance in motor

Concept of torque developed by motor and it's equation, Concept of load torque, Types of loads and dynamics of motor and load combination, Characteristics of DC shunt motor, Speed control methods of DC shunt motor, Reversal of direction of rotation of DC motor, Braking in DC motor and its types, Regenerative braking in DC shunt motor

Unit IV **Three Phase Induction Motors** **[07 Hr.]**

Constructional features, working principle of three phase induction motor, types, torque equation, torque-slip characteristics, effect of rotor resistance on characteristics, modification in squirrel cage motor with deep bar rotor construction

Power stages, efficiency, starters (DOL starter and Star Delta starter), Methods of speed control-voltage and frequency control, variable frequency drive, applications



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Unit V	Electric Vehicle (EV) Technology	[08 Hr.]

Brief history of Electric Vehicle (EV), Components of EV, Benefits of EV

Types of EVs such as Battery EV, Hybrid EV, Plug-in EV, Fuel Cell EV and their comparison, Challenges faced by EV technology

Subsystems and configurations of EV, Subsystems of Hybrid EV, Configurations of series, parallel and series-parallel Hybrid EV

Impact of EV on grid, Vehicle to grid technology- block diagram

Unit VI	Energy Storage Devices and Electric Drives	[07 Hr.]

Storage Devices: Cell construction and working of batteries like Lithium- Iron Phosphate (LFP), Lithium Nickel-Manganese-Cobalt (NMC) and Lithium- Manganese Oxide (LMO), Voltage, Impedance, Ah and Wh Capacity, Cycle Life, Energy density, Power, C-rate and safety aspects

Use of supercapacitor and hydrogen fuel cell in EVs- necessity, advantages and specifications

Factors used in selection of energy storage device in case of EVs, Vehicle Battery Management System - block diagram

Electric Drives: Factors used for selection of the electric motor in EVs

BLDC hub motor drive for EVs, characteristics and speed control of BLDC motor, three phase induction motor drive for EVs

Books & Other Resources

Text Books

1. Barret Steven F, "Arduino Microcontroller Processing for Everyone!", 3rd Ed, Morgan and Claypool Publishers
2. Michael Margolis, "Arduino Cookbook", 2nd Ed, O'Reilly Media
3. Hughes Edward, "Electrical and Electronic Technology", Pearson Education
4. Ashfaq Husain, "Electric Machines", 3rd Ed, Dhanpat Rai & Sons
5. Bhattacharya S. K., "Electrical Machine", 3rd Ed, Tata McGraw Hill
6. Nagrath & Kothari, "Electrical Machines", Tata McGraw Hill
7. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press
8. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", 2nd Ed, CRC Press

Reference Books

1. Deshmukh Ajay, "Microcontrollers Theory and Applications", Tata McGraw Hill
2. Massimo Banzi, "Getting Started with Arduino", 2nd Ed, Maker Media, Inc.
3. Brad Kendall, "Getting Started With Arduino: A Beginner's Guide", Justin Pot and Angela Alcorn (Editors)
4. Lowe, "Electrical Machines", Nelson Publications
5. [A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, "Electrical Machines", 5th Ed, Tata McGraw Hill
6. Pillai S. K., "A First Course on Electrical Drives", New Age International (P) Ltd.
7. James Larminie, John Lowry, , "Electric Vehicle Technology Explained", Wiley
8. Dhameja Sandeep, "Electric Vehicle Battery Systems", Newnes
9. R. Krishnan,"Permanent Magnet Synchronous and Brushless DC Motor Drives", CRC Press

Web References

1. www.arduino.cc *(for downloading Arduino IDE and information)*
2. www.alldatasheet.com *(for datasheets of components)*
3. https://spoken-tutorial.org/tutorial-search/ *(for video tutorials on Arduino)*
4. https://swayam.gov.in/NPTEL *(for e-learning courses and video lectures)*

Guidelines for Laboratory Conduction
The student shall complete the following activity as a Term Work
Total 10 experiments from the following list must be performed. Term Work of the Student is evaluated based on the completion of Practical, Assignments using Virtual Laboratory & Detailed Industrial Visit Report and Group Assignment using Case Study/Product Survey. **Practical - Electronics Engineering Laboratory** *(Any four experiments to be performed)* Atmega328 based Arduino board can be used for following interfaces: 1. Interfacing of LED to blink after every 1 sec 2. Display data using serial communication with PC 3. Interfacing of LCD to display given message 4. Interfacing of temperature sensor (LM35) and display output on LCD/serial monitor 5. Interfacing of strain gauge sensor to measure parameters like pressure, weight, etc., and display the measured value 6. Interfacing of LVDT sensor to measure the displacement and display the measured value **Practical - Electrical Engineering Laboratory** *(Any four experiments to be performed)* 7. Demonstration of use of starters for DC motor and three phase induction motor along with understanding of specifications on name plates of these machines 8. Brake test on DC shunt motor 9. Study of power electronic converter based DC motor drive 10. Study of electrical braking of DC shunt motor (Rheostatic/ Plugging/regenerative) 11. Load test on three phase induction motor 12. Torque- speed characteristics of three phase induction motor **Assignments using Virtual Laboratory** Virtual Labs project is an initiative of the Ministry of Human Resource Development (MHRD), Government of India under the aegis of National Mission on Education through Information and Communication Technology (NMEICT). Please visit the following link for exploring experiments on Electrical Machines: http://www.vlab.co.in/broad-area-electrical-engineering Assign following experiments by applying Virtual Labs: 1. Speed control of DC shunt motor by armature and field resistance control 2. Speed control of slip ring induction motor by rotor resistance control Please refer http://vlabs.iitb.ac.in/vlabs-dev/vlab_bootcamp/bootcamp/Sadhya/experimentlist.html **Assignments using Case Study/Product Survey** Each group consisting of maximum five number of students should carry out a case study/product survey focused on various EVs available in Indian market. *Forming groups and allotment of specific task to the students group should be done at the beginning of semester so that students get sufficient time to carry out the survey and prepare a presentation.* Students must • Compare various models in each class. • Study various main components of EVs • A formal presentation on case study/product survey must be arranged before class/batch. **Industrial Visits** *An industrial visit must be arranged to one of the following establishments during the semester.* The Industrial Visit must be preferably to • Automation/Manufacturing industries • Battery/EV Charging Stations • Retro-fitting Workshops of ICE vehicle to EVs • EV Service Stations Student must submit properly documented Detailed Industrial Visit Report in his/her own words.
Instructions for Laboratory Conduction
Electronics Engineering Laboratory 1. The instructor is expected to shortlist necessary experiments from the suggested list of experiments.

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of Engineering, Pune - 41.

2. During the practical session the instructor may divide the total students in groups of 4 to 5 students and assign them different experiments.
3. Each student in the group is supposed to execute the program.
4. The faculty should check the result of all the groups.

Electrical Engineering Laboratory

1. Check whether the MCB / ELCB / main switch is off while preparing the set-up.
2. Make connections as per circuit diagram. Use flexible wire for connection of voltmeter and pressure coil connection of wattmeter. For the rest of the connections, use thick wires. Do not keep the connections loose. Get it checked by the faculty / Lab Assistant.
3. Perform the experiment only in presence of faculty or Lab Assistant.
4. Do the calculations and get these checked from the faculty.
5. After completion of experiment, switch off the MCB / ELCB / main switch.
6. Write the experiment in the journal and get it checked regularly after conducting

Guidelines for Instructor's Manual

The Instructor's Manual should contain following related to every experiment:

1. Brief theory related to the experiment.
2. Connection diagram /circuit diagram
3. Observation table
4. Sample calculations for one reading
5. Result table
6. Graph and Conclusions.
7. Data sheets of the ICs used(if any)

Guidelines for Student's Lab Journal

Electronics Engineering Laboratory

1. Title of the program should be mentioned
2. The algorithm of the program must be written
3. Flow Chart for each program has to be drawn on separate page
4. Input data has to be specified
5. Result of the program should be highlighted

Electrical Engineering Laboratory

1. Lab journal should be hand written
2. Circuit diagrams can be drawn on graph paper
3. Specifications of the instruments/machines used for conduction of practical should be mentioned in respective write-up
4. Conclusion of each experiment should be written by student at the end

Guidelines for Lab/TW/PR Assessment

1. Continuous assessment should be carried out time to time.
2. During assessment, faculty should put the remark by writing the word "Complete" and not simply "C". Put the signature along with the date at the end of experiment and also in the index.
3. Assess each laboratory experiment/virtual lab assignment/report of industrial visit/case study for 10 marks each as per following details:
   Attendance in practical - 02 marks
   Timely completion of journal -03 marks
   Presentation of write-up and results - 02 marks
   Depth of understanding - 03 marks
4. Maintain a continuous assessment sheet on the basis of which final TW marks can be offered.

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Assistant Professor & Head
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202045 - Geometric Dimensioning and Tolerancing Lab		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical : 02 Hr./Week	**01** Practical : 01	Term Work : 25 Marks

Prerequisite Courses

Systems in Mechanical Engineering, Project Based Learning - I, Workshop Practise, Engineering Graphics

Course Objectives

1. To understand requirements of industrial drawings
2. To read, understand and explain basic Geometric Dimensioning & Tolerancing concepts
3. To apply various geometric and dimension tolerances based on type of fit
4. To include surface roughness symbols based on manufacturing process
5. To measure and verify position tolerances with applied material conditions
6. To understand requirements for manufacturing and assembly

Course Outcomes

On completion of the course, learner will be able to

CO1. SELECT appropriate IS and ASME standards for drawing
CO2. READ & ANALYSE variety of industrial drawings
CO3. APPLY geometric and dimensional tolerance, surface finish symbols in drawing
CO4. EVALUATE dimensional tolerance based on type of fit, etc.
CO5. SELECT an appropriate manufacturing process using DFM, DFA, etc.

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work Journal

Total 9 Practical Assignments from the following list must be performed. Term Work of the Student is evaluated based on the completion of Practical, Industrial Visit Report and Group Assignment.

Practical *(Assignment # 1 to 6 & 10 are compulsory; Select any Two from Assignment # 7 to 9)*
The student shall complete the following Practical in laboratory. Learner will demonstrate skills to communicate drawings as per industry standards:

1. Study of drawing sheet layout, Principles of Drawing and various IS Standards & Conventions in Machine Drawing, Dimensioning practices - Terminology & Basic Rules, Styles, Conventions [02 Hr.]
2. GD&T -
   (a) Terminology, Maximum and Minimum Material conditions, Features, Rules for GD&T, Datum Control [02 Hr.]
   (b) Adding GD&T to a Design, Form Tolerances [02 Hr.]
   (c) Orientation Tolerances, Profile Tolerances [02 Hr.]
   (d) Location Tolerances, Run out Tolerances [02 Hr.]
3. Surface finish, Welding symbols [02 Hr.]
4. Study and reading of Industrial Drawings to understand standard industrial practices viz. Dimensioning, GD&T, Surface finish, welding symbols, etc. [04 Hr.]
   (a) Machine Drawing, (b) Production Drawing, (c) Part Drawing,
   (d) Assembly Drawing - (i) Assembly Drawing for Design, (ii) Assembly Drawing for Instruction Manuals, (iii) Exploded Assembly Drawing, (iv) Schematic Assembly Drawing, (v) Patent Drawing, etc.
5. Calculation of Tolerances based on Type of Fits in Assembly [02 Hr.]
6. Tolerance Stacks-Up with suitable examples [02 Hr.]
7. Design for Manufacturing (DFM) with suitable examples [02 Hr.]
8. Design for Assembly and Dis-assembly with suitable examples [02 Hr.]
9. Design for Safety with suitable examples [02 Hr.]
10. Industrial visit / Case study

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Books & Other Resources
Text Books 1. Standards: ASME Y14.5 – 2018 2. Narayana, K. L., Kannaiah, P., Venkata Reddy, K., (2016), "Machine Drawing", 2nd edition, New Age International Publishers, New Delhi, India, ISBN-13: 978-8122440546 3. Bhatt, N. D. and Panchal, V. M., (2014), "Machine Drawing", Charotar Publishing House Pvt. Ltd, Anand, India, ISBN-13: 978-9385039232
Reference Books 1. Cogorno, G. R., (2020), "Geometric Dimensioning and Tolerancing for Mechanical Design", 3rd edition, McGraw-Hill Education 2. Blokdyk, Gerardus, (2019), "Geometric Dimensioning and Tolerancing: A Complete Guide - 2020 Edition", 5STARCooks 3. Standards: ISO/TR 23605:2018, ISO 1101:2017, SP 46, IS 15054(2001)

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202046 - Audit Course - III		
Teaching Scheme	**Credits**	**Examination Scheme**
-	-	-

GUIDELINES FOR CONDUCTION OF AUDIT COURSE

Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self learning is being pursued by the students 'in true letter and spirit'.

- If any course through Swayam/ NPTEL/ virtual platform is selected the minimum duration shall be of 8 weeks.
- However if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken.

In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from second year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself.

Selecting an Audit Course

List of Courses to be opted (Any one) under Audit Course III

- Technical English For Engineers
- Entrepreneurship Development
- Developing soft skills and personality
- Design Thinking
- Foreign Language (preferably German/ Japanese)
- Science, Technology and Society

The titles indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BoS.

Using NPTEL Platform: (preferable)

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Students can select any one of the courses mentioned above and has to register for the corresponding online course available on the NPTEL platform as an Audit course.
- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.
- After clearing the examination successfully; student will be awarded with a certificate.

Assessment of an Audit Course

- The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary.
- During the course students will be submitting the online assignments. A copy of the same can be submitted as a part of term work for the corresponding Audit course.
- On the satisfactory submission of assignments, the institute can mark as "Present" and the student will be awarded the grade AP on the marksheet.

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207002 - Engineering Mathematics - III		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week Tutorial : 01Hr/Week	**04** Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Term Work : 25 Marks

Prerequisite Courses

Differential & Integral calculus, Differential equations of first order & first degree, Fourier series, Collection, classification and representation of data and Vector algebra.

Course Objectives

1. To make the students familiarize with concepts and techniques in Ordinary & Partial differential equations, Laplace transform & Fourier transform, Statistical methods, Probability theory and Vector calculus.
2. The aim is to equip them with the techniques to understand advanced level mathematics and its applications that would enhance analytical thinking power, useful in their disciplines.

Course Outcomes

On completion of the course, learner will be able to

CO1. SOLVE higher order linear differential equations and its applications to model and analyze mass spring systems.

CO2. APPLY Integral transform techniques such as Laplace transform and Fourier transform to solve differential equations involved in vibration theory, heat transfer and related mechanical engineering applications.

CO3. APPLY Statistical methods like correlation, regression in analyzing and interpreting experimental data applicable to reliability engineering and probability theory in testing and quality control.

CO4. PERFORM Vector differentiation & integration, analyze the vector fields and APPLY to fluid flow problems.

CO5. SOLVE Partial differential equations such as wave equation, one and two dimensional heat flow equations.

Course Contents

Unit I **Linear Differential Equations (LDE) and Applications** **[08 Hr.]**

LDE of nth order with constant coefficients, Complementary Function, Particular Integral, General method, Short methods, Method of variation of parameters, Cauchy's and Legendre's DE, Simultaneous and Symmetric simultaneous DE. Modelling of Mass-spring systems, Free &Forced damped and undamped systems.

Unit II **Transforms** **[08 Hr.]**

Laplace Transform **(LT):** LT of standard functions, properties and theorems, Inverse LT, Application of LT to solve LDE.

Fourier Transform **(FT):** Fourier integral theorem, Fourier transform, Fourier sine & cosine transforms, Inverse Fourier Transforms.

Unit III **Statistics** **[07 Hr.]**

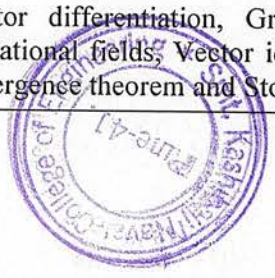
Measures of central tendency, Measures of dispersion, Coefficient of variation, Moments, Skewness and Kurtosis, Curve fitting: fitting of straight line, parabola and related curves, Correlation and Regression, Reliability of Regression Estimates.

Unit IV **Probability and Probability Distributions** **[07 Hr.]**

Probability, Theorems on Probability, Bayes Theorem, Random variables, Mathematical Expectation, Probability distributions: Binomial, Poisson, Normal, Test of Hypothesis: Chi-Square test, t-test.

UnitV **Vector Calculus** **[08 Hr.]**

Vector differentiation, Gradient, Divergence and Curl, Directional derivative, Solenoidal & Irrotational fields, Vector identities. Line, Surface and Volume integrals, Green's Lemma, Gauss's Divergence theorem and Stoke's theorem.



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Smt. Kashibai Navale College
of Engineering, Pune - 41

Unit VI	**Applications of Partial Differential Equations (PDE)**	**[08 Hr.]**
Basic concepts, modelling of Vibrating String, Solution of Wave equation, One and two dimensional Heat flow equations, Method of separation of variables, use of Fourier series. Solution of Heat equation by Fourier transforms.		

Books & Other Resources

Text Books

1. B.V. Ramana, "Higher Engineering Mathematics", Tata McGraw-Hill
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publication, Delhi

Reference Books

1. Erwin Kreyszig, "Advanced Engineering Mathematics', 10e, by Wiley India.
2. M. D. Greenberg, "Advanced Engineering Mathematics", 2e, by Pearson Education.
3. Peter V. O'Neil , "Advanced Engineering Mathematics", 7e, by Cengage Learning
4. S. L. Ross, "Differential Equations", 3e by Wiley India.
5. Sheldon M. Ross, "Introduction to Probability and Statistics for Engineers and Scientists", 5e, by Elsevier Academic Press

Guidelines for Tutorial and term Work

1. Tutorial shall be engaged in four batches (batch size of 20 students maximum) per division.
2. Term work shall be based on continuous assessment of six assignments (one per each unit) and performance in internal tests.The student shall complete the following activity as a Term Work Journal.

Assistant Professor & Head
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Smt. Kashibai Navale College
of Engineering, Pune - 41.

202047 - Kinematics of Machinery		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week Practical : 02 Hr./Week	**04** Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Oral : 25 Marks

Prerequisite Courses

Systems in Mechanical Engineering, Engineering Mathematics - I and II, Engineering Physics, Engineering Mechanics, Geometric Modeling & Drafting

Course Objectives

1. To make the students conversant with kinematic analysis of mechanisms applied to real life and industrial applications.
2. To develop the competency to analyze the velocity and acceleration in mechanisms using analytical and graphical approach.
3. To develop the skill to propose and synthesize the mechanisms using graphical and analytical technique.
4. To develop the competency to understand & apply the principles of gear theory to design various applications.
5. To develop the competency to design a cam profile for various follower motions.

Course Outcomes

On completion of the course, learner will be able to

CO1. APPLY kinematic analysis to simple mechanisms
CO2. ANALYZE velocity and acceleration in mechanisms by vector and graphical method
CO3. SYNTHESIZE a four bar mechanism with analytical and graphical methods
CO4. APPLY fundamentals of gear theory as a prerequisite for gear design
CO5. CONSTRUCT cam profile for given follower motion

Course Contents

Unit I **Fundamentals of Mechanism** **[07 Hr.]**

Kinematic link, Types of links, Kinematic pair, Types of constrained motions, Types of Kinematic pairs, Kinematic chain, Types of joints, Mechanism, Machine, Degree of freedom, Mobility of Mechanism, Inversion, Grashoff's law, Four-Bar Chain and its Inversions, Slider crank Chain and its Inversions, Double slider crank Chain and its Conversions, Mechanisms with Higher pairs, Equivalent Linkages and its Cases - Sliding Pairs in Place of Turning Pairs, Spring in Place of Turning Pairs, Cam Pair in Place of Turning Pairs

Unit II **Kinematic Analysis of Mechanisms: Analytical Method** **[07 Hr.]**

Analytical methods for displacement, velocity and acceleration analysis of slider crank Mechanism, Velocity and acceleration analysis of Four-Bar and Slider crank mechanisms using Vector and Complex Algebra Methods. Computer-aided Kinematic Analysis of Mechanism like Slider crank and Four-Bar mechanism, Analysis of Single and Double Hook's joint

Unit III **Kinematic Analysis of Mechanisms: Graphical Method** **[08 Hr.]**

Displacement, velocity and acceleration analysis mechanisms by Relative Velocity Method (Mechanisms up to 6 Links), Instantaneous Centre of Velocity, Kennedy's Theorem, Angular Velocity ratio Theorem, Analysis of mechanism by ICR method (Mechanisms up to 6 Links), Coriolis component of Acceleration (Theoretical treatment only)

Unit IV **Synthesis of Mechanisms** **[07 Hr.]**

Steps in Synthesis: Type synthesis, Number Synthesis, Dimensional synthesis, Tasks of Kinematic synthesis - Path, function and motion generation (Body guidance), Precision Positions, Chebychev spacing, Mechanical and structural errors

Graphical Synthesis: Inversion and relative pole method for three position synthesis of Four-Bar and Single Slider Crank Mechanisms

Analytical Synthesis: Three position synthesis of Four-Bar mechanism using Freudenstein's equation, Blotch synthesis

Unit V **Kinematics of Gears** **[08 Hr.]**

Gear: Classification

Spur Gear: Terminology, law of gearing, Involute and cycloidal tooth profile, path of contact, arc of contact, sliding velocity, Interference and undercutting, Minimum number of teeth to avoid interference, Force Analysis (theoretical treatment only)

Helical and Spiral Gears: Terminology, Geometrical Relationships, virtual number of teeth for helical gears

Bevel Gear & Worm and Worm Wheel: Terminology, Geometrical Relationships

Gear Train: Types, Analysis of Epicyclic gear Trains, Holding torque - simple, compound and Epicyclic gear Trains, Torque on Sun and Planetary gear Train, compound Epicyclic gear Train

Unit VI **Mechanisms in Automation Systems** **[08 Hr.]**

Cams & Followers: Introduction, Classification of Followers and Cams, Terminology of Cam Displacement diagram for the Motion of follower as Uniform velocity, Simple Harmonic Motion (SHM), Uniform Acceleration and Retardation Motion (UARM), Cycloid motion, Cam Profile construction for Knife-edge Follower and Roller Follower, Cam jump Phenomenon

Automation: Introductions, Types of Automation

Method of Work Part Transport: Continuous transfer, Intermittent or Synchronous Transfer, Asynchronous transfer, Different type of transfer mechanisms - Linear transfer mechanisms and Rotary transfer mechanisms

Automated Assembly-Line: Types, Assembly line balancing Buffer Storages, Automated assembly line for car manufacturing, Artificial intelligence in automation

Books & Other Resources

Text Books

1. S. S. Rattan, "Theory of Machines", Third Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi.
2. Bevan T, "Theory of Machines", Third Edition, Longman Publication
3. G. Ambekar, "Mechanism and Machine Theory", PHI
4. J. J. Uicker, G. R. Pennock, J. E. Shigley, "Theory of Machines and Mechanisms", Fifth Edition, International Student Edition, Oxford

Reference Books

1. Paul E. Sandin, "Robot Mechanisms and Mechanical Devices Illustrated", Tata McGraw Hill Publication
2. Stephen J. Derby, "Design of Automatic Machinery", 2005, Marcel Dekker, New York
3. Neil Sclater, "Mechanisms and Mechanical Devices Sourcebook", Fifth Edition, Tata McGraw Hill Publication
4. Ghosh Malik, "Theory of Mechanism and Machines", East-West Pvt. Ltd.
5. Hannah and Stephans, "Mechanics of Machines", Edward Arnolde Publication
6. R. L. Norton, "Kinematics and Dynamics of Machinery", First Edition, McGraw Hill Education (India) P Ltd. New Delhi
7. Sadhu Singh, "Theory of Machines", Pearson
8. Dr. V. P. Singh, "Theory of Machine", Dhanpatrai and Sons
9. C. S. Sharma & Kamlesh Purohit, "Theory of Machine and Mechanism", PHI
10. M.P. Groover, "Automation, production systems and computer-integrated manufacturing", Prentice-Hall of India Pvt. Ltd, New Delhi

Web References

1. https://nptel.ac.in/courses/112104121/ (NPTEL1, Kinematics of Machines, Prof. Ashok K Mallik, IIT Kanpur)
2. https://nptel.ac.in/courses/112/106/112106270/ (NPTEL2, Theory of Mechanism, Prof. Sujatha Srinivasan, IIT Madras)
3. https://nptel.ac.in/courses/112/105/112105268/ (NPTEL3, Kinematics of Mechanisms and Machines, Prof. Anirvan DasGupta, IIT Kharagpur)

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College of Engineering, Pune - 41

4. https://nptel.ac.in/courses/112/105/112105236/ (NPTEL4, Mechanism and Robot Kinematics, Prof.Anirvan DasGupta, IIT Kharagpur)
5. http://www.cdeep.iitb.ac.in/webpage_data/nptel/Mechanical/Robotics Course/Course_home_lect1.html (NPTEL5, Introduction to Robotics and Automation, IIT Bombay)

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

Total 10 experiments from the following list must be performed. Term Work of the Student is evaluated based on the completion of Practical, Assignments using Drawing Aids, Assignments using Software & Programming Languages, Assignments using Virtual Laboratory and Detailed Industrial Visit Report.

Practical *(Experiment # 1 is compulsory and Select any Two from Experiment # 2 to 4)*

1. To make a model of any mechanism by using waste material by the group of 4 to 6 students and to give a presentation using PPTs.
2. Speed and torque analysis of epicyclic gear train to determine holding torque.
3. To study and verify cam jump phenomenon.
4. To study manufacturing of gear using gear generation with rack as a cutter and to generate an involute profile.

Assignments using Drawing Aids *(Experiment #1 to 3 and 6 are compulsory and Select any One from Experiment #4-5)*

Do following graphical assignments on Half Imperial drawing sheet:

1. Identify mechanisms in real life and Analyze for types and number of links, pairs, obtain degrees of freedom. Submit the sheet and working video of the mechanism.
2. To solve two problems on velocity and acceleration analysis using relative velocity and acceleration method.
3. To solve two problems on velocity analysis using the ICR method.
4. To draw conjugate profile for any general type of gear tooth.
5. To study various types of gearboxes.
6. To draw cam profile for any two problems with combination of various follower motion with radial and off-set cam.

Assignments using Software *(Any Three Assignments - Minimum one computer programming based and Minimum one based on use of software)*

Do following assignments by using Software or by using Coding/Programming Languages:

1. To design a simple Planer Mechanism by using any software (Geogebra, SAM, Working Model, any 3D Modelling Software, etc.)
2. To do computer programming (using software/programming languages like C, Python, Scilab, Matlab etc.) for Kinematic Analysis of Slider Crank Mechanism using Analytical Method
3. To do computer programming (using software/programming languages like C, Python, Scilab, Matlab etc.) for Kinematic Analysis of Hooke's joint Mechanism using Analytical Method
4. To generate a Cam Profile using any Modelling Software (Mech Analyser, any 3D Modelling Software)
5. To synthesize the Four-Bar and Slider Crank Mechanism (Geogebra, SAM, any 2D/3D Modelling Software)
6. To do computer programming (using software/programming languages like C, Python, Scilab, Matlab etc.) for the Synthesis of Mechanism using Chebychevs spacing, Freudensteins equation and function generation

Assignments using Virtual Laboratory *(minimum Two experiments)*

Please visit the links given below for exploring experiments on Kinematics of Machinery using Virtual Laboratory. Write a Brief Reports of using Virtual Laboratory to perform following assignment:

1. Mechanics-of-Machines Lab (All Experiments), http://mm-nitk.vlabs.ac.in/index.html
2. Mechanisms and Robotics - Oldham Coupling Mechanism, http://vlabs.iitkgp.ernet.in/mr/index.html
3. Mechanisms and Robotics - Quick Return Mechanism, http://vlabs.iitkgp.ernet.in/mr/index.html

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Dept. of Mechanical Engg.
Smt. Kashibai Navale College of Engineering

4. Mechanisms and Robotics - CAM Follower Mechanism, http://vlabs.iitkgp.ernet.in/mr/index.html

Industrial Visits

A Compulsory industrial visit must be arranged to industries/ establishments consisting automation and mechanization during semester to provide awareness and understanding of the course.

The Industrial Visit must be preferably to

- Manufacturing industries with Assembly-line Automation
- Sugar factory
- Bottle filling plants

Student must submit properly documented Detailed Industrial Visit Report in his/her own words.

Assignments on Content beyond syllabus

Following assignments can be attempted:

1. Forward and Inverse Kinematics of 2R/2P/RP/PR Manipulators using Software (Geogebra, RoboAnalyser, Vlab, etc.)
2. Kinematic Analysis of 6 DOF Industrial Robot using Software (RoboAnalyzer, Vlab, etc.)

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

202048 - Applied Thermodynamics

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Oral : 25 Marks

Prerequisite Courses

Engineering Thermodynamics, Systems in Mechanical Engineering, Engineering Mathematics - I, Engineering Mathematics - II

Course Objectives

1. To determine COP of refrigeration cycle and study Psychrometric properties and processes.
2. To study working of engine, Actual, Fuel-Air and Air standard cycle and its Performance.
3. To understand Combustion in SI and CI engines and factors affecting performance parameters
4. To study emission from IC Engines and its controlling method, various emission norms.
5. To estimate performance parameters by conducting a test on I. C. Engines.
6. To determine performance parameters of Positive displacement compressor.

Course Outcomes

On completion of the course, learner will be able to

CO1. DETERMINE COP of refrigeration system and ANALYZE psychrometric processes.
CO2. DISCUSS basics of engine terminology,air standard, fuel air and actual cycles.
CO3. IDENTIFY factors affecting the combustion performance of SI and CI engines.
CO4. DETERMINE performance parameters of IC Engines and emission control.
CO5. EXPLAIN working of various IC Engine systems and use of alternative fuels.
CO6. CALCULATE performance of single and multi stage reciprocating compressors and DISCUSS rotary positive displacement compressors

Course Contents

Unit I **Basics of Refrigeration and Psychrometry** **[07 Hr.]**

Refrigeration: Reversed Carnot Cycle, unit of refrigeration, Simple Vapour Compression Cycle (VCC), Refrigerating Effect, Compressor Power & COP. Simple Vapor Absorption Cycle (VAC), Comparison between VCC & VAC.

Psychrometry: Introduction, Psychrometry and Psychrometric Properties, Basic Terminologies & Psychrometric Relations, Psychrometric Processes, Psychrometric Chart.

Unit II **Introduction to Internal Combustion (IC) Engine** **[06 Hr.]**

IC Engine: Components and Construction details, Terminology, Classification, Applications, Intake and exhaust system, Valves actuating mechanisms, Valve timing diagram.

Fuel, Air and Actual Cycle: Air-standard cycles, fuel air cycles, and actual cycles, Effects of variables on performance, various losses, and Comparison of Air standard with Fuel and Actual cycle.

Unit III **SI and CI Engines** **[09 Hr.]**

SI Engines: Theory of Carburetion and Types of Carburetor, Working of Simple Carburetor, Electronic Fuel Injection System, Combustion stages in SI engines, Abnormal Combustion, Theory of Detonation and Parameters affecting detonations, Rating of fuels in SI engines, Combustion Chambers used in SI Engine.

CI Engines: Fuel Injection system, Construction and Workjng of Fuel Pump, Fuel Injector and Various types of Nozzle, Combustion stages in CI engines, Theory of knocking and Parameters affecting knocking, Rating of fuels in CI engines, Combustion Chambers used in CI Engines.

Unit IV **IC Engine Testing and Emission** **[09 Hr.]**

Engine Testing: Engine Testing Procedure, Measurement of indicated power, Brake power, fuel consumption, Air Consumption, Measurement of friction power by Willan's Line Method and Morse Test, calculation of mean effective pressure, various efficiencies, specific fuel consumption, heat balance sheet of IC Engines and performance Characteristic curves.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

Emission & Control: Introduction to Indian Driving Cycle (IDC), European Driving Cycle (EDC), SI and CI Engines Emission and controlling methods, Methods to measure emission such as (Non Dispersive Infrared Red (NDIR), Flame Ionization Detector (FID), Chemiluminescent Analyzer, Smoke meter), Euro Norms and Bharat Stage Norms.

Unit V **Engine Systems and Alternative Fuels** **[07 Hr.]**

Cooling system: Air Cooling, Liquid cooling, **Lubrication system**: Objectives of lubrication system, properties of lubricant, Methods of lubrication system, **Ignition system**: battery coil ignition system, magneto ignition system, Electronics Ignition (CDI, TCI), Maximum Brake Torque (MBT) & spark advance. Supercharging and Turbo-charging.

Alternative Fuels: Bio-diesel, Ethanol, LPG, CNG and Hydrogen.

Unit VI **Compressor** **[07 Hr.]**

Reciprocating Compressor: Applications of compressed air, single stage compressor (without clearance and with clearance volume), volumetric efficiency, isothermal efficiency, effect of clearance volume, free air delivery (FAD), actual indicator diagram for air compressor, Multi staging of compressor, optimum intermediate pressure, intercooler, after cooler, Capacity control of compressors.

Rotary Compressors: Roots blower, Vane type, Screw compressor and Scroll compressor.

Books & Other Resources

Text Books

1. Arora C. P., "Refrigeration and Air Conditioning", Tata McGraw-Hill
2. V. Ganesan, "Internal Combustion Engines", Tata McGraw-Hill
3. M. L. Mathur and R.P. Sharma, "A course in Internal combustion engines", Dhanpat Rai & Co.
4. H.N. Gupta, "Fundamentals of Internal Combustion Engines", PHI Learning Pvt. Ltd.

Reference Books

1. Dossat Ray J, "Principles of refrigeration, S.I. version", Willey Eastern Ltd, 2000
2. Heywood, "Internal Combustion Engine Fundamentals", Tata McGraw-Hill
3. Domkundwar & Domkundwar, "Internal Combustion Engine", Dhanpat Rai & Co.
4. R. Yadav, "Internal Combustion Engine", Central Book Depot, Ahmedabad.
5. S.Domkundwar,C.P. Kothandaraman,A.Domkundwar,"Thermal Engineering",DhanpatRai & Co.

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

Total 10 of the following list must be performed. During Oral, the Student shall be evaluated based on the completion of Practical, Assignments, Presentations and Detailed Industrial Visit Report.

Practical *(Minimum 6 Practical must be performed)*

1. Trial on Vapour Compression System
2. Trial on Vapour Absorption System
3. Trial on Air-Conditioning Test Rig.
4. Morse Test on Petrol engine.
5. Trial on Diesel engine.
6. Trial on Petrol engine.
7. Trial on variable compression ratio engine.
8. Trial on Positive Displacement Air Compressor.
9. Demonstration on Exhaust Gas Analyser and Smoke meter.

Survey *(Minimum one)*

1. Practical Survey of various fuel supply systems.
2. Practical Survey of supercharged and turbocharged engines.

Activity: *Presentation based*

Compulsory study of following topics must be done by students during semester to gain awareness and further understanding of the course and a presentation of the same should be included in the TW:

1. **Engines**:(any one) Homogeneous charge compression ignition (HCCI)/ Stratified charge

engine/Variable valve timing (VVT)/Variable geometry turbocharger (VGT), etc.

2. **Automotive Field**: (any one) Hydrogen CNG vehicles/Adaptive cruise control system/On-board diagnostic system (OBD) / Electric Battery classification/Fuel Cell vehicle/Rear driving emission (RDE) system

Industrial Visit

A Compulsory industrial visit must be arranged to automobile manufacturing or servicing.
Students must submit properly documented Detailed Industrial Visit Report in his/her own words.

Smt. Kashibai Navale College of Engineering * Pune-41.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

202049 - Fluid Mechanics		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week Practical : 02 Hr./Week	**04** Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Oral : 25 Marks

Prerequisite Courses

Engineering Mathematics - I, Engineering Mathematics - II, Engineering Mechanics, Engineering Physics

Course Objectives

1. To understand basic properties of fluids.
2. To learn fluid statics and dynamics
3. To study basics of flow visualization
4. To understand Bernoulli's theorem and its applications.
5. To understand losses in flow, drag and lift forces
6. To learn to establish relation between flow parameters.

Course Outcomes

On completion of the course, learner will be able to

CO1. DETERMINE various properties of fluid
CO2. APPLY the laws of fluid statics and concepts of buoyancy
CO3. IDENTIFY types of fluid flow and terms associated in fluid kinematics
CO4. APPLY principles of fluid dynamics to laminar flow
CO5. ESTIMATE friction and minor losses in internal flows and DETERMINE boundary layer formation over an external surface
CO6. CONSTRUCT mathematical correlation considering dimensionless parameters, also ABLE to predict the performance of prototype using model laws

Course Contents

Unit I **Properties of Fluid** **[06 Hr.]**

Definition of fluid, concept of continuum, density, specific weight, specific gravity, viscosity, viscosity laws, types of fluid and rheology, measurement of viscosity, application based numerical on viscosity-flow through pipe, lubrication, bearing, brake fluids, parallel plates, rotating shafts etc., vapor pressure surface tension, capillarity, compressibility

Unit II **Fluid Statics** **[07 Hr.]**

Laws of fluid statics: forces acting on fluid element, pascal's law, hydrostatics law, hydraulic ram Pressure measurement: pressure scale, piezometer, barometer, manometer - simple, inclined, differential, micro manometer, inverted

Forces acting on surfaces immersed in fluid: total pressure and center of pressure on submerged plane surfaces, curved surface submerged in liquid including numerical on dam gate

Buoyancy: flotation, stability of bodies

Unit III **Fluid Kinematics** **[08 Hr.]**

Flow description methods, types of flows, velocity and acceleration fields, continuity equation in 1D & 3D flow, flow visualization (path line, stream line and streak line), stream tube, angularity, vorticity, stream function and velocity potential function, flow net

Unit IV **Fluid Dynamics** **[10 Hr.]**

Euler's equation of motion differential form and Navier Stokes equation, Euler's equation of motion along streamline, Bernoulli's theorem and modified Bernoulli's theorem, stagnation pressure, HGL, TEL

Flow measurement: venturimeter, orifice meter, pitot tubes, static pitot tube, introduction to coriolis flow meter, introduction to orifices, notches & weirs

Laminar flow: Entrance region theory, velocity and shear Stress distribution for laminar flow through pipe, fixed parallel plates and Couette flow, velocity profile of turbulent flow

Unit V	Internal & External Flow	[09 Hr.]

Internal Flow: Losses - major & minor losses, hydro dynamically smooth and rough boundaries, Moody's chart, compounding of pipes & equivalent pipe, siphons, transmission of power

External Flow: Boundary layer formation over a flat plate, boundary layer thickness, displacement thickness, momentum thickness and energy thickness, boundary layer separation and methods to control separation, drag and lift concepts, types of drag, drag & lift coefficient, aerofoil, bluff body, streamline body

Unit VI	Dimensional Analysis & Similitude	[08 Hr.]

Dimensional Analysis: Introduction, system of dimensions, Dimensional homogeneity, Buckingham-Pi Theorem, repeating variables, dimensionless numbers and their physical significance

Similitude & Model Testing: Model & prototype, similarity, scaling parameters , model laws, objectives , importance and application of model studies.

Books & Other Resources

Text Books

1. Sukumar Pati, "Fluid Mechanics and Hydraulics Machines", TATA McGraw Hill.
2. Munson, Young and Okiishi, "Fundamentals of Fluid Mechanics", Wiley India
3. Potter Wiggert, "Fluid Mechanics", Cengage Learning
4. Fox, Pichard, "Introduction to Fluid Mechanics", McDonald- Wiley
5. Modi P. N. and Seth S. M, "Hydraulics and Fluid Mechanics",Standard Book House.
6. Cengel & Cimbla, "Fluid Mechanics",TATA McGraw-Hill
7. F. M. White, "Fluid Mechanics", TATA McGraw-Hill
8. R. K. Bansal, "Fluid Mechanics & Hydraulic Machines", Laxmi Publication

Reference Books

1. Kundu, Cohen, Dowling, "Fluid Mechanics", Elsevier India
2. Chaim Gutfinger David Pnueli, "Fluid Mechanics" Cambridge University press.
3. Edward Shaughnessy, Ira Katz James Schaffer, "Introduction to Fluid Mechanics",Oxford University Press

Web References

1. https://nptel.ac.in/courses/112/105/112105171/
2. https://nptel.ac.in/courses/112/104/112104118/
3. https://nptel.ac.in/courses/112/105/112105269/
4. http://www.efluids.com/efluids/books/efluids_books.htm
5. http://web.mit.edu/hml/ncfmf.html
6. http://www.efluids.com/efluids/pages/edu_tools.htm
7. https://spoken-tutorial.org/tutorial-search/?search_foss=OpenFOAM&search_language=

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

Total 10 experiments from the following list must be performed. During Oral, the Student is evaluated based on the completion of Practical, Assignments using Virtual Lab and Detailed Mini project / Industrial Visit Report/ Simulation of fluid flow / Programming using any suitable software.

Practical *(Experiment # 3 & 9 are compulsory; Select any One Simulation of Experiments from Experiment # 4 & 6; Perform any Eight experiments)*

1. Determination of pressure using manometers (minimum two)
2. Determination of fluid viscosity and its variation with temperature.
3. Determination of Metacentric height of floating object.
4. Determination of Reynolds number and flow visualization of laminar and turbulent flow using Reynolds apparatus.
5. Draw flow net using electrical analogy apparatus to calculate discharge for rectangular / enlargement / contraction channel.
6. Verification of modified Bernoulli's equation.
7. Calibration of Orifice meter/ Venturimeter/Notch.
8. Determination of minor/major losses through metal/non-metal pipes.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

9. Mini project/Industrial visit/Simulation of fluid flow/Programming using any suitable software

Assignments using Virtual Laboratory *(Any Two Virtual Lab experiments from experiment # 1,2,5,7,8 mentioned above)*

Please visit the links given below for exploring and performing experiments on Fluid Mechanics using Virtual Laboratory. Write brief Reports using Virtual Laboratories:

1. https://eerc03-iiith.vlabs.ac.in/
2. http://fm-nitk.vlabs.ac.in/

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Smt. Kashibai Navale College
of Engineering, Pune - 41

202050 - Manufacturing Processes		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week	03 Theory : 03	In-Semester : 30 Marks End-Semester : 70 Marks

Prerequisite Courses

Material Science and Metallurgy, Engineering Physics, Systems in Mechanical Enginering

Course Objectives

1. Describe various sand and permanent mould casting methods, procedure and mould design aspects.
2. Understand basics of metal forming processes, equipment and tooling.
3. Understand sheet metal forming operations and die design procedure.
4. Classify, describe and configure the principles of various welding techniques.
5. Understand plastic processing techniques.
6. To know about composites, its fabrication processes.

Course Outcomes

On completion of the course, learner will be able to

CO1. SELECT appropriate moulding, core making and melting practice and estimate pouring time, solidification rate and DESIGN riser size and location for sand casting process

CO2. UNDERSTAND mechanism of metal forming techniques and CALCULATE load required for flat rolling

CO3. DEMONSTRATE press working operations and APPLY the basic principles to DESIGN dies and tools for forming and shearing operations

CO4. CLASSIFY and EXPLAIN different welding processes and EVALUATE welding characteristics

CO5. DIFFERENTIATE thermoplastics and thermosetting and EXPLAIN polymer processing techniques

CO6. UNDERSTAND the principle of manufacturing of fibre-reinforce composites and metal matrix composites

Course Contents

Unit I **Casting Processes** **[07 Hr.]**

Introduction to casting processes, Patterns: Pattern materials, types of pattern, allowances pattern design, Moulding sand, Properties of moulding sands, Core making, Melting practices and furnaces, Pouring and Gating system design, Numerical estimation to find mold filling time, Riser design and placement, Principles of cooling and solidification of casting, Directional and Progressive solidification Estimation of solidification rate, Cleaning and Finishing of casting, Defects and remedies, Principle and equipments of Permanent mould casting, Investment casting, Centrifugal casting, Continuous casting

Unit II **Metal Forming Processes** **[08 Hr.]**

Plastic deformation. Stress-strain diagram for different types of material, Hot and Cold working, Factors affecting plastic deformation, Yield criteria, Concept of flow stress, Forming Limit diagram

Rolling Process: Rolling terminology, Friction in rolling, Calculation of rolling load

Forging: Open and closed die forging, Forging operations

Extrusion: Types, Process parameter

Wire and Tube Drawing: Wire and tube drawing process, Die profile

Friction and lubrication in metal forming, Forming defects, causes and remedies for all forming processes

Unit III **Sheet Metal Forming** **[07 Hr.]**

Types of sheet metal operations, Press working equipment and terminology, Types of dies, Clearance analysis, Estimation of cutting forces, Centre of pressure and blank size determination, Design of strip lay-out, Blanking die design, Introduction to Drawing, Bending dies, Methods of reducing

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Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41

forces, Formability and forming limit diagrams

Unit IV **Welding Processes** **[08 Hr.]**

Classification of joining processes, Welding terminology and types of joints

Arc Welding Processes: Principles and equipments of Single carbon arc welding, FCAW, TIG, MIG, SAW

Resistance Welding: Spot, Seam and Projection weld process, Heat balance in resistance welding

Gas Welding and Cutting, Soldering, brazing and braze welding

Welding Metallurgy and Heat Affected Zone, Weld inspection, Defects in various joints and their remedies

Unit V **Processing of polymers** **[07 Hr.]**

Thermoplastics and Thermosetting, Processing of polymers, Thermoforming, Extrusion

Moulding: Compression moulding, Transfer moulding, Blow moulding, Rotation moulding, Injection moulding - Process and equipment

Extrusion of Plastic: Type of extruder, extrusion of film, pipe, Cable and Sheet – Principle

Pressure forming and Vacuum forming

Unit VI **Manufacturing of Composites** **[08 Hr.]**

Introduction to composites, Composite properties, Matrices, Fiber reinforcement

Composite Manufacturing Processes: Hand lay-up Process, Spray lay-up, Filament winding process, Resin transfer moulding, Pultrusion, and Compression moulding process, Vacuum impregnation process, Processing of metal matrix composites, Fabrication of ceramic matrix composites, Carbon-carbon composites, Polymer matrix and nano-composites

Books & Other Resources

Text Books

1. P. N. Rao, "Manufacturing Technology Vol. I & II" , Tata McGraw Hill Publishers
2. P. C. Sharma, "Production Engineering", Khanna Publishers

Reference Books

1. R. K. Jain, "Production Technology", Khanna Publishers
2. K. C. Chawala, "Composite Materials", Springer, ISBN 978-0387743646, ISBN 978-0387743653
3. Brent Strong, "Fundamentals of Composites Manufacturing: Materials, Methods", SME Book series

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Smt. Kashibai Navale College
of Engineering, Pune - 41.

202051 - Machine Shop		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical : 02 Hr./Week	**01** Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Term Work : 50 Marks

Prerequisite Courses
Workshop Practice

Course Objectives
1. To understand the basic procedures, types of equipment, tooling used for sand casting and metal forming processes through demonstrations and/(or) Industry visits..
2. To understand TIG/ MIG/ Resistance/Gas welding welding techniques.
3. To acquire skills to handle grinding and milling machine and to produce gear by milling.
4. To acquire skills to produce a composite part by manual process.

Course Outcomes
On completion of the course, learner will be able to
CO1. PERFORM welding using TIG/ MIG/ Resistance/Gas welding technique
CO2. MAKE Fibre-reinforced Composites by hand lay-up process or spray lay-up techniques
CO3. PERFORM cylindrical/surface grinding operation and CALCULATE its machining time
CO4. DETERMINE number of indexing movements required and acquire skills to PRODUCE a spur gear on a horizontal milling machine
CO5. PREPARE industry visit report
CO6. UNDERSTAND procedure of plastic processing

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

Practical *(Select any One Practical from Practical # 1 & 2; Select any Five Practical from Practical # 3 to 8; Perform Total Six Practicals)*
1. To study and observe various stages of casting through demonstration of sand casting process from pattern making, sand mould preparation and melting and pouring of metal.
2. Visit to any foundry/ permanent mould casting industry to demonstrate various stages of casting and make a report on it.
3. A compulsory visit to any one metal forming industry out of: Rolling mill, Forging plant, Wire/Tube drawing unit and prepare a report on it.
4. A demonstration of any one welding technique out of TIG/ MIG/Resistance/Gas welding. A job drawing to be prepared by an individual institute with details of welding process parameters with weld joint design such as edge preparation, type and size of electrode used, welding current, voltage etc.
5. Manufacturing of Fibre-reinforced Composites by hand lay-up process or spray lay-up techniques.
6. Demonstration on any one plastic component like bottle, bottle caps, machine handles etc. by injection moulding process/ by additive manufacturing process.
7. Demonstration on cylindrical grinding/surface grinding operations, measurement of surface roughness produced and estimation of machining time.
8. Demonstration on indexing mechanism. Calculation of index crank and index plate movement by simple/compound/differential indexing and manufacture of spur gear on a milling machine using indexing head.

Instructions for Laboratory Conduction

Please note following instructions regarding Laboratory Conduction:
1. Industrial Visits to be conducted by the Teaching **Faculty** (subject Teacher).
2. Demonstration of Welding machines, Surface/Cylindrical Grinding, Milling machine, Indexing head and calculation of indexing to be taught by a **subject Teacher in Practical slot**.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College of Engineering, Pune - 41

202052 - Project Based Learning - II		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical : 04 Hr./Week	**02** Practical : 02	Term Work : 50 Marks

Preamble

Currently, engineering education is undergoing significant structural changes worldwide. The rapidly evolving technological landscape forces educators to constantly reassess the content of engineering curricula in the context of emerging fields and with a multidisciplinary focus. In this process, it is necessary to devise, implement and evaluate innovative pedagogical approaches for the incorporation of these novel subjects into the educational programs without compromising the cultivation of the traditional skills. In this context, the educational community is showing rapidly rising interest in project-based learning approaches.

The mainstream engineering education follows traditional classroom teaching, in which the major focus is mainly on the lecture and the student has very little (if any) choice on the learning process. However rapid development in engineering and technology requires adopting a teaching approach that would assist students not only in developing a core set of industry relevant skills, but also enable them to adapt to changes in their professional career.

Course Objectives

1. To emphasize project based learning activities that are long-term, interdisciplinary and student-centric.
2. To inculcate independent and group learning by solving real world problems with the help of available resources.
3. To be able to develop applications based on the fundamentals of mechanical engineering by possibly applying previously acquired knowledge.
4. To get practical experience in all steps in the life cycle of the development of mechanical systems: specification, design, implementation, and testing.
5. To be able to select and utilize appropriate concepts of mechanical engineering to design and analyze selected mechanical system.

Course Outcomes

On completion of the course, learner will be able to

CO1. IDENTIFY the real-world problem (possibly of interdisciplinary nature) through a rigorous literature survey and formulate / set relevant aims and objectives.
CO2. ANALYZE the results and arrive at valid conclusions.
CO3. PROPOSE a suitable solution based on the fundamentals of mechanical engineering by possibly integration of previously acquired knowledge.
CO4. CONTRIBUTE to society through proposed solutions by strictly following professional ethics and safety measures.
CO5. USE of technology in proposed work and demonstrate learning in oral and written form.
CO6. DEVELOP ability to work as an individual and as a team member.

Group Structure

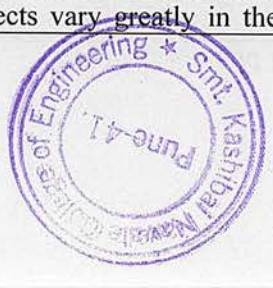
Working in supervisor/mentor –monitored groups. The students plan, manage and complete a task/project/activity which addresses the stated problem.

1. Create groups of 5 (five) to 6 (six) students in each class
2. A supervisor/mentor teacher is assigned to 3-4 groups or one batch

Project Selection

The project can be selected by undertaking a survey of journal papers, patents or field visit (A problem can be theoretical, practical, social, technical, symbolic, cultural and/or scientific). The problem shall consist of following facets: feasibility of arriving at a solution, analyzing the problem, design and development of the system (hardware or virtual).

There are no commonly shared criteria/ guidelines for what constitutes an acceptable project. Projects vary greatly in the depth of the questions explored, the clarity of the learning goals, the



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content and structure of the activity undertaken.

Solution to problem-based projects through ***"learning by doing"*** is recommended. The model begins with the identifying of a problem, often growing out of a question or "wondering". This formulated problem then stands as the starting point for learning. A problem can be theoretical, practical, social, technical, symbolic, cultural and/or scientific and grows out of students" wandering within different disciplines and professional environments. As stated in the preamble as the world has adapted and propagated multidisciplinary approach, hence the proposed project activity preferably should not be restricted to only mechanical domain specific projects rather should be Interdisciplinary in nature. However the chosen problem should be integration of other streams of engineering with Mechanical engineering.

Although in a genuine case 100% software/ virtual project topic may be allowed.

Ethical Practices, teamwork and project management:
Use Indian standards or any relevant standards for project manufacturing, respect the time of others, attend the reviews, poster presentation and model exhibitions, strictly follow the deadline of project completion, comply with all legislation requirements that govern workplace health and safety practices.

Effective Documentation
In order to make our engineering graduates capable of preparing effective documentation, it is required for the students to learn the effective writing skills. The PBL final report is expected to consist of the Literature Survey, Problem Statement, Aim and Objectives, System Block Diagram, System Implementation Details, Discussion and Analysis of Results, Conclusion, System Limitations and Future Scope. Many freely available software tools (for instance Mendley (Elsevier), Grammarly) are expected to be used during the preparation of PBL synopsis and final report. It is expected that the PBL guides/mentors shall teach students about utilizing valid sources of information (such as reference papers, books, magazines, etc) related to their PBL topic.

Evaluation & Continuous Assessment
The institution/head shall be committed to ensuring the effective and rigorous implementation of the idea of project based learning. Progress of PBL shall be monitored regularly on a weekly basis. Weekly review of the work shall be necessary. During the process of monitoring and continuous assessment and evaluation the individual and team performance is to be measured. PBL is monitored and continuous assessment is done by supervisor /mentor and authorities. Students must maintain an institutional culture of authentic collaboration, self-motivation, peer-learning and personal responsibility. The institution/department should support students in this regard through guidance/orientation programs and the provision of appropriate resources and services. Supervisor/mentor and Students must actively participate in assessment and evaluation processes.

The effectiveness of the concept PBL lies in rigorous and continuous assessment and evaluation of the student performance. It is recommended that all activities are required to be recorded regularly. A regular assessment of PBL work is required to be maintained at the department in PBL log book by students. It is expected that the PBL log book must include following:

1. Information of students and guide
2. Weekly monitoring by the PBL guide,
3. Assessment sheet for PBL work review by PBL guide and PBL Evaluation Committee (PEC).

The PEC structure shall consist of Head of the department, 1/2 senior faculties of the department and one industry expert (optional). Continuous Assessment Sheet (CAS) is to be maintained by the department.

Recommended parameters for assessment, evaluation and weightage

1. Idea Inception (kind of survey). (10%)
2. Documentation (Gathering requirements, design & modeling, implementation/execution, use of technology and final report, other documents). (15%)
3. Attended reviews, poster presentation and model exhibition. (10%)

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Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

4. Demonstration (Poster Presentation, Model Exhibition etc). (10%).
5. Awareness /Consideration of - Environment/ Social /Ethics/ Safety measures/Legal aspects. (5%)
6. Outcome (physical model/prototype/ virtual model/ product development/ assembly & disassembly and analysis of standard mechanism or system, design and development of small applications using Arduino, design of control systems, development of various systems/ subsystems of BAJA/SUPRA/Robots/GoKart/ Sunrisers/Hackathon/ application development and similar activities/ System performance and analysis) (40%)
7. Participation in various competitions/ publication/ copyright/ patent) (10%)

Learning Resources

Reference Books / Research Articles

1. John Larmer, John R. Mergendoller, and Suzie Boss, "Setting the Standard for Project Based Learning"
2. John Larmer and Suzie Boss, "Project Based Teaching: How to Create Rigorous and Engaging Learning Experiences"
3. Erin M. Murphy and Ross Cooper, "Hacking Project Based Learning: 10 Easy Steps to PBL and Inquiry"

Web resources

1. https://www.edutopia.org/project-based-learning
2. www.howstuffworks.com
3. https://www.pblworks.org/
4. www.wikipedia.org

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Assistant Professor & Head
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Smt. Kashibai Navale College
of Engineering, Pune - 41.

202053 - Audit Course - IV		
Teaching Scheme	**Credits**	**Examination Scheme**
-	-	-

GUIDELINES FOR CONDUCTION OF AUDIT COURSE

Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self learning is being pursued by the students 'in true letter and spirit'.

- If any course through Swayam/ NPTEL/ virtual platform is selected the minimum duration shall be of 8 weeks.
- However if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken.

In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from second year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself.

Selecting an Audit Course

List of Courses to be opted (Any one) under Audit Course IV

- Language & Mind Emotional Intelligence
- Advanced Foreign Language (preferably German/ Japanese)
- Human Behaviour
- Speaking Effectively
- Business Ethics
- Technical writing/ Research writing

The titles indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BoS.

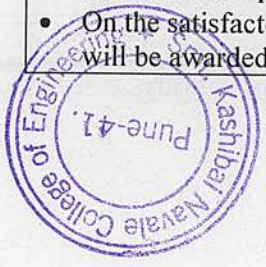
Using NPTEL Platform: (preferable)

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Students can select any one of the courses mentioned above and has to register for the corresponding online course available on the NPTEL platform as an Audit course.
- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.
- After clearing the examination successfully; student will be awarded with a certificate.

Assessment of an Audit Course

- The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary.
- During the course students will be submitting the online assignments. A copy of the same can be submitted as a part of term work for the corresponding Audit course.
- On the satisfactory submission of assignments, the institute can mark as "Present" and the student will be awarded the grade AP on the mark sheet.



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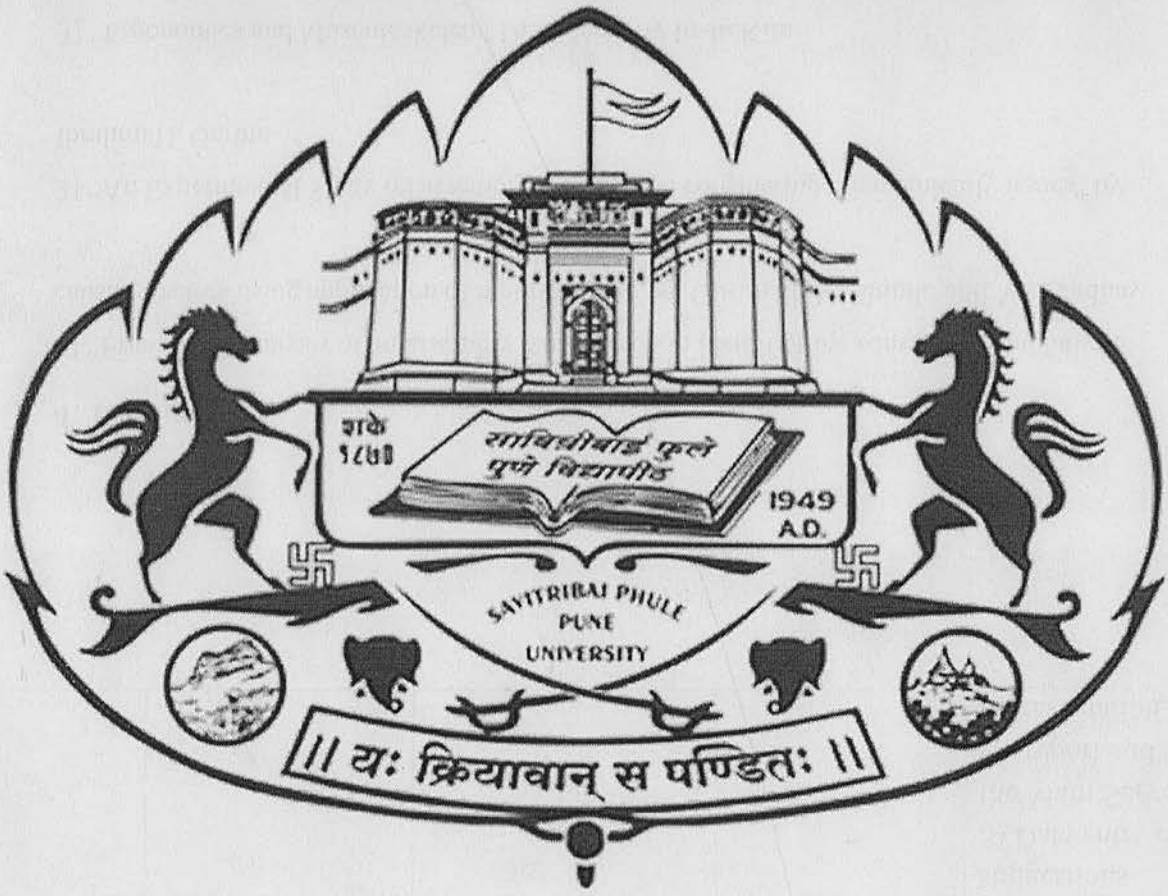

Curriculum/Syllabus
For
Third Year
Bachelor of Engineering
(Choice Based Credit System)
Mechanical Engineering
(2019 Course)
Board of Studies – Mechanical and Automobile Engineering
(With Effect from Academic Year 2021-22)

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

Savitribai Phule Pune University

Board of Studies - Automobile and Mechanical Engineering

Undergraduate Program - Mechanical Engineering (2019 pattern)

Course Code	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
Semester-V														
302041	Numerical & Statistical Methods	3	-	1	30	70	25	-	-	125	3	-	1	4
302042	Heat & Mass Transfer	3	2	-	30	70	-	50	-	150	3	1	-	4
302043	Design of Machine Elements	3	2	-	30	70	-	-	25	125	3	1	-	4
302044	Mechatronics	3	2	-	30	70	-	-	25	125	3	1	-	4
302045	Elective I	3	-	-	30	70	-	-	-	100	3	-	-	3
302046	Digital Manufacturing Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302047	Skill Development	-	2	-	-	-	25	-	-	25	-	1	-	1
302048	Audit course - V[$]	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**10**	**1**	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**5**	**1**	**21**
Semester-VI														
302049	Artificial Intelligence &Machine Learning	3	2	-	30	70	-	-	25	125	3	1	-	4
302050	Computer Aided Engineering	3	2	-	30	70	-	50	-	150	3	1	-	4
302051	Design of Transmission Systems	3	2	-	30	70	-	-	25	125	3	1	-	4
302052	Elective II	3	-	-	30	70	-	-	-	100	3	-	-	3
302053	Measurement Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302054	Fluid Power &Control Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302055	Internship/Mini project *	-	4	-	-	-	100	-	-	100	-	4	-	4
302056	Audit course - VI[$]	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**12**	**14**	**-**	**120**	**280**	**200**	**50**	**50**	**700**	**12**	**9**	**-**	**21**

Elective-I		Elective-II	
302045-A	Advanced Forming & Joining Processes	302052-A	Composite Materials
302045-B	Machining Science & Technology	302052-B	Surface Engineering

Abbreviations: TH: Theory, **PR**: Practical, **TUT**: Tutorial, **ISE**: In-Semester Exam, **ESE**: End-Semester Exam, **TW**: Term Work, **OR**: Oral

Note: Interested students of TE (Automobile Engineering and Mechanical Engineering) can opt for any one of the audit course from the list of audit courses prescribed by BOS (Automobile and Mechanical Engineering)

Instructions:

- Practical/Tutorial must be conducted in FOUR batches per division only.
- Minimum number of Experiments/Assignments in PR/Tutorial shall be carried out **as mentioned in the syllabi** of respective courses.
- Assessment of tutorial work has to be carried out similar to term-work. The Grade cum marks for Tutorial and Term-work shall be awarded on the basis of **continuous evaluation.**
- [$] Audit course is mandatory but non-credit course. Examination has to be conducted at the end of Semesters for award of grade at institute level. Grade awarded for audit course shall not be calculated for grade point & CGPA.

Assistant Professor & Head
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Smt. Kashibai Navale College of Engineering, Pune - 41.

302041: Numerical and Statistical Methods					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Tutorial	**1Hr./Week**	**Tutorial**	**1**	**End-Semester**	**70 Marks**
				Term Work	**25 Marks**

Prerequisites: System of linear equations, Partial differentiation, Statistics, Probability, Problem solving and programming.

Course Objectives:

1. **UNDERSTAND** applications of systems of equations and solve mechanical engineering applications.
2. **APPLY** differential equations to solve the applications in the domain of fluid mechanics, structural, etc.
3. **LEARN** numerical integration techniques for engineering applications.
4. **COMPARE** the system's behavior for the experimental data.
5. **INTERPRET** Statistical measures for quantitative data.
6. **ANALYZE** datasets using probability theory and linear algebra.

Course Outcomes:

On completion of the course the learner will be able to;

CO1: **SOLVE** system of equations using direct and iterative numerical methods.
CO2: **ESTIMATE** solutions for differential equations using numerical techniques.
CO3: **DEVELOP** solution for engineering applications with numerical integration.
CO4: **DESIGN** and **CREATE** a model using a curve fitting and regression analysis.
CO5: **APPLY** statistical Technique for quantitative data analysis.
CO6: **DEMONSTRATE** the data, using the concepts of probability and linear algebra.

Course Contents

Unit 1	**Roots of Equation and Simultaneous Equations**	**07 Hrs.**

Roots of Equation: Bracketing method and Newton-Raphson method

Solution of simultaneous equations: Gauss Elimination Method with Partial pivoting, Gauss-Seidel method, Thomas algorithm for Tri-diagonal Matrix.

Unit 2	**Numerical Solution of Differential Equations**	**08 Hrs.**

Ordinary Differential Equations [ODE]: Taylor series method, Euler Method, Runge-Kutta 4^{th} order. Simultaneous equations using Runge-Kutta 2^{nd} order method.

Partial Differential Equations [PDE]: Finite difference method, Simple Laplace method, PDE's Parabolic explicit solution, Elliptic explicit solution.

Unit3	**Numerical Integration**	**06 Hrs.**

Numerical Integration (1D): Trapezoidal rule, Simpson's $1/3^{rd}$Rule, Simpson's$3/8^{th}$Rule, Gauss Quadrature2-point and 3-point method.

Double Integration: Trapezoidal rule, Simpson's $1/3^{rd}$Rule.

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Smt. Kashibai Navale College of Engineering

Unit 4	Curve Fitting and Regression Analysis	08 Hrs.
Curve Fitting: Least square technique- first order, power equation, exponential equation and quadratic equation. **Regression Analysis:** Linear regression, Nonlinear regression, Multiple regressions, Polynomial regression. Lagrange's interpolation, Numerical interpolation and differentiation using Newton's forward method, inverse interpolation (Lagrange's method only).		
Unit 5	**Statistics**	**08 Hrs.**
Measures of central tendency: mean, median, mode. Measurement of variability and dispersion: Standard deviation, standard error, variance, range. Measure of shape: skewness, kurtosis Statistical diagram: scattered diagram, histogram, pie charts, and measure of association between two variables. Correlation: Karl Pearson's Coefficient of correlation and its mathematical properties, Spearman's Rank correlation and its interpretations.		
Unit 6	**Probability and Linear Algebra**	**08 Hrs.**
Probability: Joint, conditional and marginal probability, Bayes' theorem, independence, theorem of total probability, expectation and variance, random variables. Probability distributions: Binomial, Poisson, Geometric, Uniform, Exponential, Gamma, Normal and Chi square. **Linear algebra:** Review of matrix operations, vector and vector spaces, linear mapping.		

Books and other resources

Text Books:

1. Steven C. Chapra, 'Applied Numerical Methods with MATLAB for Engineers and Scientist', Tata Mc-Graw Hill Publishing Co. Ltd.
2. B. S. Grewal, 'Numerical Methods in Engineering and Science', Khanna Publication.
3. B. S. Grewal, 'Higher Engineering Mathematics', Khanna Publication.

References Books:

1. Erwin Kreyszig, 'Advanced Engineering Mathematics', Wiley India
2. Joe D. Hoffman, 'Numerical Methods for Engineers and Scientists', CRC Press
3. Sheldon M. Ross, 'Introduction to Probability and Statistics for Engineers and Scientists', 5e, by Elsevier Academic Press
4. Deisentoth, Faisal, Ong, 'Mathematics for machine learning', Cambridge University Press.
5. Kandasamy, 'Numerical methods', S Chand.
6. Jason Brownlee, 'Statistical Methods for Machine Learning', Machine learning Mastery.

Web References:

1. http://nptel.ac.in/courses/111101003/
2. http://nptel.ac.in/courses/111105038/
3. http://nptel.ac.in/courses/111107063/
4. http://nptel.ac.in/courses/111105041/
5. http://nptel.ac.in/courses/111104079/
6. https://www.analyticsvidhya.com/

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List of Tutorials
Term Work shall consist of: **Group A – (Any three programs using suitable programming language)** 1. Roots of equation 2. Simultaneous equations 3. Ordinary differential equation 4. Partial differential equation 5. Numerical Integration **Group B (Any three programs for simple dataset using suitable programing)** 6. Curve fitting using least square technique 7. Regression analysis 8. Determine statistical measures 9. Probability distribution **Group C (Mandatory)** 10. One program based mini project using mechanical engineering application dataset **Note: Tutorials shall be mandatorily conducted in the computer laboratory.**

Smt. Kashibai Navale College of Engineering * Pune-41.

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Smt. Kashibai Navale College
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302042: Heat and Mass Transfer					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3 Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Practical**	**1**	**End-Semester**	**70 Marks**
				Practical	**50 Marks**

Prerequisites: First and Second Law of Thermodynamics, Fluid properties, Continuity equation, Differential and Integral Calculus, Ordinary differential and Partial Differential Equations, Numerical solution for Differential Equations.

Course Objectives:

1. **IDENTIFY** the laws for different modes of heat transfer.
2. **UNDERSTAND** the properties and economics of thermal insulation and **ANALYZE** heat transfer through fins and thermal systems with lumped heat capacitance.
3. **ANALYZE** the natural and forced convective mode of heat transfer in various geometric configurations.
4. **UNDERSTAND AND REALIZE** various laws with their interrelations and analyze Radiation heat transfer in black and grey bodies/surfaces with or without radiation shields.
5. **UNDERSTAND** the fundamentals and laws of mass transfer and its applications.
6. **ANALYZE** various performance parameters for existing heat exchanger and **DEVELOP** methodologies for designing a heat exchanger under prescribed conditions and for a particular application, with references TEMA standards

Course Outcomes: On completion of the course, learner will be able to

CO1. **ANALYZE** & **APPLY** the modes of heat transfer equations for one dimensional thermal system.

CO2. **DESIGN a** thermal system considering fins, thermal insulation and & Transient heat conduction.

CO3. **EVALUATE** the heat transfer rate in natural and forced convection & validate with experimentation results.

CO4. **INTERPRET** heat transfer by radiation between objects with simple geometries, for black and grey surfaces.

CO5. **ABILITY** to analyze the rate of mass transfer using Fick's Law of Diffusion and understands mass diffusion in different coordinate systems.

CO6. **DESIGN & ANALYSIS** of heat transfer equipments and investigation of its performance.

Course Contents

Unit 1	**Fundamentals of Heat Transfer**	**08 Hrs.**

Basic Concepts: Different Modes and Laws of heat transfer, 3-D heat conduction equation in Cartesian coordinates (with derivation), and its simplified equations, simplified equations in cylindrical and spherical coordinates (simplified equations, no derivation) thermal conductivity,

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College of Engineering, Pune - 41.

thermal diffusivity, electrical analogy, Thermal contact Resistance.

Boundary and initial conditions: Temperature boundary condition, heat flux boundary condition, convection boundary condition, radiation boundary condition.

1-D steady state heat conduction without and with heat generation: Heat conduction without heat generation in plane wall, composite wall, composite cylinder, composite sphere. Heat conduction with heat generation in Plane wall, Cylinder and Sphere with different boundary conditions.

Unit 2	**Heat Transfer through Extended Surfaces & Transient Heat Conduction**	**08 Hrs.**

Thermal Insulation – Critical thickness of insulation, Types and properties of insulating materials, Safety considerations in thermal insulation, Economic and cost considerations, Payback period, Numerical on payback period.

Heat transfer through extended surfaces: Types of fins and its applications, Governing Equation for constant cross sectional area fins, Solution for infinitely long fin (with derivation), adequately long fin with insulated end tip and short fins (no derivation), Fin Efficiency & Effectiveness of fins, estimation of error in Temperature measurement by thermometer.

Transient heat conduction: Validity and criteria of lumped system analysis, Biot Number, Fourier Number, Time Constant and Response of thermocouple, Use of Heisler Charts for plane wall, cylinder and sphere

Unit 3	**Convection**	**08 Hrs.**

Principles of Convection: Local and average heat transfer coefficient, Hydrodynamic and Thermal boundary layer for a flat plate and pipe flow.

Forced Convection: Physical significance of non-dimensional numbers, Empirical correlations for flat plate, pipe flow, and flow across cylinders, spheres, tube banks.

Free Convection: Physical significance of non-dimensional numbers, Free convection from a vertical, horizontal surface, cylinder and sphere. Mixed Convection

Boiling and Condensation: Types of boiling, Regimes of pool boiling, Film wise condensation, Drop wise condensation (No Numerical treatment), Critical heat flux.

Unit 4	**Radiation**	**07 Hrs.**

Thermal Radiation; definition of various terms used in radiation mode; Stefan-Boltzmann law, Kirchhoff's law, Planck's law and Wein's displacement law. Intensity of radiation and solid angle; Lambert's law; Radiation heat exchange between two black surfaces, configuration or view factor. Radiation heat exchange between grey surfaces, Electrical analogy for radiation, Radiation shields, Numerical.

Unit 5	**Mass Transfer**	**07 Hrs.**

Physical origins, applications of mass transfer, Mixture Composition, Phase diagram, Fick's Law of Diffusion with numerical treatment, Restrictive Conditions, Mass diffusion coefficient, Conservation of Species,

The Mass Diffusion equation – Cartesian coordinates deviation, cylindrical coordinates and Spherical coordinates (no derivation), Boundary and initial conditions.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41

Unit 6:	Heat Exchangers and Equipment Design	07 Hrs.

Heat Exchangers: Classification and applications of heat exchangers, Heat exchanger analysis – LMTD for parallel and counter flow heat exchangers, Effectiveness– NTU method for parallel and counter flow heat exchangers, cross flow heat exchangers, LMTD correction factor, Heat Pipe, Introduction to electronic cooling - Active and passive methods of augmented heat transfer.

Process Equipment Design: Condenser Design, Introduction to TEMA standards, Design considerations for heat exchangers, Materials of construction and corrosion, Temperature effects, Radiation effects, Economic consideration, Condenser and Heat exchanger design and performance calculations, Design of shell and tube type Heat Exchanger

Books & Other Resources

Text Books:

1. Franck P. Incropera, David P. DeWitt – Fundamentals of Heat and Mass Transfer,
2. Y. A. Cengel and A.J. Ghajar, Heat and Mass Transfer – Fundamentals and Applications, Tata McGraw Hill Education Private Limited.
3. S.P. Sukhatme, A Textbook on Heat Transfer, Universities Press.
4. R.C. Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New Age Science.
5. Joshi's Process Equipment Design, by V.V. Mahajani , S.B. Umarji ,Trinity Press

Reference Books:

1. P.K. Nag, Heat & Mass Transfer, McGraw Hill Education Private Limited.
2. M.M. Rathod, Engineering Heat and Mass Transfer, Third Edition, Laxmi Publications, New Delhi
3. V. M. Domkundwar, Heat Transfer, Dhanpat Rai & Co Ltd.
4. A.F. Mills, Basic Heat and Mass Transfer, Pearson.
5. S. P. Venkatesan, Heat Transfer, Ane Books Pvt. Ltd.
6. Holman, Fundamentals of Heat and Mass Transfer, McGraw – Hill publication.
7. M. Thirumaleshwar, Fundamentals of Heat and Mass Transfer, Pearson Education India.
8. B.K. Dutta, Heat Transfer-Principles and Applications, PHI.
9. C.P. Kothandaraman, S. V. Subramanyam, Heat and Mass Transfer Data Book, New Academic Science.
10. Process heat Transfer, D. Q. Kern, Wiley Publication

NPTEL Links:

E books: Links to be provided

1. https://libgen.is
2. http://libgen.li/item/index.php?md5=314BFA11A24C3C1ACFDED2B5AB88E5E9

Links of NPTEL / related videos

1. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785
2. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785
3. https://www.youtube.com/watch?v=J_zqQcncAu4&index=3&list=PLpCr5N2IS7Nmu22MOgDWOr0sSIJptJNUz3
4. https://www.youtube.com/watch?v=SNnd0f3xXlg&list=PLpCr5N2IS7Nmu22MOgDWOr0s

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College of Engineering, Pune - 41.

SlIpUNUz3&index=11

5. https://www.youtube.com/watch?v=SNnd0f3xXlg&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3&index=11
6. https://www.youtube.com/watch?v=lnFjt30goiY&index=18&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

Complete **eight** experiments and **two** assignments (Sr. no.10 to 13).

1. Determination of Thermal Conductivity of insulating powder.
2. Determination of Thermal Conductivity of metal rod.
3. Determination of local and average heat transfer coefficient in Natural Convection.
4. Determination of local and average heat transfer coefficient in Forced Convection.
5. Determination of temperature distribution, fin efficiency in Natural / Forced Convection.
6. Determination of Emissivity of a Test surface.
7. Determination of Stefan Boltzmann Constant.
8. Determination of heat transfer, overall heat transfer coefficient and effectiveness of Plate Heat Exchanger.
9. Study of Pool boiling phenomenon and determination of Critical Heat Flux (CHF).
10. Assignment to solve transient heat transfer problem using Heisler and Grober Charts.
11. Design of heat exchanger for any simple application.
12. Industrial visit to heat treatment industry/ heat exchanger manufacturing industry.
13. Demonstration of dropwise and filmwise condensation.
14. Virtual laboratory: study of the performance of heat exchanger /study of variation of Thermal Conductivity.

Link for Virtual Lab: - https://www.vlab.co.in/

Smt. Kashibai Navale College of Engineering * Pune-41.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

302043: Design of Machine Elements					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Practical**	**1**	**End-Semester**	**70 Marks**
				Oral	**25 Marks**

Prerequisites: The basics of material elastic behavior, stress, strain, its relationship, failure modes, different theories of failure and its applications. The design cycle, basis of design considerations like strength, rigidity, manufacture, assembly and cost, standards and codes. The preferred sizes and series, tolerances and types of fits. Construction of SMD and BMD. Roots of equations, Interpolation rule.

Course Objectives:

1. **UNDERSTAND** the various design considerations, design procedure and select materials for a specific application
2. **CALCULATE** the stresses in machine components due to various types of loads and failure
3. **ANALYZE** machine components subjected to variable loading for finite and infinite life
4. **DESIGN** various machine components such as shafts, couplings, keys, screws, joints, springs

Course Outcomes:

On completion of the course, learner will be able to

CO1. **DESIGN AND ANALYZE** the cotter and knuckle Joints, levers and components subjected to eccentric loading.

CO2. **DESIGN** shafts, keys and couplings under static loading conditions.

CO3. **ANALYZE** different stresses in power screws and **APPLY** those in the procedure to design screw jack.

CO4. **EVALUATE** dimensions of machine components under fluctuating loads.

CO5. **EVALUATE & INTERPRET** the stress developed on the different type of welded and threaded joints.

CO6. **APPLY** the design and development procedure for different types of springs.

Course Contents

Unit 1	**Design of Simple Machine Elements**	**08 Hrs.**

Factor of safety, Selection of Factor of Safety, Service factor, Design of Cotter joint, Knuckle joint, Design of hand / foot lever, lever for safety valve, bell crank lever, Design of components subjected to eccentric loading.

Unit 2	**Design of Shafts, Keys and Couplings**	**08 Hrs.**

Shaft design on the Strength basis, torsional rigidity basis and lateral rigidity basis, Design of shaft as per A.S.M.E. code. Design of square and rectangular keys, Kennedy key and splines. Design of Flange Coupling and Bushed-Pin Flexible Coupling.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College of Engineering, Pune - 41.

Unit 3	Design of Power Screws	07 Hrs.
Terminology of Power Screw, Torque analysis and Design of power screws with square and trapezoidal threads, Collar friction torque, Self-locking screw, Efficiency of square threaded screw, Efficiency of self-locking screw, Design of screw, nuts and C-Clamp. Design of screw jack, Differential and Compound Screw and Re-circulating Ball Screw (Theoretical treatment only).		
Unit 4	**Design against Fluctuating loads**	**07 Hrs.**
Stress concentration and its factors, Reduction of stress concentration factors, fluctuating stresses, fatigue failures, endurance limit, S-N curve, Notch sensitivity, Endurance limit, Endurance strength modifying factors, Reversed stresses – Design for Finite and Infinite life, Cumulative damage in fatigue failure, Soderberg, Gerber, Goodman Lines, Modified Goodman diagrams, Fatigue design under combined stresses:- (Theoretical treatment only.)		
Unit 5	**Threaded and Welded joints**	**08 Hrs.**
Introduction to threaded joints, Bolts of uniform strength, locking devices, eccentrically loaded bolted joint in shear, Eccentric load perpendicular and parallel to axis of bolt, Eccentric load on circular base. Introduction to welded joints, Strength of butt, parallel and transverse fillet welds, Axially loaded unsymmetrical welded joints, Eccentric load in plane of welds, Welded joints subjected to bending and torsional moments.		
Unit 6	**Design of Springs**	**07 Hrs.**
Types and applications of springs, Stress and deflection equations for helical compression Springs, Springs in series and parallel, Design of helical springs, concentric helical springs, surge in spring, Design of Multi-leaf springs, Nipping of Leaf springs, Shot Peening.		

Books and other resources

Text Books:

1. Bhandari V.B., Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd.
2. Shigley J.E. and Mischke C.R., Mechanical Engineering Design, McGraw Hill Publication Co. Ltd.

References Books:

1. Spotts M.F. and Shoup T.E., Design of Machine Elements, Prentice Hall International.
2. Juvinal R.C., Fundamentals of Machine Components Design, John Wiley and Sons.
3. Black P.H. and O. Eugene Adams, Machine Design, McGraw Hill Book Co. Inc.
4. Willium C. Orthwein, Machine Components Design, West Publishing Co. and Jaico Publications House.
5. Hall A.S., Holowenko A.R. and Laughlin H.G, Theory and Problems of Machine Design, Schaum's Outline Series.
6. C. S. Sharma and Kamlesh Purohit, Design of Machine Elements, PHI Learing Pvt. Ltd.
7. D. K. Aggarwal & P. C. Sharma, Machine Design, S.K Kataria and Sons.
8. P. C. Gope, Machine Design: Fundamentals and Applications, PHI Learing Pvt. Ltd.
9. Design Data - P.S.G. College of Technology, Coimbatore.
10. K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, CBS Publishers.

Assistant Professor & Head
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Smt. Kashibai Navale College of Engineering, Pune - 41.

Term Work		
The student shall complete the following activity as a Term Work; The term work shall consist of three design projects. The design project shall consist of assembly drawing, with a bill of material and overall dimensions and drawings of individual components. The Project should be assigned to a group of maximum four students. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified for important surfaces. A design report giving all necessary calculations of the design of components should be submitted in a separate file. Design data book shall be referred for selection of materials and standard components for given loading conditions. All three design projects should be carried out using suitable software. Project 1: - Cotter joint/ knuckle joint/turn buckle for a specified application. Project 2: - Bush Pin Flexible Coupling for specified application. Project 3: - Bottle type/toggle jack for vehicles. OR Project 3: - A Design Project to develop and apply the knowledge of Machine Design and drafting software for any mechanical system on the basis of: (1) Idea generation, (2) Creativity, Reliability and safety, (3) Design parts of the system (4) Ergonomic Considerations (5) Use of International standards.		
Web References:		
UNIT 1: Design of Simple Machine Elements		
Sr. No	**Topic Title**	**NPTEL video Link**
1	Factor of safety, Selection of Factor of Safety, Service factor	https://www.youtube.com/watch?v=ofmbhbVCUqI&list=PL3D4EECEFAA99D9BE&index=3
2	Design of components subjected to eccentric loading.	https://www.youtube.com/watch?v=__py5xbKHGA
UNIT 2: Design of Shafts, Keys and Couplings		
3	Design of shaft as per A.S.M.E. code	https://www.youtube.com/watch?v=SL21aDqgs8Q
4	Design of a C-Clamp. Design of screw jack,	https://youtu.be/PEKfS2Q1WqM https://www.youtube.com/watch?v=PEKfS2Q1WqM&list=PL3D4EECEFAA99D9BE&index=19
5	Differential and Compound Screw and Re-circulating Ball Screw	https://www.youtube.com/watch?v=TPURJnlekeo
UNIT 4: Design against Fluctuating Loads		
6	Cumulative damage in fatigue failure,	https://www.youtube.com/watch?v=WRoPQGE0WdI
7	Soderberg, Gerber, Goodman Lines, Modified Goodman Diagrams	https://www.youtube.com/watch?v=WRoPQGE0WdI
8	Fatigue design under combined stresses	https://www.youtube.com/watch?v=WRoPQGE0WdI

UNIT 5: Threaded and Welded joints		
9	Eccentrically loaded bolted joint in shear, Eccentric load perpendicular and parallel to axis of bolt	https://www.youtube.com/watch?v=__py5xbKHGA https://www.youtube.com/watch?v=YZYcMtkZiDY
10	Eccentric load on circular base	https://www.youtube.com/watch?v=__py5xbKHGA
11	Eccentric load in plane of welds, Welded joints subjected to bending and torsional moments	https://www.youtube.com/watch?v=__py5xbKHGA https://www.youtube.com/watch?v=YZYcMtkZiDY
UNIT 6: Design of Springs		
12	Surge in spring	https://www.youtube.com/watch?v=tTBnW5gAieM
13	Shot Peening.	https://www.youtube.com/watch?v=46quOD7V-cQ
14	Design of Multi-leaf	https://youtu.be/T4IgtIkBnOo

Asst. Professor and Head
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Assistant Professor & Head
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Smt. Kashibai Navale College
of Engineering, Pune - 41.

302044: Mechatronics					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Practical**	**1**	**End-Semester**	**70 Marks**
				Oral	**25 Marks**

Prerequisites: Basics of Electrical components, Binary to Decimal Conversion, Data communication Module, Op amp Circuits, Linear Algebra, Laplace Transformation method, Logic gates.

Course Objectives:

1. **UNDERSTAND** the key elements of mechatronics, principle of sensor and its characteristics.
2. **UNDERSTAND** the concept of signal processing and use of interfacing systems such as ADC, DAC, Digital I/O.
3. **UNDERSTAND** the block diagram representation and concept of transfer function.
4. **UNDERSTAND** the system modeling and analysis in frequency domain.
5. **UNDERSTAND** the system modeling and analysis in time domain, controller modes and its industrial applications..
6. **UTILIZE** the concepts of PLC system and its ladder programming and significance of PLC system in industrial application.

Course Outcomes:

On completion of the course, learner will be able to

CO1. **DEFINE** key elements of mechatronics, principle of sensor and its characteristics.
CO2. **UTILIZE** concept of signal processing and **MAKE** use of interfacing systems such as ADC, DAC, Digital I/O.
CO3. **DETERMINE** the transfer function by using block diagram reduction technique.
CO4. **EVALUATE** Poles and Zero, frequency domain parameter for mathematical modeling for mechanical system.
CO5. **APPLY** the concept of different controller modes to an industrial application.
CO6. **DEVELOP** the ladder programming for industrial application.

Course Contents

Unit 1	**Introduction to Mechatronics, Sensors & Actuators**	**07 Hrs.**

Introduction to Mechatronics and its Applications Measurement Characteristics (Static/Dynamic), **Sensors:** Types of sensors; Motion Sensors – Encoder (Absolute & incremental), Lidar, Eddy Current, Proximity (Optical, Inductive, Capacitive), MEMS Accelerometer; Temperature sensor – Pyrometer, Infrared Thermometer; Force / Pressure Sensors – Strain gauges, Piezoelectric sensor; Flow sensors – Electromagnetic, Ultrasonic, Hot-wire anemometer; Color sensor – RGB type; Biosensors – Enzyme, ECG, EMG
Actuators: Servo motor; Hydraulic and Pneumatic (must be restricted to classification and working of one type of linear and rotary actuator); linear electrical actuators Selection of Sensor & Actuator

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

Unit 2	Data Acquisition and Signal Communication	08 Hrs.
Signal Communication: Serial, Parallel; Synchronous, Asynchronous Introduction to DAQ, Types, Components of a Data Acquisition System (Sensor, Signal conditioning, processing, controlling and storage/display/action) Data Acquisition: Signal collection, Signal conditioning – Isolation& Filtering, Amplification, Sampling, Aliasing, Sample and hold circuit, Quantization, Analog-to-digital converters (4 bit Successive Approximation type ADC), Digital-to-Analog converters (4 bit R2R type DAC), Data storage Applications: DAQ in Household ,Digital Pressure Gauge, Digital Flow measurement, DVB Digital Video Broadcast, AM/FM		
Unit 3	**Control systems & transfer function based modelling**	**07 Hrs.**
Introduction to control systems, need, Types- Open and Closed loop, Concept of Transfer Function, Block Diagram & Reduction principles and problems; Applications (Household, Automotive, Industrial shop floor) Transfer Function based modeling of Mechanical, Thermal and Fluid system; Concept of Poles & Zeros; Pole zero plot, Stability Analysis using Routh Hurwitz Criterion (Numerical Approach)		
Unit 4	**Time and Frequency Domain Analysis**	**08 Hrs.**
Time Domain Analysis – Unit step Response analysis via Transient response specifications (Percentage overshoot, Rise time, Delay time, Steady state error etc.) Frequency Domain Analysis – Frequency Domain Parameters - Natural Frequency, Damping Frequency and Damping Factor; Mapping of Pole Zero plot with damping factor, natural frequency and unit step response ; Introduction to Bode Plot, Gain Margin, Phase Margin		
Unit 5	**Controllers**	**07 Hrs.**
Introduction to controllers, Need for Control, Proportional (P), Integral (I) and Derivative (D) control actions; PI, PD and PID control systems in parallel form; (Numerical approach), Feed forward anticipatory control Manual tuning of PID control, Ziegler–Nichols method Applications: Electro–Hydraulic/Pneumatic Control, Automotive Control		
Unit 6	**Programmable Logic Controller (PLC)**	**08 Hrs.**
Introduction to PLC; Architecture of PLC; Selection of PLC; Ladder Logic programming for different types of logic gates; Latching; Timers, Counters; PLC control of Hydraulics / Pneumatics / Mechatronics systems involving timing and counting operations.		

Books and other resources

Text Books:

1. William Bolton, Mechatronics: Electronics Control Systems in Mechanical and Electrical Engineering, 6th Ed, 2019
2. K.P. Ramchandran, G.K. Vijyaraghavan, M.S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Willey Publication, 2008

References Books:

1. Alciatore and Histand, Introduction to Mechatronics and Measurement Systems, 5th Ed, 2019
2. Bishop (Editor),Mechatronics – An Introduction CRC 2006
3. Mahalik, Mechatronics – Principles, concepts and applications, Tata Mc-Graw Hill publication, New Delhi
4. C.D.Johnson, Process Control Instrumentation Technology, Prentice Hall,New Delhi
5. Bolton, Programmable Logic Controller, 4th Ed, Newnes, 2006

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College of Engineering, Pune - 41

Web References:

1. https://www.elprocus.com/what-is-a-biosensor-types-of-biosensors-and-applications/
2. https://www.elprocus.com/color-sensor-working-and-applications/
3. https://www.youtube.com/watch?v=kbjCGGTXqUo&ab_channel=Controlengineering
4. https://youtu.be/clTA0pONnMs?list=PLHMDN3JFtE5wEz95H2XuzRaafK3fUsaki
5. https://nptel.ac.in/content/storage2/courses/108105063/pdf/L-12(SS)%20(IA&C)%20((EE)NPTEL).pdf
6. https://nptel.ac.in/content/storage2/courses/112104158/lecture5.pdf

Term Work

The Term work shall consist of completion of Practical, Self-learning Study Assignments and Presentations. Oral examination shall be based on the Term work undertaken during the semester.

Practical (**Any one** experiments out of experiment no **1 to 3** from the following list whereas experiment no. **4 to 10** are mandatory).

1. Experiment on measurement of temperature using suitable sensor.
2. Experiment on measurement of load using suitable sensor.
3. Experiment on measurement of displacement using suitable sensor.
4. Development of a data acquisition / mechatronics system using low cost open source hardware and software.
5. Experiment on interfacing of suitable sensor and actuator with DAQ.
6. Modeling and analysis of mechanical system and its verification using suitable simulation software.
7. PID control of Mechanical System using suitable simulation software and experimental verification (verification only if experimental setup is available).
8. Ladder Logic Simulation of suitable application.
9. Demonstration of PLC controlled electro hydraulic / elector pneumatic circuit.
10. Industrial visit to understand integration and application of Mechatronics.

Assignments:

1. Application of Sensors and Actuators in Health Science and Selection of Suitable Sensor and Actuator.
2. Block Diagram Representation of Feedback Control System and determination of Closed Loop Transfer Function.

Smt. Kashibai Navale College of Engineering Pune-41

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

302045-A: Advanced Forming & Joining Processes					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisite Courses: Manufacturing Processes, Engineering Materials and Metallurgy, Machine shop

Course Objectives:

1. **UNDERSTAND** advances in sheet metal forming operations
2. **UNDERSTAND** the advanced special metal forming processes.
3. **UNDERSTAND** weld metallurgy and weld characterization techniques.
4. **UNDERSTAND** and describe various advanced solid state welding processes.
5. **CLASSIFY AND DESCRIBE** various advanced welding processes.
6. **KNOW** about sustainable manufacturing and its role in manufacturing industry

Course Outcomes:

On completion of the course, learner will be able to

CO1. **ANALYSE** the effect of friction in metal forming deep drawing and IDENTIFICATION of surface defects and their remedies in deep drawing operations

CO2. **ASSESS** the parameters for special forming operation and SELECT appropriate special forming operation for particular applications

CO3. **ANALYSE** the effect of HAZ on microstructure and mechanical properties of materials

CO4. **CLASSIFY** various solid state welding process and **SELECT** suitable welding processes for particular applications

CO5. **CLASSIFY** various advanced welding process and **SELECT** suitable welding processes for particular applications.

CO6. **INTERPRET** the principles of sustainable manufacturing and its role in manufacturing industry.

Course Contents

Unit 1	**Mechanics of Sheet Metal Forming**	**08 Hrs.**

Theory of plasticity – yield criteria-work of plastic deformation- Sheet Metal Forming-Formability studies-conventional processes, Effect of friction in forming operation, Experimental techniques of evaluation of friction in metal forming, deep drawing, analysis (Numerical), surface defects identification and remedies, introduction to Forming simulation, Challenges in Forming.

Unit 2	**Special Forming Processes**	**08 Hrs.**

Special Forming Processes: HVF, HERF (Explosive Forming) techniques- super plastic forming techniques-Hydro forming-Stretch forming, Laser beam forming-principles and process parameters-Advantages, limitations and applications of different forming processes. Orbital forging-Isothermal-Hot and cold isostatic pressing-High speed extrusion, Water hammer forming, Incremental Sheet forming, Magnetic Pulse forming, Metal Spinning, Electro Hydraulic Forming, Micro forming.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

Unit 3	Weld Metallurgy	07 Hrs.
Weld Metallurgy: Weld thermal cycles and their effects, effects of pre and post weld heat treatments, concept of HAZ, concept of weldability and its assessment. Welding of dissimilar materials, Weld characterization, Weld decay and weld sensitization, Introduction to ASME, ASWE, IS Welding Standards, (welding skill levels).		
Unit 4	**Solid State Welding Processes**	**07 Hrs.**
Solid State Welding Processes: Cold pressure welding, Diffusion bonding, Explosive welding, Ultrasonic welding, Friction stir welding, Forge welding, Roll welding and Hot pressure welding processes - features, advantages, limitations and applications, Advances in adhesive bonding, cladding.		
Unit 5	**Advanced Welding Processes**	**08 Hrs.**
Advanced Welding Processes: Electrogas, electroslag welding, Atomic hydrogen welding, Electron beam welding, Laser Beam welding - principle, working and applications, Cold Metal Transfer - concepts, processes and applications, Underwater welding, Welding automation in aerospace, nuclear and surface transport vehicles, Robotic Welding, Plasma Arc Welding, Plasma Transferred Arc Welding.		
Unit 6	**Sustainable Manufacturing**	**07 Hrs.**
Sustainable Manufacturing: Introduction to sustainability and drivers for sustainable development and sustainable manufacturing, fundamentals of sustainable manufacturing, various tools, factors of sustainability, Principles of Life Cycle Assessment (Goal, Scope and Life Cycle Inventory), Approaches, Role in Industry 4.0, Green Manufacturing, Environment protection norms, ISO 14000, recycling techniques, safety norms in forming and welding, socio-economic aspects, case study on waste recycling, material recycling, etc.		

Books and other resources

Text Books:

1. Sindo Kou, "Welding Metallurgy", Wiley Publications Second Edition
2. Dr. V. D. Kodgire and S. V. Kodgire, "Material Science & Metallurgy For Engineers", Everest Publication
3. William D. Callister, "Materials Science and Engineering an Introduction", Jr, John Wiley & Sons, Inc.
4. O.P. Khanna, " Welding Technology", Dhanpat Rai & Sons Publications Edition 2015
5. Dr. R. S. Parmar,"Welding Processes and Technology", Khanna Publications Edition 2017
6. J. Paulo Davim, " Sustainable Manufacturing", Wiley Publications Edition 2010

References Books:

1. Z. Marciniak, J.L.Duncan, "Mechanics of Sheet Metal Forming", Butterworth Heinemann-2002.
2. Dr. Sadhu Singh, "Theory of Plasticity and Metal Forming Processes", Khanna Publishers Edition 2008
3. O.P. Khanna, " Engineering Metallurgy", Dhanpat Rai & Sons Publications
4. Ali Hasan - Islam Nawaz, "Advanced Welding Technology", SCITECH Publications India Pvt. Ltd. Edition 2018
5. Dr. K. S. Yadav, "Advanced Welding Technology"', Rajsons Publications Pvt. Ltd.
6. Tool and Manufacturing Engineers' Handbook: Forming V by Charles Wick Publisher

Smt. Kashibai Navale College of Engineering Pune-41.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

: Society of Manufacturing Engineers; 4th edition (1 Aug. 1996)
7. Dornfeld and David, "Green Manufacturing" - Fundamentals and Applications, DOI 10.1007/978.1.4419.6016.0_2, Springer Science +Business Media, New York 2013.
8. R. Ganesh Narayanan, Jay S Gunasekera,"Sustainable Material Forming and Joining", by CRC Press 2020.

Web References:

1. NPTEL Course on "Forming" by Dr. R. Chandramouli, IIT Madras
2. NPTEL Course on "Welding Engineering" by Dr. D. K. Dwivedi, IIT Roorkee
3. NPTEL Course on "Advances in welding and joining technologies" by Prof. SwarupBag IIT Guwahati.
4. NPTEL Course on "Welding Metallurgy" by Prof. Pradeep K. Jha, IIT Roorkee
5. NPTEL Course on "Sustainability through Green Manufacturing System – An Applied Approach" by Prof. Deepu Philip IIT Kanpur and Dr. Amardeep Singh Oberaoi, NIT Jalandar.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

302045-B:Machining Science &Technology					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: Mechanics, Gear terminology, Material properties, Degree of freedom.

Course Objectives:

1. **KNOW** about fundamentals of metal cutting process, tool wear and tool life.
2. **IMPART** the knowledge of machining phenomenon like milling, gear and thread manufacturing, grinding, super finishing, etc.
3. **UNDERSTAND** the basic concepts, importance and functions of Jigs, Fixtures.
4. **PREPARE** list of operations, tools, set of manufacturing instructions and selection of quality assurance method.
5. **GENERATE** CNC program for appropriate machining processes like turning and milling.

Course Outcomes:

On completion of the course, learner will be able to

CO1. **DEFINE** metal cutting principles and mechanics of metal cutting and tool life.
CO2. **DESCRIBE** features of gear and thread manufacturing processes.
CO3. **SELECT** appropriate grinding wheel and demonstrate the various surface finishing processes.
CO4. **SELECT** appropriate jigs/fixtures and to draw the process plan for a given component.
CO5. **SELECT & EVALUATE** various parameters of process planning.
CO6. **GENERATE** CNC program for Turning / Milling processes and generate tool path using CAM software.

Course Contents

Unit 1	**Mechanics of Metal Cutting**	**08 Hrs.**

Introduction to metal cutting, Elements of machining process, Geometry of single-point cutting tool, Orthogonal and Oblique cutting processes,

Chip formation, Types of chips, Chip thickness ratio, Process parameters and their effect on machining, chip breakers,

Merchant's Circle of forces analysis – forces and energy calculations, power consumed – MRR- Effect of Cutting variables on forces,

Concepts of Machinability- Factors affecting machinability, Machinability Index, Tool Life, Tool life equation of Taylor, Tool wear and its types, Factors affecting on tool life.

Unit 2	**Gear and Thread Manufacturing**	**07 Hrs.**

Introduction, Materials of gears, Methods of gear manufacturing-casting, forging, forming etc, milling of gears (indexing methods and numerical), Helical gear cutting, Gear Shaping and Gear hobbling, Gear inspection.

Thread Manufacturing: Various methods of thread manufacturing, thread rolling, die threading & tapping, Thread milling, Thread grinding etc.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College of Engineering, Pune - 41.

6. Process Planning- Design/Manufacture Interface, Scallan P, Butterworth-Heinemann, 2003
7. CNC Machines, B. S. Pabla, M. Adithan, New Age International, 2018
8. Manufacturing Science, Amitabh Ghosh and AshokKumar Mallik, Affiliated East-West Press, 2010

Web References:

1. https://nptel.ac.in/content/storage2/courses/108105063/pdf/L-
2. https://nptel.ac.in/content/storage2/courses/112105127/pdf/LM-32.pdf
3. https://nptel.ac.in/content/storage2/courses/112105127/pdf/LM-34.pdf
4. https://nptel.ac.in/courses/112/107/112107143/

Smt. Kashibai Navale College of Engineering Pune-41.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

302046: Digital Manufacturing Laboratory					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**Term Work**	**50 Marks**

Prerequisites: Construction and operating of conventional machine tools, principles of machining and forming processes, cutting tool and machining parameters, programming languages like C, Python etc., basics of 3D printing.

Course Objectives:

1. **ACQUIRE** skills to handle conventional machines and CNC machine for manufacturing of a component.
2. **PREPARE** manual part program for given component as per ISO standards.
3. **ACCUSTOM** skills of Additive manufacturing technology.
4. **APPRECIATE** the influence of cutting tool parameters on the performance.
5. **APPLY** Digital Manufacturing tools for process simulation of manufacturing processes.
6. **SELECT** appropriate type of jigs and fixtures for a given component

Course Outcomes:

On completion of the course, learner will be able to

CO1.**DEVELOP** a component using conventional machines, CNC machines and Additive Manufacturing Techniques.

CO2.**ANALYZE** cutting tool parameters for machining given job.

CO3.**DEMONSTRATE** simulation of manufacturing process using Digital Manufacturing Tools.

CO4.**SELECT** and **DESIGN** jigs and Fixtures for a given component.

CO5.**DEMONESTRATE** different parameters for CNC retrofitting and reconditioning.

Guidelines for Laboratory Conduction

The learner shall complete the following activity as a Term Work;

1. Demonstration of cutting tool geometry and nomenclature of the tools used in conventional and CNC machines.
2. Machining of a mechanical component using conventional machines such as lathe, drilling, milling, grinding and any additional machine tool or processes as per requirement. Manufacturing drawing with appropriate geometrical and dimensional tolerances, detailed process planning to be included.
3. Preparing manual CNC part program using G Codes and M Codes as per ISO (DIN 66025) and RS274 standards for CNC lathe/mill machine.
4. Machining of mechanical component using CNC machine (Lathe/Mill/HMC/VMC). Manufacturing drawing with appropriate geometrical and dimensional tolerances, detailed process planning to be included.
5. Demonstration of Additive Manufacturing technology (from modelling to printing) (To be performed Batch-wise)
6. Demonstration of the usage of Digital Manufacturing tools for process simulation of manufacturing processes like casting, forging, sheet metal, plastic processing (free / open source software)

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College of Engineering, Pune - 41

7. Demonstration of various types of jigs and fixtures, and a case study on design and use of Jigs & Fixture for any given component.
8. Preparing Online Calculator/Catalogue for selection of cutting parameters by using programming languages like C, Python etc.
9. Study on CNC retrofitting and reconditioning
10. Visit to an Industry which uses advanced manufacturing processes

Please note following instructions regarding Laboratory Conduction:

1. Sr. No. 1 to 7are mandatory and any 2 from Sr. No. 8 to 10.
2. Practical are to be performed under the guidance of concerned faculty member.
3. Journal should consist of Job Drawing, Process Sheet and Program, appropriate write-up and shall be part of term-work submission.

Smt. Kashibai Navale College of Engineering Pune-41.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

302047: Skill Development					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**TW**	**25 Marks**

Prerequisites: Students should have knowledge of Construction and working of IC engine / compressor / gear box / centrifugal pump/tail stock. Working principles of any type of mechanism / power plants. Working of electric and hydraulic systems of 4 wheeler vehicle. Working of machine tools, engine and transmission of different automotive and home appliances. Advanced manufacturing processes. Solid mechanics and design of machine elements.

Course Objectives:

1. **INTRODUCE** the skills required in an industry such as design, development, assembly & disassembly.
2. **DEVELOP** the skills required for fault diagnose of engine and transmission of different automotive and various home appliances.
3. **ESTABLISH** the skills required for maintenance of any machine tool.
4. **CREATE** awareness about industrial environment.

Course Outcomes:

On completion of the course, learner will be able to

CO1.**APPLY& DEMONSTRATE** procedure of assembly & disassembly of various machines.
CO2.**DESIGN & DEVELOP** a working/model of machine parts or any new product.
CO3.**EVALUATE** fault with diagnosis on the machines, machine tools and home appliances.
CO4.**IDENTIFY** & **DEMONSTRATE** the various activities performed in an industry such as maintenance, design of components, material selection.

Course Contents

1. Assembly and Disassembly of any of the following mechanical systems/ subsystems: bicycle (geared), e-Bikes, e-Motor Cycles, Drones, Flying devices, gear box, IC engines, centrifugal pump etc.
2. Assembly- Disassembly/ Fault diagnosis of home appliances such as mixer, grinder, washing machine, fan, ovens, gas geyser, chopping machine, kneading machine, exercise machines, etc.
3. Development and demonstration of working/animation model of any mechanism.
4. Design a circuit of electric and hydraulic system of4 wheelers and its verification.

   OR

   Circuit design /PCB design using software for control of BLDC electric motors used in e-Vehicles.
5. Undertake total preventive maintenance for any machine tool or mechanical system.
6. Visit to an industry for awareness about preventive maintenance.
7. Use of ergonomic principles for the design of hand tools, control in automobile dashboards, human operated mobile devices.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College of Engineering, Pune - 41.

8. Use of alternative materials in the construction of daily activity machine and tool components
9. Interpretation of Drawings; Exercises in identifying the type of production, extracting important functional dimensions, checking the number of parts in an assembly. Checking and listing missing dimensions.
10. Exercises in -preparation of detailed production drawings as per BIS standard of simple machine parts having relevant notes and indications (limits/tolerances, surface finish, the process of production, relevant tools, materials, measuring instruments).

The documentation activity as a part of the Term work shall not be restricted to merely generation of 2D/3D CAD Drawings with dimensions (as applicable), Exploded View, Flowchart of Maintenance Work etc. but can be beyond.

Skill Development Documentation Diary must be maintained by every student.

Smt. Kashibai Navale College of Engineering Pune-41

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

302048: Audit Course V		
Teaching Scheme	**Credits**	**Examination Scheme**
	Non-Credit	

GUIDELINES FOR CONDUCTION OF AUDIT COURSE

Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self-learning is being pursued by the students 'in true letter and spirit'.

- If any course through Swayam/ NPTEL/ virtual platform is selected the minimum duration shall be of 8 weeks.
- However if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken.

In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from third year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself.

Selecting an Audit Course

List of Courses to be opted (Any one) under Audit Course V

- Entrepreneurship and IP strategy
- Engineering Economics
- Mangment of Inventory Systems

The titles indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BOS.

Using NPTEL Platform: (preferable)

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Students can select any one of the courses mentioned above and has to register for the

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

corresponding online course available on the NPTEL platform as an Audit course. • Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal. • After clearing the examination successfully; student will be awarded with a certificate.
Assessment of an Audit Course
• The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary. • During the course students will be submitting the online assignments. A copy of the same can be submitted as a part of term work for the corresponding Audit course. • On the satisfactory submission of assignments, the institute can mark as "Present" and the student will be awarded the grade AP on the mark-sheet.

Smt. Kashibai Navale College of Engineering Pune-41.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

302049: Artificial Intelligence & Machine Learning					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Practical**	**1**	**End-Semester**	**70 Marks**
				Oral	**25 Marks**

Prerequisites: Linear Algebra, Probability, Statistics, Logical Reasoning.

Course Objectives:

1. **ACQUAINT** with fundamentals of artificial intelligence and machine learning.
2. **LEARN** feature extraction and selection techniques for processing data set.
3. **UNDERSTAND** basic algorithms used in classification and regression problems.
4. **OUTLINE** steps involved in development of machine learning model.
5. **FAMILIARIZE** with concepts of reinforced and deep learning.
6. **IMPLEMENT AND ANALYZE** machine learning model in mechanical engineering problems.

Course Outcomes:

On completion of the course, learner will be able to

CO1. **DEMONSTRATE** fundamentals of artificial intelligence and machine learning.
CO2. **APPLY** feature extraction and selection techniques.
CO3. **APPLY** machine learning algorithms for classification and regression problems.
CO4. **DEVISE AND DEVELOP** a machine learning model using various steps.
CO5. **EXPLAIN** concepts of reinforced and deep learning.
CO6. **SIMULATE** machine learning model in mechanical engineering problems.

Course Contents

Unit 1	**Introduction to AI & ML**	**06 Hrs.**

History of AI, Comparison of AI with Data Science, Need of AI in Mechanical Engineering, Introduction to Machine Learning. **Basics:** Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation.

Approaches to AI: Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical.

Approaches to ML: Supervised learning, Unsupervised learning, Reinforcement learning.

Unit 2	**Feature Extraction and Selection**	**08 Hrs.**

Feature extraction: Statistical features, Principal Component Analysis.

Feature selection: Ranking, Decision tree - Entropy reduction and information gain, Exhaustive, best first, Greedy forward & backward, Applications of feature extraction and selection algorithms in Mechanical Engineering.

Unit 3	**Classification & Regression**	**08 Hrs.**

Classification: Decision tree, Random forest, Naive Bayes, Support vector machine.

Regression: Logistic Regression, Support Vector Regression. **Regression trees:** Decision tree, random forest, K-Means, K-Nearest Neighbor (KNN). Applications of classification and regression algorithms in Mechanical Engineering.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

Unit 4	Development of ML Model	07 Hrs.
Problem identification: classification, clustering, regression, ranking. Steps in ML modeling, Data Collection, Data pre-processing, Model Selection, Model training (Training, Testing, K-fold Cross Validation), Model evaluation (understanding and interpretation of confusion matrix, Accuracy, Precision, Recall, True positive, false positive etc.), Hyper parameter Tuning, Predictions.		
Unit 5	**Reinforced and Deep Learning**	**08 Hrs.**
Characteristics of reinforced learning; Algorithms: Value Based, Policy Based, Model Based; Positive vs Negative Reinforced Learning; Models: Markov Decision Process, Q Learning. Characteristics of Deep Learning, Artificial Neural Network, Convolution Neural Network. Application of Reinforced and Deep Learning in Mechanical Engineering.		
Unit 6	**Applications**	**08 Hrs.**
Human Machine Interaction, Predictive Maintenance and Health Management, Fault Detection, Dynamic System Order Reduction, Image based part classification, Process Optimization, Material Inspection, Tuning of control algorithms.		

Books and other resources

Text Books:

1. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
2. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
3. Parag Kulkarni and Prachi Joshi, "Artificial Intelligence – Building Intelligent Systems", PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015
4. Stuart Russell and Peter Norvig (1995), "Artificial Intelligence: A Modern Approach," Third edition, Pearson, 2003.

References Books:

1. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.
2. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
3. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.
4. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)
5. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMH

Web References:

1. http://nptel.ac.in/courses/111101003/
2. https://nptel.ac.in/courses/106/106/106106202/
3. https://nptel.ac.in/courses/112/103/112103280/
4. https://www.analyticsvidhya.com/

Smt. Kashibai Navale College of Engineering Pune-41

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College of Engineering, Pune - 41.

Term Work
List of Experiments: 1. To study supervised/unsupervised/Reinforcement learning approach. 2. To acquire, visualize and analyze the data set (from time-domain/ frequency-domain/ etc.) . 3. To extract features from given data set and establish training data. 4. To select relevant features using suitable technique. OR 5. To use PCA for dimensionality reduction. 6. To classify features/To develop classification model and evaluate its performance (any one classifier). 7. To develop regression model and evaluate its performance (any one algorithm). 8. Markov process for modelling manufacturing processes. OR 9. Reinforced Learning for optimizing engineering designs / Robot Guidance and Navigation. 10. GA for optimization of multi-dimensional function / path planning in robotics. OR 11. NN for parameter and model identification / tuning of Control Algorithms. **Note:** • Students need to apply the computational algorithms using suitable software / programming language. • Experiment 1, 2, 3, 6 & 7 are compulsory. Experiment 2 to 7 to be taken on same data set

Smt. Kashibai Navale College of Engineering Pune-41

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

302050: Computer Aided Engineering					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Practical**	**1**	**End-Semester**	**70 Marks**
				Practical	**50 Marks**

Prerequisite Courses: Solid Mechanics, Numerical and Statistical Methods, Engineering Mathematics, Manufacturing Processes, Fluid Mechanics, Heat and Mass Transfer.

Course Objectives:

1. **UNDERSTAND** the basic concepts of Computer Aided Engineering (CAE) and **CHARACTERISTICS** of various elements required for analysis.
2. **NURTURE** students about the discretization process and criteria for quality mesh.
3. **UNDERSTAND** the approaches of Finite Element Method (FEM) and to find displacement and stresses over the body.
4. **DEVELOP** the knowledge and skills needed to effectively evaluate the results using Finite Element Analysis (FEA).
5. **APPLY** computational technique to solve complex solid mechanics problems and its loading states.
6. **STUDY** the applications of CAE in the various domains of the Mechanical Engineering.

Course Outcomes:

On completion of the course, learner will be able to

CO1: **DEFINE** the use of CAE tools and **DESCRIBE** the significance of shape functions in finite element formulations.

CO2: **APPLY** the various meshing techniques for better evaluation of approximate results.

CO3: **APPLY** material properties and boundary condition to SOLVE 1-D and 2-D element stiffness matrices to obtain nodal or elemental solution.

CO4: **ANALYZE** and **APPLY** various numerical methods for different types of analysis.

CO5: **EVALUATE** and **SOLVE** non-linear and dynamic analysis problems by analyzing the results obtained from analytical and computational method.

CO6: **GENERATE** the results in the form of contour plot by the USE of CAE tools.

Course Contents

Unit 1	**Elemental Properties**	**07 Hrs.**

Introduction to Computer Aided Engineering (CAE), Use of CAE in Product development, Discretization methods – Finite Element Method (FEM), Finite Difference Method (FDM) and Finite Volume Method (FVM), CAE Tools- Pre-processor, Solver and Post-Processor.

Element Shapes – 1D, 2D and 3D elements, Nodal Unknowns and field variables, Coordinate Systems, Shape Functions- linear, quadratic and cubic, Convergence Requirements of Shape Functions, Derivation of Polynomial Shape Functions using coordinate systems for Bar, Beam, Triangular, and rectangular elements.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

Unit 2	Meshing Techniques	06 Hrs.
Discretization of a Structure, 1D, 2D and 3D element Meshing, Element selection criteria, Refining Mesh, Effect of mesh density in critical region, Use of Symmetry. Element Quality Criterion:-Jacobian, Aspect ratio, Warpage, Minimum and Maximum angles, Average element size, Minimum Length, skewness, Tetra Collapse etc., Higher Order Element vs Mesh Refinement, Geometry Associate Mesh, Mesh quality, Bolted and welded joints representation, Mesh independent test.		
Unit 3	**1D Finite Element Analysis**	**08 Hrs.**
Consistent Unit System, Introduction to approaches used in Finite Element Analysis (FEA) such as direct approach and energy approach **Bar and Truss Element** - Element stiffness matrix, Assembling stiffness Equation, Load vector, stress and reaction forces calculations. **Temperature effect on Bar Element-** Calculation due to uniform temperature change, Stress and reaction forces calculations.		
Unit 4	**2D Finite Element Analysis**	**08 Hrs.**
Plane Stress-Strain, axi-symmetric problems in 2D elasticity. **Constant Strain Triangle (CST) -** Element Stiffness matrix, Assembling stiffness equation, Load vector, Stress and reaction forces calculations. **Post Processing Techniques** – Check and validate accuracy of results, Average and Un-average stresses, and special tricks for Post Processing. Interpretation of results and design modifications, CAE reports.		
Unit 5	**Non-Linear and Dynamic Analysis**	**08 Hrs.**
Non-Linear Analysis: Introduction to Nonlinear Problems, Comparison of Linear and Nonlinear analysis, Types of Nonlinearities, Stress-strain measures for Nonlinear analysis, Analysis of Geometric, Material Nonlinearity, Solution Techniques for Nonlinear analysis, Newton Raphson Method, Essential steps in Nonlinear analysis. **Dynamic Analysis:** Introduction to Dynamic Analysis, Comparison of Static and Dynamic analysis, Time domain and frequency domain, Types of loading, Simple Harmonic motion, Free vibration, Boundary conditions of free vibration, Solution.		
Unit 6	**Applications of Computer Aided Engineering**	**08 Hrs.**
Computational Fluid Dynamics (CFD): Introduction, Three dimensions of Fluid Dynamics, Equilibrium Equation for a fluid, Conservation form of Fluid flow equation, Integral form of the Conservation Laws. **Injection moulding of Plastics:** Simplification of Mould Geometry for FEA, Material Model for Mould FEA, Boundary Conditions for Mould FEA, Loading of Mould in FEA, Results Analysis. **Simulation for Manufacturing Processes like Casting and Sheet Metal Applications:** Introduction and workflow of Casting Simulation Software and Sheet Metal Applications. **Durability Analysis:** Durability, Reliability and Fatigue, FEA bases fatigue analysis viz: Stress-Life approach (S-N method) and Strain-Life approach (E-N method). **Crash Analysis:** Introduction, Explicit time integration schemes, implicit integration schemes. **Noise Vibration and Harshness (NVH) Analysis:** NVH Concepts, Terminology, FEA for structural Dynamics, FEA for Acoustics.		

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College of Engineering, Pune - 41.

Books and other resources
Text Books: 1. Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., Practical Finite Element Analysis, Finite to Infinite, Pune, 1st Edition, 2008. 2. S. S. Bhavikatti, Finite Element Analysis, New Age International Publishers, Third Edition, 2015. 3. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 2002. 4. G Lakshmi Narasaiah, Finite Element Analysis, BS Publications / BSP Books, 2nd edition, 2020. 5. J. N. Reddy, An Introduction to the Finite Element Method, Mcgraw Hill Series in Mechanical, 2005. 6. P. Seshu, Text book of Finite Element Analysis, PHI Learning Private Limited, New Delhi, 10th Printing, 2012.
References Books: 1. K. J. Bathe, Finite Element Procedure, Prentice-Hall of India (P) Ltd., New Delhi, 1996. 2. Cook R. D., Finite Element Modeling for Stress Analysis, John Wiley and Sons Inc, 1995. 3. G.R. Liu S. S. Quek, The Finite Element Method- A Practical Course, Butterworth Heinemann, 2013. 4. Fagan M. J., Finite Element Analysis Theory and Practice, Harlow Pearson/Prentice Hall, 2012. 5. S. Moaveni, Finite element analysis, theory and application with Ansys, Pearson, Third Edition, 2011. 6. David V. Hutton, Fundamental of Finite Element Analysis, Tata McGraw-Hill, 2017. 7. Mukhopadhyay M and Sheikh A. H., Matrix and Finite Element Analyses of Structures, Ane Books Pvt. Ltd., 2009 8. Daryl L. Logan, A First Course in the Finite Element Method, Fourth Edition, Thomson Canada Limited, 2007. 9. O.C. Zienkiewicz, The Finite Element Method: Its Basis and Fundamentals, Sixth Edition, Elsevier Butterworth-Heinemann, 2005.
Web References: • **https://nptel.ac.in/courses/112/104/112104116/-**for Basics of Finite Element Analysis by Prof.Nachiketa Tiwari, IIT Kanpur • **https://nptel.ac.in/courses/112/106/112106130/**for Advanced Finite Element Analysis by Dr. R. Krishnakumar, Department of Mechanical Engineering, IIT Madras • **https://nptel.ac.in/courses/112/103/112103299/**for Finite Element Analysis for Welding Analysis by Prof. Swarup Bag, Department of Mechanical Engineering, IIT Guwahati. • **https://sites.ualberta.ca/~wmoussa/AnsysTutorial/** for ANSYS Tutorials

Smt. Kashibai Navale College of Engineering, Pune-41.

Assistant Professor & Head
Dept. of Mechanical Engg.
Smt. Kashibai Navale College
of Engineering, Pune - 41.

#	Block	CIE - ESE (Credits per course)	Course Type	Credits	Courses	Nature
1.1	A1	50-50 (3 Credits)	GENERIC CORE (GC)	42	14	COMPULSORY
1.2	A2	50-50 (3 Credits)	SUBJECT CORE (SC)	18	6	COMPULSORY
1.3	A3	50-50 (3 Credits)	PROJECT	6	1	COMPULSORY
2	B	0 - 50 (2 Credits)	GENERIC ELECTIVE (UNIVERSITY LEVEL) GE – UL	22	11	ELECTIVES
3.1	C1	50-0 (2 Credits)	GENERIC ELECTIVE (INSTITUTE LEVEL) GE – IL	8	4	ELECTIVES
3.4	C2	50-0 (2 Credits)	SUBJECT ELECTIVE (INSTITUTE LEVEL) SE - IL	14	7	ELECTIVES
			TOTAL	**110**	**43**	
OPTIONAL COURSES (In Lieu of C1 / C2 ONLY)						
4.1	D	25 - 0 (1 Credit)	FOUNDATION COURSES	0 -10	0 - 10	ELECTIVES
4.2	E	25 - 0 (1 Credit)	ENRICHMENT COURSES	0- 14	0 - 14	ELECTIVES
4.3	F	50 - 0 (2 Credits)	ALTERNATIVE STUDY CREDIT COURSES	0 -22	0 -11	ELECTIVES

Specializations offered: The following specializations shall be offered as MAJOR /MINOR:

1. Marketing Management(MKT)
2. Financial Management(FIN)
3. Human Resources Management(HRM)
4. Operations & Supply Chain Management(OSCM)
5. Business Analytics(BA)

The following specializations shall be offered ONLY as MINOR Specializations:

1. Rural & Agribusiness Management(RABM)
2. Pharma & Healthcare Management(PHM)
3. Tourism & Hospitality Management(THM)
4. International Business Management(IB)

Note:

1. Institutes may offer ONLY SELECT specializations based on industry needs, faculty strength & competencies, student demands, employability potential,etc.
2. Institutes MAY NOT offer a specialization if a **minimum of 20% of students** are not registered for that specialization.
3. The Institute MAY NOT offer an elective course if a **minimum of 20% of students** are not registered for that electivecourse.

HEAD
Dept. of Management Studies
Smt. Kashibai Navale College of Engg
Vadgaon (Bk.), Pune - 411 041.

Smt. Kashibai Navale College of Engineering
Vadgaon(Bk.)
Pune-41.

ANNEXURE I

GENERIC CORE (GC) COURSES – 3 Credits Each			
50 Marks CCE, 50 Marks ESE			
Course No.	**Course Code**	**Course**	**Semester**
101	GC – 01	Managerial Accounting	I
102	GC – 02	Organizational Behaviour	I
103	GC – 03	Economic Analysis for Business Decisions	I
104	GC – 04	Business Research Methods	I
105	GC – 05	Basics of Marketing	I
106	GC – 06	Digital Business	I
201	GC – 07	Marketing Management	II
202	GC – 08	Financial Management	II
203	GC – 09	Human Resources Management	II
204	GC – 10	Operations & Supply Chain Management	II
301	GC – 11	Strategic Management	III
302	GC – 12	Decision Science	III
303	GC – 13	Summer Internship Project*	III
401	GC – 14	Enterprise Performance Management	IV
402	GC – 15	Indian Ethos & Business Ethics	IV

* Six Credits

HEAD
Dept. of Management Studies
Smt. Kashibai Navale College of Engg
Vadgaon (Bk.), Pune - 411 041.

Smt. Kashibai Navale College of Engineering
Vadgaon(Bk.)
Pune-41.

GENERIC ELECTIVES UNIVERSITY LEVEL (GE – UL) COURSES – 2 Credits Each			
00 Marks CCE , 50 Marks ESE			
Course #	Course Code	Course	Semester
Any 3 courses to be selected from the following list in Semester I			
107	GE - UL - 01	Management Fundamentals	I
108	GE - UL - 02	Indian Economy	I
109	GE - UL - 03	Entrepreneurship Development	I
110	GE - UL - 04	Essentials of Psychology for Managers	I
111	GE - UL - 05	Legal Aspects of Business	I
112	GE - UL - 06	Demand Analysis & Forecasting	I
Any 3 courses to be selected from the following list in Semester II			
207	GE - UL - 07	Contemporary Frameworks in Management	II
208	GE - UL - 08	Geopolitics & World Economic Systems	II
209	GE - UL - 09	Start Up and New Venture Management	II
210	GE - UL - 10	Qualitative Research Methods	II
211	GE - UL - 11	Business, Government & Society	II
212	GE - UL - 12	Business Process Re-engineering	II
Any 3 courses to be selected from the following list in Semester III			
306	GE - UL - 13	International Business Economics	III
307	GE - UL - 14	International Business Environment	III
308	GE - UL - 15	Project Management	III
309	GE - UL - 16	Knowledge Management	III
310	GE - UL - 17	Corporate Governance	III
311	GE - UL - 18	Management of Non-profit organizations	III
Any 2 courses to be selected from the following list in Semester IV			
405	GE - UL - 19	Global Strategic Management	IV
406	GE - UL - 20	Technology Competition and Strategy	IV
407	GE - UL - 21	Cyber Laws	IV
408	GE - UL - 22	Corporate Social Responsibility & Sustainability	IV

Smt. Kashibai Navale College of Engineering Vadgaon(Bk.) Pune-41.

HEAD
Dept. of Management Studies
Smt. Kashibai Navale College of Engg
Vadgaon (Bk.), Pune - 411 041.

GENERIC ELECTIVES INSTITUTE LEVEL (GE – IL) COURSES – 2 Credits Each			
50 Marks CCE , 00 Marks ESE			
Course No.	Course Code	Course	Semester
Maximum 3 courses to be selected from the following list in Semester I			
113	GE - IL - 01	Verbal Communication Lab	I
114	GE - IL - 02	Enterprise Analysis & Desk Research	I
115	GE - IL - 03	Selling & Negotiation Skills Lab	I
116	GE - IL - 04	MS Excel	I
117	GE - IL - 05	Business Systems & Procedures	I
118	GE – IL- 06	Managing Innovation	I
119	GE – IL- 07	Foreign Language – I	I
Maximum 1 course to be selected from the following list in Semester II			
213	GE – IL - 08	Written Analysis and Communication Lab	II
214	GE – IL - 09	Industry Analysis & Desk Research	II
215	GE – IL - 10	Entrepreneurship Lab	II
216	GE – IL - 11	SPSS	II
217	GE – IL - 12	Foreign Language – II	II

HEAD
Dept. of Management Studies
Smt. K... Navale College of Engg
..., Pune - 411 041.

Smt. Kashibai Navale College of Engineering
Vadgaon(Bk.)
Pune-41.

SUBJECT CORE (SC) COURSES: Specialization – Marketing Management (MKT)			
3 Credits Each, 50 Marks CCE, 50 Marks ESE			
Course No.	**Course Code**	**Course**	**Semester**
205 MKT	SC – MKT- 01	Marketing Research	II
206 MKT	SC – MKT- 02	Consumer Behaviour	II
304 MKT	SC – MKT- 03	Services Marketing	III
305 MKT	SC – MKT- 04	Sales & Distribution Management	III
403 MKT	SC – MKT- 05	Marketing 4.0	IV
404 MKT	SC – MKT- 06	Marketing Strategy	IV

SUBJECT ELECTIVE (SE - IL) COURSES: Specialization – Marketing Management (MKT)			
2 Credits Each, 50 Marks CCE, 00 Marks ESE			
Course No.	**Course Code**	**Course**	**Semester**
Maximum 2 courses to be selected from the following list in Semester II			
217 MKT	SE – IL - MKT- 01	Integrated Marketing Communications	II
218 MKT	SE – IL - MKT- 02	Product & Brand Management	II
219 MKT	SE – IL - MKT- 03	Personal Selling Lab	II
220 MKT	SE – IL - MKT- 04	Digital Marketing - I	II
221 MKT	SE – IL - MKT- 05	Marketing of Financial Services - I	II
222 MKT	SE – IL - MKT- 06	Marketing of Luxury Products	II
Maximum 3 courses to be selected from the following list in Semester III			
312 MKT	SE – IL - MKT- 07	Business to Business Marketing	III
313 MKT	SE – IL - MKT- 08	International Marketing	III
314 MKT	SE – IL - MKT- 09	Digital Marketing - II	III
315 MKT	SE – IL - MKT- 10	Marketing of Financial Services - II	III
316 MKT	SE – IL - MKT- 11	Marketing Analytics	III
317 MKT	SE – IL - MKT- 12	Marketing of High Technology Products	III
Maximum 2 courses to be selected from the following list in Semester IV			
409 MKT	SE – IL - MKT- 13	Customer Relationship Management	IV
410 MKT	SE – IL - MKT- 14	Rural & Agriculture Marketing	IV
411 MKT	SE – IL - MKT- 15	Tourism & Hospitality Marketing	IV
412 MKT	SE – IL - MKT- 16	Retail Marketing	IV
413 MKT	SE – IL - MKT- 17	Retailing Analytics	IV
414 MKT	SE – IL - MKT- 18	Marketing to Emerging Markets & Bottom of the Pyramid	IV

HEAD
Dept. of Management Studies
Smt. Kashibai Navale College of Engg
Vadgaon (Bk.), Pune - 411 041.

Smt. Kashibai Navale College of Engineering
Vadgaon(Bk.)
Pune-41.

SUBJECT CORE (SC) COURSES: Specialization – Financial Management (FIN)			
3 Credits Each, 50 Marks CCE, 50 Marks ESE			
Course No.	**Course Code**	**Course**	**Semester**
205 FIN	SC – FIN - 01	Financial Markets and Banking Operations	II
206 FIN	SC – FIN - 02	Personal Financial Planning	II
304 FIN	SC – FIN - 03	Advanced Financial Management	III
305 FIN	SC – FIN - 04	International Finance	III
403 FIN	SC – FIN - 05	Financial Laws	IV
404 FIN	SC – FIN - 06	Current Trends & Cases in Finance	IV

SUBJECT ELECTIVE (SE - IL) COURSES: Specialization – Financial Management (FIN)			
2 Credits Each, 50 Marks CCE, 00 Marks ESE			
Course No.	**Course Code**	**Course**	**Semester**
Maximum 2 courses to be selected from the following list in Semester II			
217 FIN	SE – IL - FIN - 01	Securities Analysis & Portfolio Management	II
218 FIN	SE – IL - FIN - 02	Futures and Options	II
219 FIN	SE – IL - FIN - 03	Direct Taxation	II
220 FIN	SE – IL - FIN - 04	Financial Reporting	II
221 FIN	SE – IL - FIN - 05	Retail Credit Management- Lending & Recovery	II
222 FIN	SE – IL - FIN - 06	Banking Laws & Regulations	II
223 FIN	SE – IL - FIN - 07	Fundamentals of Life Insurance – Products and Underwriting	II
224 FIN	SE – IL - FIN - 08	General Insurance - Health and Vehicle	II
Maximum 3 courses to be selected from the following list in Semester III			
312 FIN	SE – IL - FIN - 09	Behavioural Finance	III
313 FIN	SE – IL - FIN - 10	Technical Analysis of Financial Markets	III
314 FIN	SE – IL - FIN - 11	Commodities Markets	III
315 FIN	SE – IL - FIN – 12	Indirect Taxation	III
316 FIN	SE – IL - FIN – 13	Corporate Financial Restructuring	III
317 FIN	SE – IL - FIN - 14	Financial Modeling	III
318 FIN	SE – IL - FIN – 15	Digital Banking	III
319 FIN	SE – IL - FIN – 16	Treasury Management	III
320 FIN	SE – IL - FIN – 17	Project Finance and Trade Finance	III
321 FIN	SE – IL - FIN – 18	Insurance Laws & Regulations	III
322 FIN	SE – IL - FIN – 19	Marine Insurance	III
323 FIN	SE – IL - FIN – 20	Fire Insurance	III
Maximum 2 courses to be selected from the following list in Semester IV			
409 FIN	SE – IL - FIN – 21	Fixed Income Securities	IV
410 FIN	SE – IL - FIN – 22	Business Valuation	IV

Smt. Kashibai Navale College of Engineering, Vadgaon(Bk.) Pune-41.

HEAD
Dept. of Management Studies
Smt. Kashibai Navale College of Engg
Vadgaon (Bk.), Pune - 411041.

SUBJECT CORE (SC) COURSES: Specialization – Human Resource Management (HRM)			
3 Credits Each, 50 Marks CCE, 50 Marks ESE			
Course No.	**Course Code**	**Course**	**Semester**
205 HR	SC – HRM – 01	Competency Based Human Resource Management	II
206 HR	SC – HRM – 02	Employee Relations & Labour Legislation	II
304 HR	SC – HRM – 03	Strategic Human Resource Management	III
305 HR	SC – HRM – 04	HR Operations	III
403 HR	SC – HRM – 05	Organizational Diagnosis & Development	IV
404 HR	SC – HRM – 06	Current Trends & Cases in Human Resource Management	IV

SUBJECT ELECTIVE (SE - IL) COURSES: Specialization – Human Resource Management (HRM)			
2 Credits Each, 50 Marks CCE, 00 Marks ESE			
Course No.	**Course Code**	**Course**	**Semester**
Maximum 2 courses to be selected from the following list in Semester II			
217 HRM	SE – IL - HRM – 01	Labour Welfare	II
218 HRM	SE – IL - HRM – 02	Lab in Recruitment and Selection	II
219 HRM	SE – IL - HRM – 03	Learning and Development	II
220 HRM	SE – IL - HRM – 04	Public Relations & Corporate Communications	II
221 HRM	SE – IL - HRM – 05	HR Analytics	II
222 HRM	SE – IL - HRM – 06	Conflict and Negotiation Management	II
Maximum 3 courses to be selected from the following list in Semester III			
312 HR	SE – IL - HRM – 07	Talent Management	III
313 HR	SE – IL - HRM – 08	Psychometric Testing and Assessment	III
314 HR	SE – IL - HRM – 09	HR perspective in Mergers and Acquisition	III
315 HR	SE – IL - HRM – 10	International HR	III
316 HR	SE – IL - HRM – 11	Mentoring and Coaching	III
317 HR	SE – IL - HRM – 12	Compensation and Reward management	III
318 HR	SE – IL - HRM – 13	Performance Management System	III
319 HR	SE – IL - HRM – 14	Change Management & New Technologies in HRM	III
Maximum 2 courses to be selected from the following list in Semester IV			
409 HR	SE – IL - HRM – 15	Labour Legislation	IV
410 HR	SE – IL - HRM – 16	Designing HR Policies	IV
411 HR	SE – IL - HRM – 17	Labour Economics and Costing	IV
412 HR	SE – IL - HRM – 18	Best Practices in HRM	IV
413 HR	SE – IL - HRM – 19	Employee Engagement and Ownership	IV
414 HR	SE – IL - HRM – 20	Leadership and Succession Planning	IV
415 HR	SE – IL - HRM – 21	E - HRM	IV

Smt. Kashibai Navale College of Engineering Vadgaon(Bk.) Pune-41.

HEAD
Dept. of Management Studies
Smt. Kashibai Navale College of Engg
Vadgaon (Bk.), Pune - 411 041.

SUBJECT CORE (SC) COURSES: Specialization – Operations & Supply Chain Management (OSCM)			
3 Credits Each, 50 Marks CCE, 50 Marks ESE			
Course No.	**Course Code**	**Course**	**Semester**
205 OSCM	SC – OSCM - 01	Services Operations Management - I	II
206 OSCM	SC – OSCM - 02	Supply Chain Management	II
304 OSCM	SC – OSCM - 03	Services Operations Management - II	III
305 OSCM	SC – OSCM - 04	Logistics Management	III
403 OSCM	SC – OSCM - 05	E Supply Chains & Logistics	IV
404 OSCM	SC – OSCM - 06	Industry 4.0	IV

SUBJECT ELECTIVE (SE - IL) COURSES : Specialization – Operations & Supply Chain Management (OSCM)			
2 Credits Each, 50 Marks CCE, 00 Marks ESE			
Course No.	**Course Code**	**Course**	**Semester**
Maximum 2 courses to be selected from the following list in Semester II			
217 OSCM	SE – IL - OSCM - 01	Planning & Control of Operations	II
218 OSCM	SE – IL - OSCM - 02	Productivity Management	II
219 OSCM	SE – IL - OSCM - 03	Inventory Management	II
220 OSCM	SE – IL - OSCM - 04	Theory of Constraints	II
221 OSCM	SE – IL - OSCM - 05	Quality Management Standards	II
222 OSCM	SE – IL - OSCM - 06	Service Value Chain Management	II
Maximum 3 courses to be selected from the following list in Semester III			
312 OSCM	SE – IL - OSCM – 07	Manufacturing Resource Planning	III
313 OSCM	SE – IL - OSCM – 08	Sustainable Supply Chains	III
314 OSCM	SE – IL - OSCM – 09	Business Excellence	III
315 OSCM	SE – IL - OSCM – 10	Toyota Production System	III
316 OSCM	SE – IL - OSCM – 11	Operations and Services Strategy	III
317 OSCM	SE – IL - OSCM – 12	Six Sigma for Operations	III
Maximum 2 courses to be selected from the following list in Semester IV			
409 OSCM	SE – IL - OSCM – 14	Enterprise Resource Planning	IV
410 OSCM	SE – IL - OSCM – 15	World Class Manufacturing	IV
411 OSCM	SE – IL - OSCM – 16	Supply Chain Strategy	IV
412 OSCM	SE – IL – OSCM – 17	Financial Perspectives in Operations Management	IV
413 OSCM	SE – IL - OSCM – 18	Facilities Planning	IV
414 OSCM	SE – IL - OSCM – 19	Purchasing and Supplier Relationship Management	IV
415 OSCM	SE – IL - OSCM - 20	Strategic Supply Chain Management	IV

HEAD
Dept. of Management Studies
Smt. Kashibai Navale College of Engg
Vadgaon (Bk.), Pune - 411 041.

Smt. Kashibai Navale College of Engineering
Vadgaon(Bk.)
Pune-41.

SUBJECT CORE (SC) COURSES: Specialization – Business Analytics (BA)			
3 Credits Each, 50 Marks CCE, 50 Marks ESE			
Course No.	Course Code	Course	Semester
205 BA	SC – BA - 01	Basic Business Analytics using R	II
206 BA	SC – BA - 02	Data Mining	II
304 BA	SC – BA - 03	Advanced Statistical Methods using R	III
305 BA	SC – BA - 04	Machine Learning & Cognitive intelligence using Python	III
403 BA	SC – BA - 05	Economics of Network Industries	IV
404 BA	SC – BA - 06	Artificial Intelligence in Business Applications	IV

SUBJECT ELECTIVE (SE - IL) COURSES: Specialization – Business Analytics (BA)			
2 Credits Each, 50 Marks CCE, 00 Marks ESE			
Course No.	Course Code	Course	Semester
Maximum 2 courses to be selected from the following list in Semester II			
217 BA	SE – IL - BA - 01	Marketing Analytics	II
218 BA	SE – IL - BA - 02	Retailing Analytics	II
219 BA	SE – IL - BA - 03	Workforce Analytics	II
220 BA	SE – IL - BA - 04	Tableau	II
221 BA	SE – IL - BA - 05	Data Warehousing Project Life Cycle Management	II
Maximum 3 courses to be selected from the following list in Semester III			
312 BA	SE – IL - BA – 06	Social Media, Web & Text Analytics	III
313 BA	SE – IL - BA – 07	Industrial Internet of Things	III
314 BA	SE – IL - BA – 08	Supply Chain Analytics	III
315 BA	SE – IL - BA – 09	Cognos Analytics	III
316 BA	SE – IL - BA – 10	Predictive Modelling using SPSS Modeler	III
317 BA	SE – IL - BA – 11	E commerce Analytics - I	III
Maximum 2 courses to be selected from the following list in Semester IV			
409 BA	SE – IL - BA - 13	E Commerce Analytics - II	IV
410 BA	SE – IL - BA - 14	Healthcare Analytics	IV
411 BA	SE – IL - BA – 15	Watson	IV
412 BA	SE – IL - BA – 16	Scala and Spark	IV

Smt. Kashibai Navale College of Engineering Vadgaon(Bk.) Pune-41.

HEAD
Dept. of Management Studies
Smt. Kashibai Navale College of Engg
Vadgaon (Bk.), Pune - 411 041.

Master of Business Administration (MBA) – Revised Syllabus 2019

2 year, 4 Semester Full time Programme
Choice Based Credit System (CBCS) and Grading System
Outcome Based Education Pattern

MBA I effective from AY 2019-20
MBA II effective from AY 2020-21

1.0 Preamble: The revised MBA Curriculum 2019 builds on the implementation of the Choice Based Credit System (CBCS) and Grading System initiated in the AY 2013. The curriculum takes the MBA programme to the next level in terms of implementing Outcome Based Education along with the Choice Based Credit System (CBCS) and Grading System.

2.0 Definitions:

2.1 Outcome Based Education:

2.1.1 Outcome Based Education (OBE) Approach: Outcomes are about performance, and this implies:

a) There must be a performer – the student (learner), not only the teacher
b) There must be something performable (thus demonstrable or assessable) to perform
c) The focus is on the performance, not the activity or task to be performed

2.1.2 Programme Educational Objectives (PEOs): Programme Educational Objectives are a set of **broad future-focused student performance outcomes** that explicitly identify what students will be **able to do with what they have learned,** and **what they will be like** after they leave school and are **living full and productive lives**. Thus PEOs are what the programme is preparing graduates for in their **career and professional life** (to attain within a **few years** after graduation[1]).

2.1.3 Graduate Attributes (GAs): Graduate Attributes (GAs) are the **qualities, knowledge and capabilities** that students are encouraged to take responsibility for developing throughout their studies and are the **defining characteristics** of the students passing out of the MBA program**.** These attributes include, but go **beyond, the disciplinary expertise or technical knowledge.**

2.1.4 Programme Outcomes (POs): Programme Outcomes are a set of **narrow statements** that describes what students (learners) **of the programme** are expected to know and be able to perform or attain **by the time of graduation.**

2.1.5 Programme Specific Outcomes (PSOs): Programme Outcomes are a set of **narrow statements** that describes what students (learners) **of a particular specialization of the programme** are expected to know and be able to perform or attain **by the time of graduation.** PSOs are also a function of the various course combinations offered by the Institute.

2.1.6 Learning Outcomes: A learning outcome is what a student CAN DO as a result of a learning experience. It describes a **specific task** that he/she is able to perform at a **given level of competence under a certain situation**. The three broad types of learning outcomes are:

a) Disciplinary knowledge and skills
b) Generic skills
c) Attitudes and values

2.1.7 Course Outcomes (COs): A set of specific statements that describes the **complex performances** a student should be capable of as a result of **learning experiences within a course.**

2.1.8 Teaching and Learning Activities (TLAs): The set of **pedagogical tools and techniques** or the teaching and learning activities that aim to **help students to attain** the intended learning outcomes and engage them in these learning activities through the teaching process.

2.1.9 Outcome Based Assessment (OBA): An assessment system that asks course teachers to first identify what it is that we expect students to be able to do once they have completed a course or program. It then asks course teachers to provide evidence that they are able to do so. In other words, how will each learning outcome be assessed? What **evidence of student learning** is most **relevant for each learning outcome** and **what standard or criteria** will be used to evaluate that evidence? Assessment is therefore a key part of outcome-based education and used to determine whether or not a qualification has been achieved.

2.2 Credit: *In terms of credits, for a period of one semester of 15 weeks:*

[1] Graduation refers to passing out of the MBA programme. Graduation does NOT refer to 10+2+3/4 degree e.g. BA, BE, etc.

HEAD
Dept. of Management Studies
Smt. Kashibai Navale College of Engg
Vadgaon (Bk.), Pune - 411 041.

a) *every ONE hour session per week of L amounts to 1 credit per semester*
b) *a minimum of TWO hours per week of T amounts to 1 credit per semester,*
c) *a minimum of TWO hours per week of P amounts to 1 credit per semester,*

Each credit is a combination of 3 components viz. Lecture (L) + Tutorials (T) + Practice (Practical / Project Work / Self Study) (P) i.e. LTP Pattern. Indicative LTP, for each course, is documented in the syllabus.

The course teacher may modify the LTP of the course in view of the course requirements, nature of the course, the level of learners and the type of pedagogy and assessment tools proposed. The modified LTP shall have to be approved by the Director / Head of the Department / Designated academic authority of the Institute.

2.3 **Session:** Each teaching-learning, evaluation session shall be of 60 minutes. However, institutes shall have the flexibility to define their time slots in a manner as to use their faculty and infrastructure resources in the best possible way and ensure effective learning.

2.4 **Course Announcement:** The institute shall announce the elective courses and specializations it proposes to offer the students out of the wider course basket. It is not mandatory to offer all the specializations and all the electives. The decision of the Director shall be final in this case. However, in the spirit of Choice Based Credit System, institutes should offer choices to the students for the elective courses and not offer only the minimum number of electives.

2.5 **Course Registration:** It is mandatory for every student, to register every semester, for the courses opted for that semester. Each student, on admission shall be assigned to a Faculty Advisor who shall advise her/him about the academic programs and counsel on the choice of courses considering the student's profile, career goals and courses taken in the earlier semesters. With the advice and consent of the Faculty Advisor, the student shall register for a set of courses he/she plans to take up for the Semester. Students shall have to register for the courses for the semester within first week of Semester I and immediately after conclusion of the preceding term for subsequent Semesters II, III and IV.

3.0 MBA Programme Focus:

3.1 Programme Educational Objectives (PEOs):

1. **PEO1:** Graduates of the MBA program will *successfully integrate core, cross-functional and inter-disciplinary* aspects of management *theories, models and frameworks* with the *real world practices* and the *sector specific nuances* to *provide solutions to real world business, policy and social issues* in a *dynamic and complex world.*
2. **PEO2:** Graduates of the MBA program will possess excellent *communication skills*, excel in *cross-functional, multi-disciplinary, multi-cultural teams,* and have an appreciation for *local, domestic and global contexts* so as to manage *continuity, change, risk, ambiguity and complexity.*
3. **PEO3:** Graduates of the MBA program will be appreciative of the significance of *Indian ethos and values in managerial decision making* and *exhibit value centered leadership.*
4. **PEO4:** Graduates of the MBA program will be ready to *engage in successful career pursuits* covering a broad spectrum of areas in *corporate, non-profit organizations, public policy, entrepreneurial ventures* and engage in *life-long learning.*
5. **PEO5:** Graduates of the MBA program will be recognized in their chosen fields for their *managerial competence, creativity & innovation, integrity & sensitivity* to local and global issues of social relevance and earn the *trust & respect* of others as *inspiring, effective and ethical leaders, managers, entrepreneurs, intrapreneurs* and change agents.

3.2 Programme Outcomes (POs): At the end of the MBA programme the learner will possess the

1. **Generic and Domain Knowledge -** Ability to articulate, illustrate, analyze, synthesize and apply the knowledge of principles and frameworks of management and allied domains to the solutions of real-world complex business issues
2. **Problem Solving & Innovation** - Ability to Identify, formulate and provide innovative solution frameworks to real world complex business and social problems by systematically applying modern quantitative and qualitative problem solving tools and techniques.

HEAD
Dept. of Management Studies
Smt. Kashibai Navale College of Engg
Vadgaon (Bk.), Pune - 411 041.

3. **Critical Thinking** - Ability to conduct investigation of multidimensional business problems using research based knowledge and research methods to arrive at data driven decisions
4. **Effective Communication** - Ability to effectively communicate in cross-cultural settings, in technology mediated environments, especially in the business context and with society at large
5. **Leadership and Team Work** - Ability to collaborate in an organizational context and across organizational boundaries and lead themselves and others in the achievement of organizational goals and optimize outcomes for all stakeholders.
6. **Global Orientation and Cross-Cultural Appreciation:** Ability to approach any relevant business issues from a global perspective and exhibit an appreciation of Cross Cultural aspects of business and management.
7. **Entrepreneurship** - Ability to identify entrepreneurial opportunities and leverage managerial & leadership skills for founding, leading & managing startups as well as professionalizing and growing family businesses.
8. **Environment and Sustainability** - Ability to demonstrate knowledge of and need for sustainable development and assess the impact of managerial decisions and business priorities on the societal, economic and environmental aspects.
9. **Social Responsiveness and Ethics** - Ability to exhibit a broad appreciation of the ethical and value underpinnings of managerial choices in a political, cross-cultural, globalized, digitized, socio-economic environment and distinguish between ethical and unethical behaviors & act with integrity.
10. **LifeLong Learning** – Ability to operate independently in new environment, acquire new knowledge and skills and assimilate them into the internalized knowledge and skills.

3.3 Programme Specific Outcomes (PSOs): It is expected that **Institutes define the PSOs** for **each specialization / major-minor combination.** PSOs shall also vary based upon the **customized combination** of Generic Core, Generic Elective, Subject Core, Subject Elective, Foundation, Enrichment & Alternative Study Credit Courses that they offer.

3.4 Graduate Attributes (GAs): At the end of the MBA programme the learner shall exhibit:
GA1: Managerial competence
GA2: Proficiency in Communication, Collaboration, Teamwork and Leadership
GA3: Competence in Creativity & Innovation
GA4: Research Aptitude, Scholarship & Enquiry
GA5: Global Orientation
GA6: Proficiency in ICT & Digital Literacy
GA7: Entrepreneurship & Intrapreneurship Orientation
GA8: Cross-functional & Inter-disciplinary Orientation
GA9: Results Orientation
GA10: Professionalism, Ethical, Values Oriented & Socially Responsible behaviour
GA11: Life-Long Learning Orientation

4.0 MBA Programme Course Types & Evaluation Pattern:

Sr.No.	Course Type	Credits	Nature	Comprehensive Concurrent Evaluation (CCE)	End Semester Evaluation (ESE) Marks	Total Marks
			BASIC COURSE TYPES			
1	Generic Core (GC)	3	Compulsory	50	50	100
2	Subject Core (SC)	3	Compulsory (Specialization specific)	50	50	100
3	Generic Elective (GE - UL)	2	Elective	0	50	50
4	Generic Elective (GE - IL)	2	Elective	50	0	50
5	Subject Elective (SE - IL)	2	Elective (Specialization specific)	50	0	50
6	Summer Internship Project (SIP)	6	Project (Compulsory)	50	50	100
			ADDITIONAL COURSE TYPES			
1	Enrichment Courses (ENR)	1	Elective	25	0	25

HEAD
Dept. of Management Studies
Smt. K... Navale College of ...
Vadgaon (Bk.), Pune - 411 041.

Smt. Kashibai Navale College of Engg. Dept. of Management Studies Vadgaon (Bk.)

2	Foundation Courses (FOU)	1	Elective	25	0	25
3	Alternative Study Credit Courses (ASCC)	2	Elective	50	0	50
4	Open Electives (OE)	3 or 2	Subject Core / Subject Elective	As per Subject Core / Subject Elective Pattern		

4.1 Course Types

4.1.1 **Foundation Course:** These courses focus on developing the basic abilities that support the understanding of other courses.

4.1.2 **Core courses** are the compulsory courses for all the students. Core courses are of two types: Generic Core & Subject Core.

4.1.3 **Generic Core:** This is the course which should compulsorily be studied by a candidate as a core requirement to complete the requirement of a degree in a said discipline of study. Therefore, Generic Core courses are mandatory and fundamental in nature. These courses cannot be substituted by any other courses. Such courses are also known as Hard Core Courses.

4.1.4 **Subject Core:** A Core course may be a Subject Core if there is a choice or an option for the candidate to choose from a broad category (grouping) of subjects (specializations / electives). These are also known as Soft Core Courses.

4.1.5 **Elective Course:** Elective course is a course which can be chosen from a pool of courses. It may be:

a) Very Specialized or advanced course focusing on a specific aspect
b) Supportive to the discipline of study
c) Providing an extended scope
d) Enabling an exposure to some other discipline/domain
e) Nurturing candidate's proficiency/skills.

4.1.6 **Generic Elective:** An elective course which is common across disciplines / subjects is called a generic elective. 'Generic Elective' courses develop generic proficiencies amongst the students.

4.1.7 **Generic Elective – University Level**: These elective courses are supportive to the discipline of study and focus on the knowledge aspect of competence building. The course outcomes for such courses can be better assessed through traditional End Semester Evaluation.

4.1.8 **Generic Elective – Institute Level:** These elective courses are aimed to develop inter-personal, technical and other skills aspect of competence building. The course outcomes for such courses can be better assessed through Comprehensive Concurrent Evaluation.

4.1.9 **Subject Elective:** A 'Discipline (specialization) centric' elective is called 'Subject Elective.' Subject Elective courses, in the Semester II, III and IV are focused on a specialization.

4.1.10 **Open Elective:** A subject elective course chosen generally from another Discipline / specialization / subject, with an intention to seek cross-functional exposure is called an Open Elective. A Subject Elective offered in one specialization area may be treated as an Open Elective by another specialization area and vice-a-versa.

4.1.11 **Enrichment Course:** This is a course generally offered to bright learners / fast learners for advanced inputs beyond the curriculum. Enrichment / Add-on Course shall be a 1 Credit Course. The course is of the nature of Course of Independent Study (CIS) and is designed for learners who have the ability and inclination to work independently with limited guidance, supervision and interaction with the faculty member(s).

4.1.12 **Alternative Study Credit Courses:** These courses prepare the learners for a VUCA (Volatile Uncertain, Complex and Ambiguous) world by going beyond the boundaries of their campus. Apart from core and elective courses, these courses engage students in discussion, debate and solution of real world challenges.

4.1.13 **Massive Open Online Courses (MOOCs)[2]:** Massive Open Online Courses (MOOCs) are such online courses which are developed as per the pedagogy stated in the AICTE regulation (2016) or equiavelent; following the four quadrant approach and made available on the SWAYAM platform of Government of India.

4.2 MBA Programme Structure: The Basic Programme Structure shall be as depicted below

[2] AICTE (Credit Framework for online learning course through SWAYAM) Regulations, 2016

	Course#	Semester I		Semester II		Semester III		Semester IV		Credits	CCE Marks	ESE Mark
COMPULSORY CORE COURSES (GENERIC (GC) + SUBJECT (SC) + Summer Internship Project SIP)												
A	1	GC - 1	1	GC - 7	1	GC - 11	1	GC - 14		66 Credits		
	2	GC - 2	2	GC - 8	2	GC - 12	2	GC - 15				
	3	GC - 3	3	GC - 9	3	GC -13 (SIP)	3	SC - 5				
	4	GC - 4	4	GC - 10	4	SC - 3	4	SC - 6				
	5	GC - 5	5	SC - 1	5	SC - 4					1050	105
	6	GC- 6	6	SC - 2							2100	
GENERIC ELECTIVE COURSES (UNIVERSITY LEVEL) – GE - UL												
B	7	GE UL - 1	7	GE UL - 4	6	GE UL – 7	5	GE UL - 10		22 Credits		
	8	GE UL - 2	8	GE UL - 5	7	GE UL – 8	6	GE UL - 11			0	55
	9	GE UL - 3	9	GE UL - 6	8	GE UL – 9					550	
GENERIC / SUBJECT ELECTIVE COURSES (INSTITUTE LEVEL) - GE – IL / SE - IL												
C	10	GE IL - 1	10	GE IL - 4	9	SE IL -3	7	SE IL -6		22 Credits		
	11	GE IL - 2	11	SE IL -1	10	SE IL -4	8	SE IL -7			550	
	12	GE IL - 3	12	SE IL -2	11	SE IL -5					550	
	12		12		11		8		43	110 Credits	1600 CCE	1600 ESE

FOUNDATION COURSES (OPTIONAL)

D — FOUNDATION 1, FOUNDATION 2, FOUNDATION 3, FOUNDATION 4, FOUNDATION 5, FOUNDATION 6, FOUNDATION 7, FOUNDATION 8, FOUNDATION 9, FOUNDATION 10 — 0 to 10 Credits

ENRICHMENT COURSES (OPTIONAL)

E — ENRICHMENT 1, ENRICHMENT 2, ENRICHMENT 3, ENRICHMENT 4, ENRICHMENT 5, ENRICHMENT 6, ENRICHMENT 7, ENRICHMENT 8, ENRICHMENT 9, ENRICHMENT 10, ENRICHMENT 11, ENRICHMENT 12, ENRICHMENT 13, ENRICHMENT 14 — 0 to 14 Credits

ALTERNATIVE STUDY CREDIT COURSES (OPTIONAL)

F — ASCC 1, ASCC 2, ASCC 3, ASCC 4, ASCC 5, ASCC 6, ASCC 7, ASCC 8, ASCC 9, ASCC 10, ASCC 11 — 0 to 22 Credits

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Note:

1. The basic programme structure comprises of Block A, B & C above.
2. Variations to the basic programme structure shall be defined at the institute level using any permissible combination of A,B,C,D,E and F blocks depicted above, taking into consideration institutional vision-mission-focus areas, industry demand, student learning capabilities, faculty competencies, availability of learning resources, etc. PSOs shall be appropriately defined by the institute.

LEGEND:

#	Block	CIE - ESE (Credits per course)	Course Type	Credits	Courses	Nature
1.1	A1	50-50 (3 Credits)	GENERIC CORE (GC)	42	14	COMPULSORY
1.2	A2	50-50 (3 Credits)	SUBJECT CORE (SC)	18	6	COMPULSORY
1.3	A3	50-50 (6 Credits)	PROJECT	6	1	COMPULSORY
2	B	0 - 50 (2 Credits)	GENERIC ELECTIVE (UNIVERSITY LEVEL) GE – UL	22	11	ELECTIVES
3.1	C1	50-0 (2 Credits)	GENERIC ELECTIVE (INSTITUTE LEVEL) GE – IL	8	4	ELECTIVES
3.4	C2	50-0 (2 Credits)	SUBJECT ELECTIVE (INSTITUTE LEVEL) SE - IL	14	7	ELECTIVES
			TOTAL	**110**	**43**	
OPTIONAL COURSES (In Lieu of C1 / C2 ONLY)						
4.1	D	25 - 0 (1 Credit)	FOUNDATION COURSES	0 -10	0 - 10	ELECTIVES
4.2	E	25 - 0 (1 Credit)	ENRICHMENT COURSES	0- 14	0 - 14	ELECTIVES
4.3	F	50 - 0 (2 Credits)	ALTERNATIVE STUDY CREDIT COURSES	0 -22	0 -11	ELECTIVES

5.0 Specializations offered: The following specializations shall be offered as MAJOR / MINOR:

1. Marketing Management (MKT)
2. Financial Management (FIN)
3. Human Resources Management (HRM)
4. Operations & Supply Chain Management (OSCM)
5. Business Analytics (BA)

The following specializations shall be offered ONLY as MINOR Specializations:

1. Rural & Agribusiness Management (RABM)
2. Pharma & Healthcare Management (PHM)
3. Tourism & Hospitality Management (THM)
4. International Business Management (IB)

Note:

1. Institutes may offer ONLY SELECT specializations based on industry needs, faculty strength & competencies, student demands, employability potential, etc.
2. Institutes MAY NOT offer a specialization if a **minimum of 20% of students** are not registered for that specialization.

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3. The Institute MAY NOT offer an elective course if a **minimum of 20% of students** are not registered for that elective course.

5.1 Open Elective(s):

1. Learners who intend to learn specific courses from other specialization(s) can opt for Subject Elective (SE - IL) courses from other specializations in lieu of the Subject Elective (SE - IL) courses from their native specialization.
2. These open electives MAY BE from two different specializations.
3. Open Electives can be opted for only in Sem III and Sem IV.
4. Students can opt for maximum 1 Subject Elective (SE - IL) course in Sem III and Sem IV each. i.e. Students can opt for maximum 2 Open Electives (total 4 credits).

5.2 Major Specialization + Minor Specialization Combination:

1. For a **Major + Minor Specialization combination** the learner shall **complete**
   a) Major Specialization – Courses: Total 9 (4 Subject Core courses and 5 Subject Elective courses)
   b) Minor Specialization – Courses: Total 4 (2 Subject Core courses and 2 Subject Elective courses)
2. For a **Major + Minor Specialization combination** the learner shall **earn**
   a) Major Specialization – Credits: Total 22 (12 Credits from Subject Core + Minimum 10 Credits from Subject Electives)
   b) Minor Specialization – Credits: Total 10 (6 Credits from Subject Core + Minimum 4 Credits from Subject Electives)
3. The 10 credits of the MINOR specialization shall be from a single specialization, out of which 6 credits shall be mandatorily earned through the Subject Core Courses.
4. The Major + Minor specialization combination is OPTIONAL.
5. Students shall be permitted to opt for **ANY Major + ANY Minor** specialization combination, subject to institutional norms and guidelines, issued from time to time.
6. A student opting for Major + Minor specialization combination shall opt for Foundation Courses / Enrichment Courses / Alternative Study Credit Courses **ONLY in lieu of Generic Elective (GE - IL) Courses.**
7. Institutes may stipulate additional criteria of minimum SGPA / CGPA, number of backlogs, expectations about specific graduation discipline for students who wish to take up a specific specialization / specific major minor combination. Such criteria may also involve the potential employability criteria for a particular specialization / Major + Minor specialization combination.

5.3 Options & Guidelines for Choice of Specialization:

1. Students can opt for a single specialization (i.e. Major Only – 5 choices)
2. Students can opt for a two specializations (i.e. Major + Minor Combination – 1(Major) + 8(Minor) choices)
3. Specializations which are offered ONLY as MINOR shall be offered in SECOND YEAR ONLY. (4 choices)
4. Courses for the Minor specialization shall be taken up in the second year ONLY (in either Sem III or Sem IV or in a combination of Sem III and IV).
5. The Major specialization of a student shall be determined by the Subject Core (SC) courses and the Subject Elective (SE - IL) courses chosen in Sem II.
6. All courses (Subject Core (SC) courses and the Subject Elective (SE - IL) courses) chosen in Sem II shall belong to the same specialization.
7. The learners shall generally complete 6 Subject Core courses (2 each in semester II, III, IV) and 7 Subject Elective courses (2, 3, 2 each in semester II, III, IV respectively). In this case he /she shall be awarded MBA (Functional Area Specialization) degree, e.g. MBA (Marketing), MBA (Finance), etc.
8. The learners shall complete 4 Subject Core courses and 5 Subject Elective courses of Major specialization and 2 Subject Core courses and 2 Subject Elective courses of Minor specialization. In this case he /she shall be awarded MBA (Functional Area Specialization Major + Functional Area Specialization Minor) degree, e.g. MBA (Marketing + Finance), etc.

5.4 Foundation Courses:

1. All the Foundation Courses shall be of 1 credit each.
2. Maximum credits for Foundation Courses **shall not exceed 10 (Ten) Credits.**

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Vadgaon (Bk.), Pune - 411 041.

3. Foundation Courses can be opted for ONLY IN LIEU of Generic Elective (GE - IL) and / or Subject Elective (SE - IL) courses.[3]
4. This choice can be exercised in Semester I (minimum zero Credits – maximum six credits) or Semester II (minimum zero Credits – maximum four credits) ONLY.
5. Foundation Courses CANNOT be opted for in Sem III and in Sem IV.
6. It is NOT MANDATORY for a learner to opt for Foundation Courses. However, Faculty members may advise a student to enroll for Foundation Course(s) after a methodical assessment of the relevant competencies of the student.
7. Foundation Courses shall be offered ONLY to those students who lack the basic competencies in the specific course. The institute shall conduct a methodical assessment of the relevant competencies of the student. to identify the learners who need to take up foundation courses. Records of the evaluation shall be preserved.
8. Institutes may stipulate additional criteria for students desirous to take up Foundation Courses.
9. Foundation Courses shall be taught by the course teacher in workshop mode / project mode.
10. The course teacher shall oversee the progress of the learner as well as evaluate the learner for 25 marks / 1 credit.
11. Pre- and post-test: A test or other assessment activity shall be administered to the students both at the beginning of the foundation course and at the end of the foundation course, with the intention of demonstrating improved skills upon completion. The tests shall be essentially SKILL based.
12. Best of the two assessments shall be treated as the final evaluation.
13. The list of Foundation Courses is mentioned in Annexure I.

5.5 Enrichment Courses:

1. All the Enrichment Courses shall be of 1 credit each.
2. Maximum credits for Enrichment Courses **shall not exceed 14 (Fourteen) Credits**.
3. Enrichment Courses can be opted for, ONLY IN LIEU of Generic Elective (GE - IL) and / or Subject Elective (SE - IL) courses[4].
4. This choice can be exercised in Semester I (minimum zero Credits – maximum six credits) or Semester II (minimum zero Credits – maximum four credits) or Semester III (minimum zero Credits – maximum two credits) or Semester IV (minimum zero Credits – maximum two credits).
5. It is NOT MANDATORY for a learner to opt for Enrichment Courses. However, Faculty members may advise a student to enroll for Enrichment Course(s) after a methodical assessment of the relevant competencies of the student.
6. Institutes may stipulate additional criteria for students desirous to take up Enrichment Courses.
7. Enrichment Courses shall be executed as **Course of Independent Study** (CIS) in guided self study mode.
8. A faculty guide shall be assigned for such courses. The learner shall select the Enrichment Course that he/she desires to opt for and submit an outline of the proposed study relevant to the course. The faculty guide shall approve the proposal after considering the nature of the work, learning effort required, desired outcomes and comprehensive coverage of the topic.
9. Since enrichment course is a guided self study course, 40 - 45 hours of work shall be equivalent to one credit. The faculty shall oversee the progress of the learner as well as evaluate the learner for 25 marks / 1 credit.
10. The learners shall document and submit details such as questionnaires, interview schedules, interview transcripts, observation sheets, photographs, testimonials from the organizations / persons interacted with, permission letters, acceptance letters, field work sampling plans, etc.
11. Enrichment Courses can be carried out in the campus library / in the campus IT lab / in a local community setting / in a start-up / in a government undertaking / in a NGO / in a cooperative / in a corporate entity.
12. The Enrichment Courses are organized in different Proficiency Tracks. Learners shall normally opt for enrichment courses from **NOT MORE THAN 3 Proficiency Tracks**.
13. **Enrichment Courses are of the following types:**

a) **Seminar** - Involves Desk Research of distributed learning material and information resources and submission and presentation of an analytical report. Maximum credits for Enrichment Courses of Seminar type shall not exceed 10 (Ten) Credits.

[3] Except for a learner who opts for Major + Minor Specialization combination
[4] Except for a learner who opts for Major + Minor Specialization combination

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Vadgaon (Bk.), Pune - 411 041.

b) **Review** – Involves Desk Research of a small set of specific published reports/ databases and submission and presentation of an analytical report. Maximum credits for **Enrichment Courses of Seminar type** shall not exceed 10 (Ten) Credits.

c) **Case Study Development and Presentation** – Involves desk research and field work leading to the development, presenting and publishing of a case study. Maximum credits for **Enrichment Courses of Case Study Development and Presentation type** shall not exceed 10 (Ten) Credits.

d) **Project** – Involves field work leading to presentation of a comprehensive report based on the experiential learning. Maximum credits for **Enrichment Courses of Project type** shall not exceed 10 (Ten) Credits.

e) **Lab / Workshop** - Involves experiential learning through focused skill building activity. Maximum credits for **Enrichment Courses of Lab / Workshop type** shall not exceed 10 (Ten) Credits.

f) **Clinic / Fest** – Involves experiential learning through organizing an event / campaign. Maximum credits for **Enrichment Courses of Clinic / Fest type** shall not exceed 4 (Four) Credits.

g) **Personal Interest Course** - Involves experiential learning through club activities at the Institute Level. Maximum credits for **Enrichment Courses of Personal Interest Course type** shall not exceed 4 (Four) Credits.

14. A well documented and comprehensive spiral bound report / publication, with appropriate referencing, is essential for all the enrichment courses. Relevant Audio, Video Material, should be included as a part of the report.
15. The Evaluation for the Enrichment Courses shall be as follows –
    a) Proposal and Scope of Work – 5 Marks
    b) Report – 10 Marks
    c) Presentation – 5 Marks
    d) Viva Voce – 5 Marks
16. The presentation shall be similar to an open defence. The Viva Voce shall be carried out by minimum two faculty members including the guide.
17. The sum total of the number of Foundation Courses and the number of Enrichment Courses opted by a student in a particular semester should generally be an even number.
18. The list of Enrichment Courses is provided in Annexure I.

5.6 Alternative Study Credit Courses:

1. All the ASCC shall be of 2 credits each.
2. Maximum credits for ASCC **shall not exceed 22 (Twenty two) Credits.**
3. Alternative Study Credit Courses (ASCC) can be opted for, ONLY IN LIEU of Generic Elective (GE - IL) and / or Subject Elective (SE - IL) courses[5].
4. This choice can be exercised in Semester I (minimum zero Credits – maximum six credits) or Semester II (minimum zero Credits – maximum six credits) or Semester III (minimum zero Credits – maximum six credits) or Semester IV (minimum zero Credits – maximum four credits). i.e. a learner may skip Generic Elective (GE - IL) courses all together and earn the required 22 credits entirely through ASCC.
5. It is NOT MANDATORY for a learner to opt for Alternative Study Credit Courses. However, Faculty members may advise a student to enroll for Alternative Study Credit Course(s) after a methodical assessment of the relevant competencies of the student.
6. Institutes may stipulate additional criteria for students desirous to take up Alternative Study Credit Courses.
7. **A MINIMUM of 60% of the total credits earned by a learner through ASCC shall either be from MOOCs or from Professional Certification Programmes.**
8. Thus a learner may skip all Generic Elective (GE - IL) courses and skip all Subject Elective (SE - IL) courses and earn the required 22 credits entirely through ASCC.
9. The same TYPE of ASCC can be opted for multiple number of times. Norms for the same are prescribed in the relevant section later in this syllabus document. For e.g. A student may undertake 11 "Professional Certification Programs" and earn 22 credits or complete 11 MOOCS and earn 22 Credits. 4 WEEKS MOOC shall be treated as 1 credit , 8 WEEKS MOOC shall be treated as 2 credits & 12 WEEKS MOOC shall be treated as 3 credits.
10. ASCC shall be executed in online study mode / field work or project mode / certification mode.
11. A faculty guide shall be assigned for such courses. The faculty shall oversee the progress of the learner as well as evaluate the learner for 50 marks / 2 credits.

[5] Except for a learner who opts for Major + Minor Specialization combination

12. The learner shall select the ASCC that he/she desires to opt for and submit an outline of the proposed study relevant to the course. The faculty guide shall approve the proposal after considering the nature of the work, learning effort required, desired outcomes and comprehensive coverage of the topic.
13. There is no defined syllabus for the ASCC courses. Institutes shall define the syllabus and announce the same on the website.
14. Since ASCC is a guided self study course 40 - 45 hours of work shall be equivalent to one credit. The faculty shall oversee the progress of the learner as well as evaluate the learner for 50 marks / 2 credits.
15. The start date of the ASCC such as Professional Certifications shall be after the admission date for the MBA programme and the end date of the ASCC shall be within 6 months of the start date of the ASCC, but before the completion of Sem IV.
16. The list of ASCC is provided in Annexure I.

5.7 Combination of Options: A learner may opt for any combination of earning the 22 credits assigned to Generic Elective (GE - IL) courses and Subject Elective (SE - IL) courses through

e) Generic Elective (GE - IL) courses
f) Subject Elective (SE - IL) courses
g) Open Elective Courses
h) Major + Minor specialization combination
i) Foundation Courses
j) Enrichment Courses
k) Alternative Study Credit Courses

SUBJECT TO THE minimum and maximum limits of credits prescribed and, subject to institutional norms and guidelines, issued from time to time.

6.0 Summer Internship Project: At the end of Second Semester each student shall undertake a Summer Internship Project (SIP) for a **minimum of 8 weeks**. For SIP, 1 credit is equivalent to minimum 40-45 hours of effective work. SIP shall have 6 credits. It is mandatory for the student to seek advance written approval from the faculty guide and the Director of the Institute about the topic and organization before commencing the SIP.

The SIP may or may not have a Functional Focus, i.e. the student may take up a SIP in his/her intended area of specialization or in any other functional area of management. **Ideally the SIP should exhibit a cross-functional orientation.** SIP can be carried out in a Corporate Entity / NGO / SME / Government Undertaking / Cooperative Sector. SIP may be a research project – based on primary / secondary data or may be an operational assignment involving working by the student on a given task/assignment/project/ etc. in an organization / industry. It is expected that the SIP shall sensitize the students to the demands of the workplace.

Each student shall maintain a SIP Progress Diary detailing the work carried out and the progress achieved on a daily basis. The student shall submit a written structured SIP report based on work done during this period. The student shall submit the SIP Progress Diary along with the SIP Report.

Students shall also seek a formal evaluation of their SIP from the company guide. The formal evaluation by the company guide shall comment on the nature and quantum of work undertaken by the student, the effectiveness and overall professionalism. The learning outcomes of the SIP and utility of the SIP to the host organization must be specifically highlighted in the formal evaluation by the company guide. The SIP evaluation sheet duly signed and stamped by the industry guide shall be included in the final SIP report.

The SIP report must reflect 8 weeks of work and justify the same. The SIP report should be well documented and supported by –

1. Institute's Certificate
2. Certificate by the Company
3. Formal feedback from the company guide
4. Executive Summary
5. Organization profile
6. Outline of the problem/task undertaken
7. Research methodology & data analysis (in case of research projects only)

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8. Relevant activity charts, tables, graphs, diagrams, AV material, etc.
9. Learning of the student through the project
10. Contribution to the host organization
11. References in appropriate referencing styles. (APA, MLA, Harvard, Chicago Style etc.)

The completion of the SIP shall be certified by the respective Faculty Guide & approved by the Director of the Institute. The external organization (Corporate / NGO/ SME/ Government Entity/ Cooperative/ etc.) shall also certify the SIP work.

The students shall submit a spiral bound copy of the SIP report by 15th September. The Institute shall conduct an internal viva-voce for evaluation of the SIP for 50 marks between 15th September to 30th September. The Panel shall comprise of two evaluators appointed by the Director of the Institute / Head of Department (for MBA departments in engineering colleges). Institutes are encouraged to involve senior alumni, industry experts, recruiters to conduct the internal viva-voce. The internal viva-voce panel shall provide a detailed assessment of the SIP report and suggest changes required, if any.

After the internal viva-voce, the student shall finalize the SIP report by incorporating all the suggestions and recommendations of the internal viva-voce panel. The internal guide shall then issue the Institute's Certificate to the student.

The student shall submit TWO hard copies & one soft copy (CD) of the project report before 30th October in Sem III. One hard copy of the SIP report is to be returned to the student by the Institute after the External Viva-Voce. In the interest of environmental considerations, students are encouraged to print their project reports on both faces of the paper. Spiral bound copies may be accepted.

There shall be an external viva-voce for the SIP for 50 marks. The external viva-voce shall be conducted after the theory exam of Semester III.

The Internal & the External viva-voce shall evaluate the SIP based on:

1. Adequacy of work undertaken by the student
2. Application of concepts learned in Sem I and II
3. Understanding of the organization and business environment
4. Analytical capabilities
5. Technical Writing & Documentation Skills
6. Outcome of the project – sense of purpose
7. Utility of the project to the organization
8. Variety and relevance of learning experience

Copies of SIP report and records of evaluation shall be maintained by the Institute for a period of 3 academic years.

7.0 Comprehensive Concurrent Evaluation (CCE) / Concurrent Internal Evaluation (CIE):

1. The course teacher shall prepare the scheme of Comprehensive Concurrent Evaluation (Formative Assessment) before commencement of the term. The scheme of Comprehensive Concurrent Evaluation shall explicitly state the linkages of each CCE with the Course Outcomes and define the targeted attainment levels for each CO.
2. The Director / Head of the Department / designated academic authority shall approve the scheme of Comprehensive Concurrent Evaluation with or without modifications.
3. The course teacher shall display, on the notice board, the approved CCE scheme of the course and the same shall also be hosted on the website, not later than the first week of the term.
4. Each CCE item shall be of minimum 25 marks.
5. For a 3 Credit Course there shall be a MINIMUM of three CCE items. The final scores shall be converted to 50, using an average or best two out of three formula.
6. For 2 Credit Course there shall be a MINIMUM of two CCE items. The final scores shall be converted to 50.
7. For a 1 Credit Course there shall be a MINIMUM of one CCE item.
8. CCE shall be spread through the duration of course and shall be conceptualized, executed, assessed and documented by the course teacher along with student-wise and class-wise attainment levels of the COs and the attainment levels of the course.

HEAD
Dept. of Management Studies
Smt. Kashibai Navale College of Engg
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9. The assessment outcome of each CCE shall be duly signed by the course teacher, programme coordinator / academic head and the Director / Head of the Department / designated academic authority of the Institute.
10. A copy of the duly signed CCE *outcome* shall be displayed on the notice boards, within a week of the assessment and course teachers shall guide the students on a need basis.
11. Institute may conduct additional make up / remedial CCE items at its discretion.
12. At the end of the term aggregate CCE scores / grades shall be calculated and the CO attainment levels shall be calculated by the course teacher. The same shall be displayed on the notice board

7.1 Comprehensive Concurrent Evaluation Methods: Course teachers shall opt for a combination of one of more CCE methods listed below.

Group A (Individual Assessment) – Not more than 1 per course

1. Class Test
2. Open Book Test
3. Written Home Assignment
4. In-depth Viva-Voce

Group B (Individual Assessment) – Atleast 1 per course

5. Case Study
6. Caselet
7. Situation Analysis
8. Presentations

Group C (Group Assessment) – Not more than 1 per course

9. Field Visit / Study tour and report of the same
10. Small Group Project & Internal Viva-Voce
11. Model Development
12. Role Play
13. Story Telling
14. Fish Bowls

Group D (Creative - Individual Assessment) – Not more than 1 per course

15. Learning Diary
16. Scrap Book / Story of the week / Story of the month
17. Creating a Quiz
18. Designing comic strips
19. Creating Brochures / Bumper Stickers / Fliers
20. Creating Crossword Puzzles
21. Creating and Presenting Posters
22. Writing an Advice Column
23. Library Magazines based assessment
24. Peer assessment
25. Autobiography/Biography
26. Writing a Memo
27. Work Portfolio

Group E (Use of Literature / Research Publications- Individual Assessment) – Not more than 1 per course

28. Book Review
29. Drafting a Policy Brief
30. Drafting an Executive Summary
31. Literature Review
32. Term Paper
33. Thematic Presentation
34. Publishing a Research Paper
35. Annotated Bibliography

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Revised Syllabus

Master of Business Administration

(MBA)

Choice Based Credit System and Grading System

Two Year Full Time Four Semester

POST GRADUATE PROGRAMME

MBA I Year Curriculum Applicable w.e.f. AY 2016-17

MBA II Year Curriculum Applicable w.e.f. AY 2017-18

1. Title

Name of the Programme: Master of Business Administration (MBA).

Nature of the Programme: MBA is two year full time post-graduate degree programme.

2. Preamble: The revised curriculum for MBA is developed keeping in mind the *national priorities* and *international practices.* It also attempts to align the programme structure and course contents with student aspirations & recruiter expectations. This syllabus also attempts to align with National Goal of "Make in India", "Start – Up and Stand – Up India" and "Digital India".

2.1 Need for Revision of the Curriculum: The MBA programme curriculum of the Savitribai Phule Pune University was last revised in the AY 2013 and there was a need for revision of the curriculum in view of the dynamism in the industry practices, evolution in technology and the evolving expectations of key stakeholders viz. students, the industry and faculty members at large. It also has relevance due to changed technological, social, cultural and economic environment of the nation.

Specifically, the triggers for the comprehensive revamp of the curriculum are -

a) **New Skills & Competencies desired due to dynamic business environment:** Jobs of today were perhaps not created about 5 years ago. This aspect has a direct linkage with contents and structure of syllabus across the *Knowledge, Skills and Attitude (KSA) dimensions,* which calls for frequent and meaningful updating of the curriculum.

b) **Concerns expressed by the Industry:** The industry has expressed concerns about the need for improvement in the *communication skills, inter-personal skills, domain knowledge basics, business environment awareness, technology proficiency, and attitude* of the MBA graduates. *Newer and innovative evaluation methods* are necessary to address these concerns of the industry.

c) **Application Orientation:** There is a pressing need to *imbibe application oriented thinking*, based on sound knowledge of management theories, principles and concepts. Management education needs to move out of the classrooms and instead focus on *group activity, field work, experiential learning, etc.* This can be achieved only through a radical change in the evaluation pattern and course delivery methodology.

d) **Changing mindset of the Learner:** The profile of the students for the management programme, their learning styles and the outlook towards higher education has undergone a gradual transformation. The expectations of the students from the MBA programme have changed over the last decade.

e) **Integrate a basket of skill sets:** B-Schools are expected to imbibe varied aspects of 'learning beyond the syllabus through innovative curriculum design, contemporary syllabus, effective delivery and comprehensive evaluation.

f) **Entrepreneurial aspirations and preparedness for the same:** The youth now aspires to become masters of their own and wish to start up their new ventures. These will create further growth opportunities.

Specifically the following skill sets are in focus:

i. Reading & Listening Skills
ii. Problem Definition& Problem Solving Skills
iii. Application of Technology Tools
iv. Mastery of Analytics (Quantitative Aspects)
v. Sensitization to Cross-Functional skills
vi. Sensitization to Cross-Cultural skills
vii. Sensitization to Global perspectives
viii. Peer-based Learning - Working in groups
ix. Learning by application and doing – Experiential learning
x. Team building basics and its orientation

2.2 MBA Programme Objectives: The MBA programme prepares a student for a career in diverse sectors of the industry domestically and globally. The MBA programme facilitates learning in theory and practice of different functional areas of management and equips the students with an integrated approach to various functions of management. However, the demand for managerial skills is not limited to the industry. Managerial talent is much sought by the Government Sector, NGOs, non-corporate sector as well.

Students also expect to become entrepreneurs. Their aspirations also require a broad based learning encompassing the end to end processes involved in developing entrepreneurial skills. Institutes, Faculty and Students need to move away from the excessive focus on industry and look at needs and demands of broader sections of the society also.

Specifically the objectives of the MBA Programme are:

1. To equip the students with requisite knowledge, skills &right attitude necessary to provide effective leadership in a global environment.
2. To develop competent management professionals with strong ethical values, capable of assuming a pivotal role in various sectors of the Indian Economy &Society, aligned with the national priorities.
3. To develop proactive thinking so as to perform effectively in the dynamic socio-economic and business ecosystem.
4. To harness entrepreneurial approach and skillsets.

2.3 Highlights of the New Curriculum: The New Curriculum intends to add immense value to all stakeholders by effectively addressing their requirements in more than one way by:

1. Enhancing *the brand value of the MBA programme of the Savitribai Phule Pune University.*
2. Providing the much needed flexibility to individual Institutes to carve a niche for themselves.
3. Emphasizing the *centrality of the student and teacher-student relationship* in the learning process.
4. Focusing on *'Concurrent Evaluation'* i.e. continuous evaluation throughout the programme.
5. Empowering the Institutes through *cafeteria approach – by providing Generic Core, Subject Core, Generic Elective, and Subject Elective Courses.* This shall provide in-built flexibility in the curriculum to help the institutes to offer tailor made courses preferred by students, from a wider basket of courses.
6. Evaluating *all Half Credit Courses completely on Concurrent Evaluation* pattern.
7. Emphasizing *Experiential Learning* aspect through Half Credit Courses.
8. Supplementing traditional classroom teaching/learning with focus on *group activity, field work,* experiential learning, self-study, projects, Industry Exposure Programmes etc.
9. Incorporating new specializations viz. Retail Management, Services Management, International Finance, Travel & Tourism, Media & Communication and Entrepreneurship Development thereby providing wider choice to the students.
10. A thorough revamp of Systems and Operations Specializations to make them more meaningful and attractive to BCA, BCS, BE students.
11. Providing opportunity to students to choose courses from other electives to explore *cross-functional issues.*
12. Emphasizing on *Research, Inter-personal, Analytical, Cross-Cultural, Entrepreneurial Skills, and Global aspects* of managerial careers throughout the curriculum.

3. Pattern: The Programme comprises of 4 Semesters and adopts the Choice Based Credit System (CBCS) and Grading System.

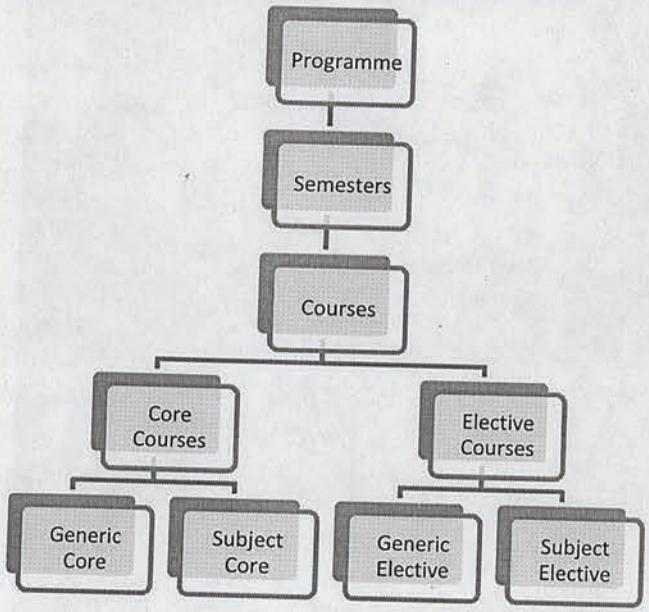
3.1 Choice Based Credit System: Choice Based Credit System (CBCS) offers wide ranging choice for students to opt for courses based on their aptitude and their career goals. CBCS works on the fundamental premise that students are mature individuals, capable of making their own decisions.

CBCS enables a student to obtain a degree by accumulating required number of credits prescribed for that degree. The number of credits earned by the student reflects the knowledge or skill acquired him / her. Each course is assigned a fixed number of credits based on the contents to be learnt & the expected effort of the student. The grade points earned for each course reflects the student's proficiency in that course. CBCS is a process of evolution of educational reforms that would yield the result in subsequent years and after a few cycles of its implementation.

3.1.1 Key features of CBCS:

1. **Enriching Learning Environment:** A student is provided with an academically rich, highly flexible learning system blended with abundant provision for skill practice and activity orientation that he/she could learn in depth without sacrificing his/her creativity. There is a definite movement away from the traditional lectures and written examination.
2. **Learn at your own pace:** A student can exercise the option to decide his/her own pace of learning- *slow, normal or accelerated plan.* Students can select courses according to their aptitude, tastes and preferences.
3. **Continuous Learning & Student Centric Concurrent Evaluation: CBCS** makes the learning process continuous and the evaluation process is not only made continuous but also made learner-centric. The evaluation is designed to recognize the capability and talent of a student.
4. **Active Student-Teacher Participation:** CBCS leads to quality education with active teacher-student participation. This provides avenues to meet student's scholastic needs and aspirations.
5. **Industry, Institute Collaboration:** CBCS provides opportunities for meaningful collaboration with industry and foreign partners to foster innovation, by introduction of electives and half credit courses through the cafeteria approach. This will go a long way in capacity building of students and faculty.
6. **Interdisciplinary Curriculum:** Cutting edge developments generally occur at the interface of two or more discipline. Interdisciplinary approach enables integration of concepts, theories, techniques, and perspectives from two or more disciplines to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline.
7. **Employability Enhancement:** CBCS shall ensure that students enhance their skill/employability by taking up project work, entrepreneurship and vocational training.
8. **Faculty Expertise:** CBCS shall give the Institutes the much needed flexibility to make best use of the expertise of available faculty.

3.1.2 Programme Structure in Choice Based Credit System:



3.2 Time Schedule: An academic year is divided into two terms – I and II. Each term has one semester. Term I shall have SEM I and III, whereas Term II shall have SEM II and IV. In each semester, courses are offered in 15 teaching weeks and the remaining 5 weeks are to be utilized for conduct of examinations and evaluation purposes.

For students, each week has 40 working hours spread over 5/6 days a week consisting of lectures, tutorials, assignments, class participation, library work, special counseling, Sports, project work, field visit, youth welfare and social activities.

3.3 Course: A "Course" is a component of programme, i.e. in the new system; papers will be referred to as courses. Each course is identified by a unique course code. While designing curriculum, course can have defined weightage. These weightages are called credits.

Each course, in addition to having a syllabus, has learning objectives and learning outcomes. A course may be designed to comprise lectures/ tutorials/ laboratory work/ field work/ project work/vocational training /viva voce etc. or a combination of some of these.

3.3.1 Core Courses: The Curriculum comprises of Core Courses and Elective Courses.

Core courses are the foundation courses of management education. They are compulsory for all the students. Core courses are of two types: Generic Core & Subject Core.

Generic Core: This is the course which should compulsorily be studied by a candidate as a core requirement to complete the requirement of a degree in a said discipline of study. Therefore, Generic Core courses are mandatory and fundamental in nature. These courses cannot be substituted by any other courses. Such courses are also known as **Hard Core Courses.**

A Hard core course may be a Theory, Practical, Field based or Project Work based subject which is a compulsory component in the Programme Structure.

Subject Core: A Core course may be a Subject Core if there is a choice or an option for the candidate to choose from a broad category (grouping) of subjects (specializations). These are also known as **Soft Core Courses.**

Following Specializations shall be offered:

1. Marketing Management (MKT)
2. Financial Management (FIN)
3. Information Technology Management (IT)
4. Operations Management (OPE)
5. Human Resources Management (HR)
6. International Business Management (IB)
7. Supply Chain Management (SCM)
8. Rural &Agribusiness Management (RABM)
9. Family Business Management (FBM)
10. Technology Management (TM)
11. Banking and Insurance Management (BIM)
12. Healthcare Management (HM)
13. Entrepreneurship Development (ED)
14. Services Management (SM)
15. Retail Management (RM)
16. Digital Media & Communication Marketing(MC)
17. Tourism and Hospitality Management (THM)
18. Defence Management (DM)

Students shall study 2 Full Credit Courses & 4 Half Credit Courses in Semester III and IV each for specialization courses i.e. a total of 16 specialization courses of which 4 are full credits and 8 are half credits.

- Generic Core courses in Semester I provide *foundations of management.*
- Generic Core courses in Semester II focus on *functional areas.*

- Generic Core courses in the Semester III and IV are *integrative* in nature along with the Subject Core subjects.

3.3.2 Elective Course: Elective course is a course which can be chosen from a pool of courses. It may be:

a) Very Specialized or advanced course focusing on a specific aspect
b) Supportive to the discipline of study
c) Providing an extended scope
d) Enabling an exposure to some other discipline/domain
e) Nurturing candidate's proficiency/skill.

Generic Elective: An elective course which is common across disciplines / subjects is called a generic elective. 'Generic Elective' courses develop generic proficiencies amongstthe students.
Subject Elective: A 'Discipline centric' elective is called 'Subject Elective.'

- Generic Elective courses, in Semester I and II facilitate self-development and skill building.
- Subject Elective courses, in the Semester III and IV are focused on a specialization.

Open Elective: A subject elective course chosen generally from an unrelated discipline/ subject, with an intention to seek cross-functional exposure is called an Open Elective. A Subject Elective offered in a discipline / subject may be treated as an Open Elective by other discipline / subject and vice versa.

Choice of Cross Functional Half Credit Courses (Subject Elective chosen as Open Elective): Out of the 8 half credit subject elective courses (to be taken collectively in Semester III and IV); *a student may choose 2 half credit subject courses from another elective* (i.e. other than his chosen elective). The student may exercise this choice either in Semester III and/or in Sem IV. The final say in this matter shall rest with the Director of the Institute.

Generic and Subject Electives will provide flexibility to each Institute to offer courses based on: -

a) Intended positioning of the Institute
b) Targeted Industry Linkages – sectoral requirements and networking at the Institute Level
c) Student Composition – rural/urban, commerce/engineering/others, fresh/experienced, etc.
d) Present & Future Faculty Competencies – generic and specialization areas
e) Locational Aspects - rural/urban/ semi-urban

An Institute may offer varied combinations of Half Credit courses to various groups of students enrolled in a particular academic year / enrolled for a particular specialization based on student interests and competencies, faculty availability.

3.4 Pre-requisites for successful implementation of CBCS: The success of the CBCS also requires certain commitments from both the students and the teachers.

1. The student should be regular and punctual to his classes, studious in carrying out the assignments and should maintain consistency in his tempo of learning. He should make maximum use of the available library, internet and other facilities.
2. The teachers are expected to be alert and punctual and strictly adhere to the schedules of teaching, tests, seminars, evaluation and notification of results.
3. All teachers should notify the tentative schedule of teaching and tests of the entire semester, including the dates of tests, dates of score notification and all other schedules, which can be planned in advance.
4. The teachers are expected to adhere to unbiased and objective evaluation and marking of concurrent evaluation scores (internal examinations) which will not only maintain the confidence of the students, but, at the same time, ensure that merit is given due credit.
5. Transparency, objectivity and quality are the key factors that will sustain a good CBCS system.
6. **At the post-graduate level, and in a professional programme, the syllabus is to be looked upon as the bare minimum requirement to be fulfilled and sufficient emphasis shall be laid on contemporary aspects, going beyond the syllabus.**

3.5 Credits

Credit: The definition of 'credits' can be based on various parameters—such as the learning hours put in, learning outcomes and contact hours, the quantum of content/syllabus prescribed for the course.

The credit system requires that a student progresses in the academic programmes not in terms of time (years or semesters), but in terms of courses.

Each course is assigned a certain credit, depending on the estimated effort put in by a student. When the student passes that course, he/she earns the credits associated with that course.

In the Credit system the emphasis is on the **hours put in by the learner and not on the workload of the teacher**. Each credit can be visualized as a combination of **3 components viz. Lecture (L) + Tutorials (T) + Practical / Project Work (P) i.e. LTP Pattern.**

The effort of the learner for each Credit Point may be considered under two parts –

a) One part consisting of the hours actually spent in class room / practical / field work instructions and
b) The other part consisting of notional hours spent by the Learner in self-study, in the library, peer interactions, case study, writing of journals and assignments, projects etc. for the completion of that course.

Every course offered shall have three components associated with the teaching-learning process of the course, viz.

a) Lecture – L : Classroom sessions delivered by faculty in an interactive mode
b) Tutorial- T : Session consisting of participatory discussion/ self-study/ desk work/ brief seminar presentations by students and such other novel methods that make a student to absorb and assimilate more effectively the contents delivered in the Lecture sessions
c) Practice - P: Practice session /Project Work consisting of Hands-on experience / Field Studies / Case studies that equip students to acquire the much required skill component.

In terms of credits, for a period of one semester of 15 weeks:

a) every ONE hour session per week of L amounts to 1 credit per semester
b) a minimum of TWO hours per week of T amounts to 1 credit per semester,
c) a minimum of TWO hours per week of P amounts to 1 credit per semester,

The teaching / learning as well as evaluation are to be interpreted in a broader perspective as follows:

a) Teaching – Learning Processes: Classroom sessions, Group Exercises, Seminars, Small Group Projects, Self-study, etc.
b) Evaluation: Tutorials, Class Tests, Presentations, Field work, Assignments, Research papers, Term papers, etc.

A course shall have either or all the three components, i.e. a course may have only lecture component, or only practice component or a combination of any two or all the three components.

The total credits earned by a student at the end of the semester upon successfully completing a course are 'L + T + P'. The credit pattern of the course is indicated as L: T: P.

If a course is of 3 credits then the different credit distribution patterns in L: T: P format could be 3:0: 0, 1:2: 2, 2: 0: 2, 2: 2: 0, etc. In no instance the credits of a course can be greater than the number of hours (per week for 15 weeks) allotted to it.

Full Credit Course: A course with weightage of 3 credits is considered as a full course. (Except for Summer Internship Project and Dissertation which are full credit courses with 4 Credits each.)

Half Credit Course: A course with weightage of 2 credits is considered as a half course.

The MBA programme is a combination of:

a) Full Credit Courses (100 Marks each) : 3 Credits each
b) Half Credit Courses (50 Marks each) : 2 Credits each

3.6 Adoption of Credit and Grading System

As per national policy and international practices, we have adopted the Credit and Grading System for the MBA programme w.e.f. AY 2013-14.

3.6.1 Rationale for adoption of the Credit and Grading System:

a) **Learner's Perspective:** The current practice of evaluation of student's performance at the end of a semester is flawed. The students are expected to express their understanding or mastery over the content included in their curriculum for a complete semester within a span of three hours and their efforts over the semester are often completely ignored. It also promotes to an unhealthy practice of cramming before the examinations and focusing on marks rather than on learning.

b) **Evaluation Perspective:** The present system of evaluation does not permit the flexibility to deploy multiple techniques of assessment in a valid and reliable way. Moreover, the current practice of awarding numerical marks for reporting the performance of learners suffers from several drawbacks and is a source of a variety of errors. Further, the problem gets compounded due to the variations in the marks awarded in different subjects. The 'raw score' obtained by the learner, is, therefore, not a reflection of his true ability.

In view of the above lacunae, it is desirable that the marking system used for the declaration of results is replaced by the grading system. The system of awarding grades provides a more realistic picture of learner's ability than the prevailing marking system. *Excellence in quality education can be achieved by evaluating the true ability of the learners with the help of continuous evaluation.*

3.6.2 Salient features of the grading system:

1. In this system, students (learners) are placed in ability bands that represent a range of scores. This ability range may be designated with alphabetical letters called as 'GRADE'.
2. Grading reflects an individual learner's performance in the form of a certain level of achievement.
3. The Grading system ensures natural classification in qualitative terms rather than quantitative terms since it expresses a range /band of scores to which a learner belongs such as O,A,B,C,D,E & F
4. Grades can be interpreted easily and directly and can be used to prepare an accurate 'profile' of a learner.
5. A properly introduced grading system not only provides for a comparison of the learners' performance but it also indicates the quality of performance with respect to the amount of efforts put in and the amount of knowledge acquired at the end of the course by the learners.

3.6.3 Basics of Credit and Grading System: Grading is a method of reporting the result of a learner's performance subsequent to his evaluation. It involves a set of alphabets which are clearly defined and designated and uniformly understood by all the stake holders.

Grading is carried out in a variety of ways. The classification of grades depends upon the reference point.

With 'Approach towards Grading' as the reference point, Grading may be classified as:

a) **Direct grading:** When the performance exhibited by the examinees is assessed in qualitative terms and the impressions so obtained by the examiners are directly expressed in terms of letter grades, it is called, *'Direct Grading'.*

b) **Indirect grading:** When the performance displayed by the examinees is first assessed in terms of marks and subsequently transformed into letter grades by using different modes, it is called, *'Indirect Grading.'*

With 'Standard of Judgment', as the reference point Grading may be classified as:

a) **Absolute grading:** The method that is based on a predetermined standard which becomes a reference point for the learner's performance is called 'Absolute Grading'. This involves direct conversion of marks into grades irrespective of the distribution of marks in a subject.
b) **Relative grading:** Relative Grading is popularly known as grading on the curve. The curve refers to the normal distribution curve or some symmetric variant of it. This method amounts to determining in advance approximately what percentage of learners can be expected to receive different grades, such as O,A,B,C,D,E,F. In this grading system the grade is not determined by the learner's performance but on the basis of group performance.

Absolute grading has several advantages such as –

a) the procedure is simple and straightforward to use,
b) each grade is distinctly understandable,
c) the learner has the freedom to strive for the attainment of the highest possible grade and
d) It enables the learners to know their strengths and weaknesses.

The few limitations in Absolute Grading method are that –

a) The distribution of scores is taken at its face value regardless of the errors of measurement creeping in due to various types of subjectivity.
b) Besides, the cut-offs of different categories are also arbitrarily decided.

It is proposed to use the **Indirect and Absolute Grading System for the MBA programme,** i.e. the assessment of individual Courses in the concerned examinations will be on the basis of marks, but the marks shall later be converted into Grades by a defined mechanism wherein the overall performance of the Learners can be reflected after considering the Credit Points for any given course. However, the**overall evaluation shall be designated in terms of Grade.**

3.7 Session Duration: Each teaching-learning, evaluation session shall be of 60 minutes. However, institutes shall have the flexibility to define their time slots in a manner as to use their faculty and infrastructure resources in the best possible way. Batch size for tutorials shall be 50% of the normal class size, subject to a minimum of 30 students.

3.8 Courses Offered: Institutes are free to offer only a *select number of specializations* from amongst the list provided by the University. Likewise, institutes may provide only a *sub-set of the generic electives, subject electives* as prescribed semester-wise in the Programme structure.

However, it shall be mandatory for the Institutes to provide all information relating to the specializations offered, generic electives, subject electives, their respective credits, evaluation pattern, etc. to all the students so as to enable them to make an informed choice. Such information should be hosted on the website/prospectus of the Institute in sufficient advance, prior to commencement of the classes. Other information such as the credits, the prerequisites, and syllabus shall also be hosted on the website of the institute.

3.9 Registration: *It is mandatory for every student, to register every semester, for the courses opted under CBCS system, for that semester.*

Such registration forms the basis for a student to undergo concurrent evaluation, online evaluation and end-semester examination. Application forms for University examinations are to be filled up based on the choices finalized during the registration process and submitted to the University along with the prescribed examination fee.

3.9.1 Registration Process:

i. Each student, on admission shall be assigned to a ***Faculty Advisor*** who shall advise her/him about the academic programs and counsel on the choice of courses considering the student's profile and career objectives.

ii. With the advice and consent of the Faculty Advisor the student shall register for a set of courses he/she plans to take up for the Semester.

iii. The student should meet the criteria for prerequisites, if defined for a course, to become eligible to register for that course.

iv. The Institute shall follow a selection procedure on a first come first served basis, determining the maximum number of students, giving counseling to the students, etc., to avoid overcrowding to particular course(s) at the expense of some other courses.

v. It is expected that a student registers for 26 credits in SEM I and II each, 27 Credits in SEM III each and balance 21 credits in Sem IV.

vi. However fast learners (under accelerated plan), may be permitted to register for 2 full credit / 3 half credit courses in excess of the normal credits defined for a semester. However, registration for Repeat courses (backlogs) is allowed in excess of this limit.

vii. Likewise, slow learners, may be permitted to register for 2 full credit / 3 half credit courses less than the normal credits defined for a semester.

viii. A candidate may register for a minimum of say, 20 credits per semester, but it is possible that he/she may earn less than 20 credits in a semester. It may be theoretically possible that he/she may just earn ZERO credits in a semester. However, he/she should register for credits less than or equal to permissible maximum and more than or equal to permissible minimum per semester, excluding the courses of earlier semester(s), for which he/she has not earned the credits (uncleared courses) if any.

ix. Students shall have to register for the courses for the semester within first week of Semester I and immediately after conclusion of the earlier term for Semester II, III and IV. i.e. The fresh inducted batch shall register for various courses at the end of the first week of their Sem I after their induction. They will register for Semester II courses immediately at the end of Semester I and likewise for subsequent semesters. In Semester I the registration window shall be open for sufficiently long duration to take care of late admissions.

x. The maximum number of students to be registered in each elective course shall depend upon the physical facilities available. Every effort shall be made by the Institute to accommodate as many students as possible.

xi. Students who do not earn credits for an elective course (generic / subject / open) are permitted to opt for another elective course (generic / subject / open) in case they feel to do so. In such a case they shall be said to have **dropped the original course and opted for a new one**. Alternatively, they are permitted to continue with the same elective course (generic / subject / open) i.e. If a student secures a F Grade in say course no 111 for which he has opted in Sem I, during the successive attempt he may drop course 111 and take up another course from 107 to 115, or continue with 111.

xii. Normally, every Lecture-based course shall, be delivered by one teacher.

xiii. The Institute may not offer a course if a minimum of 20% of students is not registered for that course.

4. Eligibility: The eligibility for admissions shall be defined by the Competent Authority viz. AICTE / DTE Maharashtra State for the relevant academic year.

5. Examination:

Pattern of Examination: The evaluation scheme comprises of:

a) University Evaluation
b) Concurrent Evaluation

For each full credit course –
a) 70 marks shall be evaluated by the University and
b) 30 marks shall be evaluated by the respective Institute.

For each half credit course –

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