UNIVERSITY OF DELHI

SCHEME OF EXAMINATION
AND
COURSES OF READING
FOR
B.E.MANUFACTURING PROCESS AND AUTOMATION ENGG.

Semester I Examination,
Semester II Examination,
Semester III Examination,
Semester IV Examination,
Semester V Examination,
Semester VI Examination,
Semester VII Examination,
Semester VIII Examination,

Syllabus applicable to students seeking admission to the B.E. Manufacturing Process and Automation Engg.
Course in the Academic year, 2000-2001

Price : Rs.30-00

FACULTY OF TECHNOLOGY

(UNIVERSITY OF DELHI)

NEW SCHEME OF EXAMINATION

1. **There shall be** the **following four** year Degree Courses under the Faculty of Technology;

i Bachelor of Engineering (Electrical)

ii Bachelor of Engineering (Electronics & Communication)

iii Bachelor of Engineering (Mechanical)

iv Bachelor of Engineering (Civil)

v Bachelor of Engineering (Production & Industrial)

vi Bachelor of Engineering(Polymer Science and Chemical

vii Technology)

viii Bachelor of Engineering (Computer) (viii) Bachelor of Engineering (Instrumentation & Control)

ix Bachelor of Engineering (Manufacturing Process & Automation)

2. In addition to the conditions laid down in Ordinance I, a candidate seeking admission to any of the above Courses of study for the bachelor's Degree should satisfy the following conditions.

(a) Educational Qualifications :

A candidate passing any one of the following examinations and securing 60 per cent or more marks in the aggregate of Physics, Chemistry and Mathematics shall be eligible for admission to the first Semester of Bachelor of Engineering Course provided he/she has passed in each subject separately;

(i) Senior School Certificate Examination (12 year Course of the Central Board of Secondary Education (C.B.S.E.), New Delhi.

(ii) Indian School Certificate Examination (12year Course) of the Council for Indian School Certificate Examination, New Delhi.

(iii) B.Sc. (Gen.) Group 'A' final Examination of the University of Delhi or equivalent examination.

(iv) B.Sc. (Hons.) Examination in Physics. Chemistry and Mathematics of the University of Delhi with Combination of Physics, Chemistry, Mathematic and equal weightage to the subsidiary subjects or equivalent examination.

(v) Any other examination recognized as equivalent to the Senior School Certificate Examination of the C.B.S.E.bythe University of Delhi.

A Candidate must additionally have passed English as a subject of study either at the 10th class level or 12th class (core or elective).

Note ; There shall be no direct admission to any level of the Courses above the 1st Semester.

3. Under each B.E. Degree Course certain subjects are offered which can be classified as Theory/Practical/Drawing/Design/Project/ Practical Training Further classification is based on the relationship of the subjects with the degree courses admitted to, namely Humanities S Social Science/Basic Sciences/Allied Engineering; Departmental, Core, etc.

   In addition to the above, a subject could be classified as a compulsory one or as one of the pre-requisite for another subject. The committee of Courses and studies ol the concerned Department shall do this classification.

4. A student who joins the first semester will ! be automatically, deemed to have registered for the subjects which are listed under the first Semester of the SUGGESTED SCHEME OF LEARNING. Every student is required to register for the subjects to be taught in the second and subsequent semesters. This process of registration shall start just before the start of next semester. The student" will also indicate during registration of subject/subjects of earlier Semester(s) in which he/she desires to appear, if other wise eligible. Such a student will be allowed to appear in the End Semester Examination and his/her marks of mid terms activities will remain unaltered since attendance is compulsory, a student will be permitted to register for course/courses which he can attend. The number ot theory subjects permitted will not be more than five. The total duration of contact Periods should not ordinarily exceed thirty hours per week.

5. B.E. Degree shall be awarded if a student has earned a minimum of 220 credits as specified in each degree programme subject to break up and compulsory credit as mentioned there in. However, a student may register in subjects leading to a maximum of 240 credits in the entire course.

   A student should keep a watch on his progress and register in those papers in which he must earn the credit to satisfy the above requirement of the particular degree.

If a student earns more than a specified minimum credit for degree the best marks in the minimum credits (satisfying the above conditions) will be considered for the purposes of classification of result.

6. EVALUATION AND REVIEW :

The Committee of Courses and studies in each department shll specify the following for the degree course :

(a) SUGGESTED SCHEME OF LEARNING :

(b) Minimum credits needed for the degree course and break up in terms of classification of courses i.e.

(i) Humanities and Social Sciences
(ii) Basic Sciences
(iii) Allied Engineering
(iv) Departmental core
(v) Practical Training
(vi) Unspecified/Electives and
(vii) Major Project

The Committee of Courses & Studies in each department shall appoint one or more Evaluation-cum-Review Committees each dealing with a group of subjects. This E.R.C. consist of the teachers who are likely to teach subjects in the group.

The E.R.C. has the following functons :

(i) To recommend appointment of paper setters/ examiners of various examinations at the start of each Semester,

(ii) To get prepared quizzes, assignments, test papers etc. for the mid-term and the end semester examination and to get them evaluated. Normally each concerned teacher, who is also a member of E.R.C, will do this job for his class. However, in exceptional circumstances any part of the work will be enterusted to some other member of E.R.C.

(iii) The mode of evaluation of the mid-term activitiess whose weightage shall be 30% and the end of term examination whose weightage shall be 70% (The mid-term activities will be of one mid term test or 20% weightage which will be supplemented by assignments, quizzes etc. for a theory course with weightage of 10%). For a practical Course, 30% weightage be given for internal evaluation and 70% for End Semester Examination: At the end of the Semester, the E.R.C. Chairman will send to the University the consolidated marks for the mid-term activities and the **End semester in** separate column for tabulation and for **declaration of result.**

(iv) To consider the individual representation of students about evaluation and take the remedial action if needed. After scrutinizing the E.R.C. may alterthe marks awarded upward/ downward. The decision of the E.R.C. shall be final. **The** candidate shall apply for the same on a prescribed proforma alongwith the evaluation fee prescribed by the University from time to time only for the End Semester Examination with in seven days from the date of declaration of result.

(v) To moderate the quiz/assignment/test papers given by each concerned teacher in his class with a view to maintain uniformity of standards and course coverage amogst various classes and to attain stipulated level of learning.

(vi) To review and moderate the mid term and end of term results of each class with a view to maintain uniformity of standards and after finalisation to submit the same for classification of the results.

(vii) To lay guide-lines for teaching a subject.

7. CLASSIFICATION OF RESULT :

A Student has to secured 40% or more marks in a subject evaluation to earn the credits assigned to the subject. A student after having secured the minimum credit as needed for the degree course will be eligible for the award of degree. The final result will be evaluated as below :

Each subject will carry 100 marks.

$$\text{average Marks} = \frac{\sum(CreditsxMarksSecured)}{\sum(Credits)}$$

(See clause 5 for best grades in the minimum credits)

The final result will be classified based on the average marks as follows.

First Class with Distinction 75% or more

First Class 60% or more but less than 75%

Second Class 50% or more but less than 60%

Pass Class 40% or more but less than 50%

8. A Student has to put in a minimum of 75% attendance separately in each Subject for which he has registered. A relaxation up to a maximum of 25% may be given on the production of satisfactory evidence that :

(a) The student was busy in authorized activities.

(b) The student was ill.

Note : (i) A student should submit the evidence to the above fact within three working days of resuming the studies. Certificates submitted later will not be considered.

(ii) No relaxation in attendance beyond 25% is permitted in any case.

(ii) The registration of a student stands cancelled if his attendance requirements are not satisfied in the subject.

9. The duration of the course is not less than 8 Semesters and the span is not more than 14 semesters.

A student who earns 15 credits or less at the end of the first semester will receive a warning for his/her poor performance, if he fails to earn at least 25 credits at the end of second semester, he has to leave the course and institution.

In case a student has not earned a minimum of 100 credits at the end of eight semester, his admission to the course and the institution stands cancelled. The admission stands cancelled at the end of 14th Semester in any case.

10. The institution/University May cancel the registration of all the subjects in a given semester if :

1. The students has not cleared the dues to the institution/ hostel.
2. A punishment is awarded leading to the cancellation.

At discretion of the institution the result may be withheld even if the registration of the student stands.

11. There shall be a Central Advisory Committee consisting of the following :

(a) Dean, Faculty of Technology, (Chairman of the Committee)

(b) Heads, of the Institutions

(c) Heads of the Departments in the Faculty of Technology.

This Committee shall have the following functions.

(i) lay guidelines for the process of registration.

(ii) give an interpretation of the rules in case of difference of opinion which shall be binding on all.

12. Under very exceptional conditions minor relaxations in rules may be allowed and implemented by the Central Advisory Committee. However, same relaxation in rules can not be granted in a subsequent semester. In case the conditions warrant such a relaxation again, the rules shall have to be amended.

GENERAL NOTES :

1. For all Theory Papers (Code : TH) there is one mid-semester test, of 30 marks (20+10 Assignments) and an end-semester exam of 3' hours duration for 70 marks. The total marks for the Theory Paper is thus 100.
2. For all practical Papers (code: PR) there is semester assessment of 30 marks and an end-semester exam of 3/4 hours duration for 70 marks. The total marks for the Practical Paper is thus 100.
3. For all valuation of Sessional (Code : VS) there is Semester assessment of 100 marks. There is no end-Semester exam for these courses.
4. At VII and VIII Semester level there is assessment of Practical Training Reports by a duly constituted Board. The report is to be submitted by the student after eight weeks of Industrial Training undergone during summer/winter breaks. The total marks associated with each Practical Training Report is 100 marks of which 30 marks are awarded by the Department on the basis of supervision of Industrial Training.
5. At VIII Semester level there is assessment of Project Report by a duly constituted Board. The report is to be submitted by the student of the Project. Work performed at the VII and VIII Semester levels. The total marks associated with the Project Report is 100 marks of which 30 Marks are awarded by the Department on the basis of guidance of Project Work.
6. The total credits in all scheme of Examinations to B.E. Courses upto VIII Semester will be 232 and the denominator for Calculation of average marks for final result will be 220.
7. The Project and the practical Training at VII & VIII Semester are mandatory.
8. Candidates securing 228 to 232 credits are declared to have passed B.E. Final Examination.
9. Candidates securing 221 to 227 credits are declared to have passed B.E. Final examination provided they skip/fail in not more than 4 credits in CORE
10. Candidates securing exactly 220 credits are declared to have passed B.E. final examination, provided they skip/fail in not more than 4 credits in CORE, not more than 4 credits in ALLIED ENGINEERING and not more than 4 credits in APPLIED SCIENCES & HUMANITIES.

Annexure-I

Suggested Scheme for B.E. Manufacturing Process and Automation Engineering

1 MA 540				Credit & Type	
TH1	MA	101	Humanities	4H	3-1-0
TH2	MA	1-2	Mathematics I	4H	3-1-0
TH3	MA	103	Physics	4H	3-1-0
TH4	MA	104	Chemistry	4H	3-1-0
TH5	MA	105	Manufacturing Processes (Introduction)	4C	3-0-0
PR1	MA	106	Engineering Drawing	3C	0-0-3
PR2	MA	107	Physics Lab	2H	0-0-2
PR3	MA	108	Chemistry Lab	2H	0-0-3
PR4	MA	109	Workshop Practice	2C	0-0-3
				29	15-4-11
2 MA 541					
TH1	MA	111	Electrical Sciences	4A	3-1-0
TH2	MA	112	Mathematics II	4A	3-1-0
TH3	MA	113	Mechanical Sciences	4A	3-1-0
TH4	MA	114	Science of Materials	4A	3-0-0
TH5	MA	115	Mechanics of Solids	4A	3-1-0
PR1	MA	116	Electrical Sciences Lab	2A	0-0-2
PR2	MA	117	Mechanical Sciences Lab	2A	0-0-2
PR3	MA	118	Introduction to Computer Lab	2C	0-1-2
PR4	MA	119	Mechanics of Solids Lab	2A	0-0-2
VS1	MA	120	Programming (during the semester	1C	0-0-2
				29	15-5-10
3MA 541					
TH1	MA	201	Machine Drawing & Graphics	4C	2-0-0
TH2	MA	202	Manufacturing Processes I	4C	3-1-0
TH3	MA	203	Electro mechanics	4A	3-1-0
TH4	MA	204	Analog and Digital Electronics	4A	3-1-0
TH5	MA	205	Technology and Society	4H	3-1-0
PR1	MA	206	Machine Drawing & Graphics Lab	2C	0-0-4
PR2	MA	207	Science of Materials & Manufacturing Processes I Lab	2C	0-0-2
PR3	MA	208	Electro mechanics Lab	2A	0-0-2
PR4	MA	209	Analog and Digital Electronics Lab	2C	0-0-2
VS1	MA	210	Programming I	1C	0-0-2
				29	14-4-12

5 MA 542			Credits & Type	
TH1	MA 211	Kinematics & Dynamics of Machinery	4C	3-1-0
TH2	MA 212	Control Systems	4A	3-1-0
TH3	MA 213	Mathematics III	4H	3-1-0
TH4	MA 214	Manufacturing Processes II	4C	3-1-0
TH5	MA 215	Management of Manufacturing Systems	4C	3-1-0
PR1	MA 216	Kinematics and Dynamics of Machinery Lab	2C	0-0-2
PR2	MA 217	Control Systems Lab	2A	0-0-2
PR3	MA 218	Manufacturing Processes II Lab	2C	0-0-3
PR4	MA 219	Practical Training (after III Sem.)	2C	
VS1	MA 220	Report Writing	1H	0-0-1
VS2	MA 221	Programming II	1C	0-0-2
			30	15-4-10

5 541				
TH1	MA 301	Machine Tools, CNC & Automation	4C	3-1-0
TH2	MA 302	Transducers and Measurements	4C	3-1-0
TH3	MA 303	Tool Design	4C	4-0-0
TH4	MA 304	Industrial Control Systems OR Information System and Data management OR Communication Principles and Circuits	4C	3-1-0
TH5	MA 305	Microprocessors and Applications	4C	3-2-0
PR1	MA 306	Machine Tools Lab	2C	0-0-2
PR2	MA 307	Tool Design Lab	2C	0-0-2
PR3	MA 308	MA 304 based Lab	2C	0-0-2
PR4	MA 309	Transducers and Measurements Lat)	2C	0-0-2
VS1	MA 310	Programming III	1C	0-0-2
			29	16-5-10

6 542				
TH1	MA 311	Robotics and CAM I	4C	3-1-0
TH2	MA 312	Computer Graphics OR Telemetry and Data Transmission	4C	3-1-0
TH3	MA 313	Applied Plasticity (Forming Processes)	4C	3-1-0
TH4	MA 314	Mechanical Design	4C	3-1-0
TH5	MA 315	Metroloay & Statistical Quality Control	4C	3-2-0

6 MA 542(Continued)				Credits & Type
PR1	MA	316	Robotics and CAM I Lab	2C 0-0-2
PR2	MA	317	MA 312 based Lab	2C 0-0-2
PR3	MA	318	Forming Processes Lab	2C 0-0-2
PR4	MA	319	Mechanical Design	2C 0-0-2
VS1	MA	320	Practical Training (after V Sem.)	1C
VS2	MA	321	Programming IV (AUTOCAD)	1C 0-0-2
				30 15-6-10
7 MA 541				
TH1	MA	401	Introduction to CAD and Product Design	4C 3-1-0
TH2	MA	402	Modern Methods of Manufacturing	4C 3-1-0
TH3	MA	403	Industrial Electronics	4A 3-1-0
TH4	MA	404	Elective I	4C 3-1-0
TH5	MA	405	Elective II	4C 3-1-0
PR1	MA	406	CAD Lab	2C 0-0-3
PR2	MA	407	Modern Methods of Manufacturing Lab	2C 0-0-3
PR3	MA	408	Industrial Electronics Lab	2A 0-0-2
PR4	MA	409	Practical Training (After VI Sem.)	2M
VS1	MA	410	Programming V (AUTOCAD)	1C 0-0-2
				29 15-5-10
8 MA 341				
TH1	MA	411	Macaronis OR Artificial Intelligence	4C 3-1-0
TH2	MA	412	Elective III	4C 3-1-0
TH3	MA	413	Elective IV	4C 3-1-0
PR1	MA	414	MA 411 based Lab	2C 0-0-3
PR2	MA	415	Elective III and IV Lab	2C 0-0-3.
PR3	MA	416	Project	8M 0-0-10
PR4	MA	417	Practical Training (after VII Sem.)	2M
VS1	MA	418	Seminar and Reports	1C 0-0-1
				27 9-3-17
			Total =	232

BE-MANUFACTURING PROCESS & AUTOMATION ENGINEERING

List of Electives:

MA 404/405 : Elective I & II
Any two of the following :

1. Industrial Economics
2. Reliability
3. Optimization Techniques
4. Preventive Maintenance and Condition Monitoring
5. Robotics and CAM II
6. Manufacturing Information System
7. FEM (Finite Element Method)

(In the pipe line)
Advanced Topics in Flexible Manufacturing
Automated Plant
Ergonomics
Expert Systems
Industrial and Control Applications of Microprocessors
Industrial Psychology
Value Engineering
Virtual Reality

MA 412/413 : Elective III & IV
Any two of the following :

1. Personnel Management
2. Financial Management
3. Composite Materials
4. Industrial Drives
5. Machine Tool Vibrations
6. Advanced Physics
7. Prime Movers

(In the pipe - line)

Advanced Manufacturing Processes
Advanced Mechanical System Design
Industrial Chemistry
Plant Location and Industrial Layout
Project Management
Product Design
Tribology

NOTE : IT WOULD BE INCUMBENT UPON THE INSTRUCTOR CONCERNED TO PREPARE :—

(a) OPEN ENDED LABORATORY WORK BASED ON DESIGN

(b) AT LEAST ONE OPEN ENDED ASSIGNMENT QUESTION FOR SOLUTION.

B. E. (Mfg. Process & Automation Engg.) I Year I Semester

Examination Theory

Paper I MA 101 Humanities (English)
(Same as COE101.EE 101 and IC 101) LTP
310

(A) Text: Essay, Short Stories and One Act Plays; Editor R.K. Kaushik & S.C. Bhatia, Published by Oxford University Press.

The following chapters are prescribed for study :

(i) Essays:
1. Nehru the Democrat by M. Chalapathi Rao
2. Bores by E.V. Lucas
3. Freedom by George Bernard Shaw
4. What I require from Life by J.B.S. Haldane
5. Student Mobs by J.B. pristley

(ii) Short stories :
1. The fortune - Teller by Karal Capek
2. Grief by Anton Chekov
3. The Doll' s House by Katherine Mansfield

(iii) One Act plays :
1. A Marriage proposal by Anton Chekov
2. The Boy comes Home by A.A. Milne

(B) ENGLISH LANGUAGE PRACTICE

Applied Grammer:

Common errors, Use of words, Synonymous and Antonyms, Formation of Words-Prefixes and Suffixes.

Presentation of Technical Information :

Technical description of (i) simple objects, tools and appliances (ii) Processes and operations (iii) Scientific principles.

Composition :

Comprehension, Dialogues-conversational and colloquial idiom.

Spoken English :

Practice in self expression talks, Lectures and speeches.

		L	T	P
Paper MA 102	**MATHEMATICS I**	3	1	0 **4**

(Same as COE 102 and IC 102)

Algebra : Partial fraction : Hyperbolic and inverse hyperbolic functions, De-Moiver' s Theorem and its applications; Relations between circular and hyperbolic functions; Positive term infinite series and their convergence (Comparison and Ratio tests), Alternating series.

Differential Calculus: Derivatives of hyperbolic functions; successive differentiation and Leibnitz' s theorem. Taylor' s and Maclaurin' s series, Maxima and minima of functions of one variable; Curvature and radius of curvature, points of inflexion.

Integral Calculus integration by partial fractions : Integration of forms I, I/R where R=ax2 + bx + c; Properties of definite Integrals.

Reduction formulae : Application of integration to areas, length of arcs, surface and volume of solids of revolutions, Trapezoidal and Simpson' s rules.

MA 103 PHYSICS 31 04

(Same as EE 103, COE 103 and IC 103)

Relativity : Absolute and intertial frames of reference, Newtonian (Galilean) relativity; Galiieantransformation. Michelson-Morely experiment and its implications, Lorentz Transformation Einstein' s law of addition of velocities. Mass variation with velocity, concept of energy and momentum as four vector, Einstein' s masœnergy relation.

Inverse Square Law of Forces: Fundamental interactions, Electromagnetic and gravitational interactions. Force and potentials, Central Force.

Invariance and Symmetry Principles : Invariance of a Physical quantity, Laws of conservation of mementum, energy and charge, Concept of symmetry and its implications.

Wave Oscillations. Free damped and forced oscillatory motions, Resonant vibrations with applications, sharpness of resonance, quality factor.

Formation of waves in strings, rods and air, Acoustic waves, Acoustic impedance, Transmission through partitions, Ultrasonics and its applications.

Interference of Light, Wave theory of light, superposition principle, Double lit experiment, Bi-prism and Newton' s rings. Theory of interference in thin films, Interference filters, Michelson' s interferometer.

Diffraction of Light : Fresnel and Fraunhofer class of diffraction. Diffraction at straight edge, Comics spiral, Fraunhofer diffraction at a slit and its extension for number of slits, Diffraction gratings, Resolving power of optical instrument, telescope, prism and grating.

Polarization of Light: Elementary aspects of E.M. theory of light, Polarization, Reflection and Transmission, Brewster law, Polarization due to pile of plates and double-refraction, Elliptically and circularly polarized light, Nicol prism, quarter and half-wave plates.

Polarimeters. Half shade & Pi=quartz.
Optical instruments. Cardinal points of a co-axial iens system. Defects in the images, Spherical and chromatic aberrations, Nodal slide assembly Eye pieces.

Paper IV MA 104 **CHEMISTRY** 3 10 **4**

(Same as COE 104, EE 104 and IC 104)

Chemical Kinetics :

Rate constant, order and molecularity of a reaction, 1st, 2nd, 3rd order reactions, Methods of determining order of reactions, Effect of catalyst on reactions rate, Activating energy, Industrial applications of catalysts.

Electro-Chemistry :

Transport number, Galvanic cells, E.M.F. and its measurements, Nearnst equation of electrode potentials, Reference and Indicator electrodes at measurements, Solar energy.

Phase rule :

Phase diagrams and phase transformations in Pb-Ag and Cu-Ni systems.

Thermal Methods of Analysis :

Elementary discussions of thermograviometric analysis, Differential thermal analysis and differential scanning calorimetry.

Metals and Non-Metals of Elements :

S and P block elements, Bonding in complexes, Molecular explanations for magnetic properties and colour, extraction and technical applications of Titanium, Vanadium, Ziroconium, Tungsten and Uranium.

Alloys Classification :

Necessity for making alloys, composition, properties and uses of following alloys, Brass, Bronze, Gun metal, Duralumin, Effect of alloying elements like C, Ni, Mn, Si, V, Mo, W and Co on the properties of steel.

Electronic-Effects :

Inductive effect, Conjugation and resonance and their effect on physical and chemical properties of molecules, carbanion and carboniumious and free radicals.

Organic Polymers :

Polymerisation, Effect of polymer structureon properties, production, Properties and technical applications of some important theromolastics and thermosetting resins, Natural rubber and elastomers (SNR, GR-P Polyurethane and silicon) Molecular weights.

Oils, Fats, Waxes and Detergents :

Production and Physico-chemical properties of fatty acids and Glycerides, Manufacture of edible facts, soap glycerine, waxes, essential oils, perfumes and cosmetics.

MA 105 INTRODUCTION TO MANUFACTURING PROCESSES 3 0 0 4

(Same as COE 105 and IC 105 Manufacturing processes)

Materials :

Compositions, Properties and uses of Wrought iron, Pig iron, Cast iron, Malleable iron, S.G. iron carbon and alloy steels, Copper, Aluminum, Lead, Brass Bronze, Duralumin, bearing metals, high temperature metals, cutting tool materials.

Casting Processes :

Principles of metal casting: Pattern materials, types and allowance; Study of moulding, sand moulding, tools, moulding materials, classification of moulds, description and operation of cupola: special Casting processes e.g. die-casting, permanent mould casting, centrifugal casting, investment casting.

Smithy and Forging :

Basic operations e.g. upsetting, fullering, flattening, drawing, swaging; tools and appliances; drop forging, press forging.

Metal joining :

Welding principles, classification of welding techniques; Oxyacetylene Gas welding, equipment and field of application, Arcweiding, metal arc, Carbon arc, submerged arc and atomic hydrogen arc welding, Electric resistance welding : spot, seem, butt, butt seam and percession welding; Flux; composition, properties and function, Electrodes;

Types of joints and edge preparation. Brazing

and soldering, Sheet Metal Work :

Common processes, tools and equipments; metals used for sheets, standard specification for sheets.

Bench Work and Fitting :

Fitting, sawing, chipping, thread cutting (die), tapping; Study of hand tools, Marking and marking tools.

BE-MANUFACTURING PROCESS AND AUTOMATION ENGINEERING

SEMESTER I

EXAMINATION PRACTICAL

Paper I PR 1 MA 106 **ENGINEERING DRAWING** 0 0 3 3

(Same as COE 106, EE 106 and EC 106)

Introduction :

Instruments and their uses :' letterings construction and uses of various scales : dimensioning as per I.S.I. 696-1972.

Engineering Curves :

Parabola; hyperbola; ellipse : cycloid, in volute; spiral; helix and loci of points of simple moving mechanism (4-bar chain)

Projections :

Straight lines; Planes and solids; development of surfaces of right and oblique solids; section of solids, interpenetration and intersection of solids; isometric and oblique parallel projection of solids.

Paper II PR 2 MA 107 **PHYSICS LAB** 0 0 22

(Same as COE 107, EE 107 and EC 107)

Based on course work corresponding to .MA 103 - Physics.

Paper III PR 3 MA 108 **CHEMISTRY LAB** 0 0 32

(Same as COE 108, EE 108 and EC 108)

Based on course work corresponding to MA 104 - Chemistry.

Paper IV PR 4 MA 109 **WORKSHOP PRACTICE** 0 0 3 2

(Same as COE 109, EE 109 and EC 109)

Based on course work corresponding to MA 105-Manufacturing Processes.

MA 111 . **ELECTRICAL SCIENCES** 3 1 0 4

Basic laws of electrical Engg., resistance, capacitance and inductance and factors affecting these; energy and power.

Network analysis by MESH currents and node pair voltages, Network theorms and applications: Superposition, Thevenin and Norton theorems and their applications.

Alternating Current: alternating quantities; peak, average and RMS values of sinusoidal wave forms; power and power factor steady state response of circuits to sinusoidal inputs; phasor reprensentation of sinusoidal complex impedances, resonance, Maximum power transfer theorem.

Balanced three phase circuits, star/delta connection and relation between line and phase quantities.

Electromagnetism : permeability, magnetic field, magnetisation curves, hysteresis losses and eddy current losses in ferromagnetic materials, magnetic circuits.

Transformers: basic constructional features, types of transformers, principle of operation, E.M.E. equation, no load operation, operation under load, equivalent circuits, phasor diagram, voltage regulation, short circuit and open circuit tests, applications of single phase transformers, three phase transformers, auto transformers, three/two phase transformations.

introduction to two port network, parametrers.

MA 112 MATHEMATICS II 3 10 4

Differential Calculus: partial differention, total differentation. Taylor' s Series for functions of two variables, Maxima and Minima of two or more variables.

Integral Calculus : Double and triple integrations, change of oredr of integration, Volume of simple solids.

Matrices : simultaneous algebraic equations; Matrix operations, transpose, inverse, rank, linear transformation, Vectro spaces, characteristic equations, Eigen values and Eigen Vectors, Caley - Hamilton Theorem.

Differential Equations: Lineardifferential equation of first order and first degree, General lineardifferential equations with constant coefficeients, D-Operators, solution of differential equations, complementary function and particular integral, Simultaneous lineardifferential equations, Solution of differential equations in power series.

Fourier Series : Harmonic functions, periodic function, Fourier series.

Transforms : Laplace and Fourier transforms, Dirichlet conditions.

MA 113 MECHANICAL SCIENCES 3 10 4

Thermodynamics :

Introduction, Definitions and concepts : systems, energy, work, thermodynamic equilibrium, property and state.

Laws of thermodynamics: Zeroth law, fist law and its consequences, Thermodynamic properties of fluids, equation of state; second law of thermodynamics, reversibility, Carnot' s cycle, entropy.

Power Cycles : Rank in cycle and its modifications, Otto cycle, Diesel cycle, Brayton cycle.

Fluid Mechanics:

Fluid and flow, fluid properties, Hydrostatic pressure and hydrostatic forces on plane and curved surfaces, Stability of floating bodies.

Fluid Flow : Steady and unsteady, stream lines, streak lines, continuity equation, strain rate, gradient, vorticity.

Euler' s equation, Bernoulli' equation, momentum equation, energy equation and their applications.

Newton' s viscosity law, laminar and turbulent flows : drag and lift, boundary layer flows, flow through pipes, Non-dimensional numbers.

MA 114 **SCIENCE OF MATERIALS** 3 1 0 4

Phase diagram : Iron-carbon diagram, fundamentals of heat treatment, heat treatment processes, anstenitizing, annealing, normalizing, tempering. Hardening and hardenability, carburizing, carbonitrinding, nitriding, induction and flame hardening, heat treatment of non-ferrous alloys.

Material testing : Tensile, torsion, hardness and impact testing; creep and fatigue-factors affecting; ductile and brittle behaviour **and** transition temperature.

Composites : classification, micro-mechanics of fibre and particle reinforced composites, strength, stiffness and factors affecting, failure modes.

Plastics : Thermosetting and Thermoplastic, properties and applications.

Selection criteria of engineering materials and alloys for high strength, high temperature, antifriction, corrosive resistance, electrical, magnetic and space applications.

MA 115 MECHANICS OF SOLIDS 3 1 0 **4**

Equilibrium: Force, vector representation, couple, equivalent force system, equations of equilibrium.

Concept of free body diagram equilibrium. application of equilibrium, Two force member, solution f simple plane trusses.

Friction, sliding and rolling friction, friction in simple machines. Review of

centroid, area and mass moment of inertia.

Simple stresses and strains; Tensile test, tensile compressive shear and volumetric strains, elastic constants and their relations.

Stress and strain at a point, co-ordinate transformation (2-D), stress and strain analysis, principal values, invariants, Motif' s circle.

Shear force and bending moment diagrams of beams subjected to concentrated and distributed loads.

Theory of simple bending : Shear stress distribution.

Torsion of solid and hollow shafts, closed coiled helical spring.

Combined stresses : direct and bending, bending and torsion.

Strain energy under statically applied tensile, shear, bending and torsion loads, stresses due to sudden and impact loads.

Slope and deflection of simple beams under concentrated and distributed loads, Castigaliano' s theorems, reciprocal law.

Concept of stability and its application to columns.

Thermal Stresses.

SEMESTER I

EXAMINATION PRACTICAL

Paper I PR 1 MA 116 **ELECTRICAL SCIENCES LAB** 0 0 22

Based on course work corresponding to M A111-Electrical Sciences.

Paper II PR 2 MA 117 **MECHANICAL SCIENCES LAB** 0 0 22

Based on course work corresponding to MA 113-Mechanical Science.

Paper III PR 3 MA 118 **INTRODUCTION TO COMPUTER LAB** **0 1 2 2**

PRACTICALS BASED ON

Basic computer organization, various I/O devices, introduction to computer applications in various fields of science and management, Binary codes, Number representation (hex, octal etc.) Binary arithmetic, floating point arithmetic, signed numbers, introduction to various translators, operation system, flow chart, detailed study of a third generation programming language, usage of array, matrix, file, record, points and functions *etc.*

Paper IV PR 4 MA 119 **MECHANICS OF SOLIDS LAB** **0 1 2 2**

Based on course work corresponding to MA 115-Mechanics of solids.

EXAMINATION SESSIONAL

Paper I VS1 MA 120 **PROGRAMMING** 00 21

Programming in Institute Computer Centre during the semester (non-examination) using PASCAL.

MA 201 **MACHINE DRAWING AND GRAPHICS** 2 0 0 4

Review of lettering, dimensioning : standards; orthographies and sectional views.

Selection and indication of fits and tolerances; Indian standards.

Different kinds of threaded fasteners and their uses : locking arrangements, thread forms and their uses.

Drawing of simple assemblies and machine parts-assembly, and dis-assembly.

Sketching from models of assemblies and parts. Computer

graphics.

MA 202 **MANUFACTURING PROCESS I** 3 **10 4**

Casting Processes : Review of casting processes, Melting of Cl, A1, steel; Furnaces, selection criteria.

Green-sand characteristics and their testing. Patterns, Cores, Getting and

their Design. Solidification of pure metals, alloys defects and precautions.

Residual stresses, defects, inspection and precautions to reduce. Sand

Casting : large quantity production. Cleaning and finishing.

Product development and design of sand-casting. "

Presentation of case studies. Introduction to powder

metallurgy.

Welding Processes : Review of welding processes, Weld ability, Arc-welding, manual and automatic, characteristics of welding equipments, selection criteria.

Case study of welding of a pressure vessel, a structure. Welding

codes and practices. Design for welding.

Laser beam welding, Hermit welding, explosive welding, electron-beam welding.

Defects and inspection: No-destructive testing, pressure liquid penetration radio-graphy, X-rays, Gama-rays, magnetic particle.

MA 203 ELECTROMECHANICS 3104

D. C. Machines

D.C. Machines, constructional features, Principle of operation. DC. generator analysis, D.C. motor analysis, Motor-speed-torque characteristic, speed control, applications pf D.C. motors, starters and controllers for D.C. motors.

A. C. Motors

Three phase induction motors, revolving magnetic field theory, induction motor as a transformer, equivalent circuit, computation of performance, starting, auto start, speed control.

Three phase synchronous machine : Synchronous generator/ motorphasordiagrams, equivalent circuits, computation of synchronous machine performance, synchronous condenser.

Single phase induction motors, double revolving field theory, different types of single phase induction motors, characteristics and typical applications.

Fractional KW motors, stepper motors, hysteresis motor, Servo motors, A.C. series motor and Universal motors.

MA 204 **ANALOG & DIGITAL ELECTRONICS** 3 10 **4**

Semiconductor diode, BJT & FET, Zener diode characteristics and models; Diode circuits, Rectifiers and DC power suppJies; BJT circuits : amplifiers, biasing : analysis and design; JFET and MOSFET : characteristics & models; MOS amplifier example.

IC op-amp and applications : linear circuits (integrators, differentiators, filters, oscillators); nonlinear circuits : waveform generators; op^mp regulator, IC voltage regulators; IC Analog multiplier and applications; IC Timer 555 (astable, monostable and other timing circuits).

Transistor as a switching element; combinatorial logic, designing with K-map, QM-techniques. Introduction to Boolean Algebra and codes, Half adder, full adder, digital comparator, multiplexer, decoders, ROM, RAM etc. and their applicatons.

Flip flops, counters, registers, waveform generators; Design using MSI circuits;

A/D, D/A Converters.

MA 205 **TECHNOLOGY AND SOCIETY** 3 1 0 **4**

introduction to some of the important social realities and Institutions in India; interrelationship between Science, Technology; socio-cultural context of Scientific and Technological growth. State of Science and Technology in Indian Society today and the policy opt'ons for the fdlure.

SEMESTER III

EXAMINATION PRACTICAL

Paper **I PR 1 MA** 206 **MACHINE DRAWING & GRAPHICS** **0 0 4 2**

Based on course work corresponding to MA-Machine Drawing & Graphics.

Paper II PR 2 MA 207 **SCIENCE OF MATERIALS/ Manufacturing Processes I LAB** **0 0** 22

Based on course work corresponding to MA 114-Science of Materials/MA 202 Manufacturing Processes I.

Paper III PR 3 MA 208 **ELECTROMECHANICS LAB** 0 0 22

Based on course work corresponding to M A 203-Electromechanics.

Paper IV PR 4 MA 209 **ANALOG & DIGITAL ELECTRONICS LAB** **0** 0 3 2

Based on course work corresponding to MA 204-Analog and Digital Electronics.

EXAMINATION SESSIONAL

Paper **I PR 1 VSI MA** 210 **PROGRAMMING** 0 02 1

Programming in Institute Computer Centre during the" semester (non-examination). Exercises based on datastructure.

MA 211 KINEMATICS AND DYNAMICS OF MACHINERY 3 10 4

Review of Kinematics and kinetics of a particle in plane motion-Cartesian and polar coordinates. Tangent and normal components : work-energy principle.

Kinematics of a particle in space motion-Cartesian, cylindrical and spherical coordinates, rotating set of coordinates.

Kinematics and kinetics of a rigid body in plane motion. Kinematics and kinetics of interconnected rigid bodies. Rotating set of coordinates, Corkrfist coponent; work-energy principle. Conservation principles.

Linkages, kinematic pair, inversion and equivalent linkages: Velocity and acceleration analysis of planar mechanisms-analytical and graphical methods, tnstataneous centres and velocity analysis.

Kinematics of higher pair mechanisms :—

CAM — Nomenclature, follower motions, graphical and analytical methods of synthesis of cam profiles, presure angle.

GEARS — Introduction, law of gearing, synthesis of tooth profile, undercutting and interference; simple compound and epicyclic gear trains.

Dynamic analysis of single and multiple degrees of freedom systems.

Dynamics of planar mechanisms with special reference to slider-crank, mechanism and internal combustion engines.

BALANCING : — Static and dynamic, single and multicylinder engines.

MA 212 **CONTROL SYSTEMS** 3 10 4

Control System Types..

Open loop and closed loop control systems illustrations, block representation, signal terminology, explanation with illustrations of servomechanism, regulating system, Linear and non-linear controls, Continuous and sampled data controls, Digital control.

Mathematical Modelling and System Representation.

Differential equations of physical systems such as mechanical, elctrical, electromechanical, thermal, pneumatic, liquid level etc. analogous systems, Transfer function, Block *diagram* representation and reduction technique, signal flow graph-construction, terminology, algebra and Mason' s gain formula, effects of feedback on variation fo system parameters, system dynamics and effect of disturbances. System state space equation.

Control System Components.

Potentiometers, Synchros, Armature and field controlled d.c. servomotor, a.c. servomotor, steppermotor, rotating amplifiers, magnetic amplifiers, tachogenerators.

Time Domain Analysis.

Standard test singnals, transient response fo first and second order systems, transient response specificative control action on system performance, performance index concept and error performance indices-ISE, ITSE, IAE, ITAE, Root locus technique concept, construction rules and root contours.

Frequency Domain Analysis.

Concept of frequency response, Frequency response plots-polar plot, Bode plots, Log magnitude vs. phase angle plot, performance specifications, corelation between time and frequency responses.

Stability Analysis.

Concept of stability, conditions for stability. Routh-Hurwitz criterion, Nyquist criterion, Gain and phase mangin. Constant M and N loci, Use of Nichols chart for performance evaluation. Controlability and observability using state space concept.

Compensation Techniques.

Control systems using compensation networks such as, Lag, Lead, Lag-lead networks via frequency domain techniques.

MA 213 **MATHEMATICS III** 3 1 0 4

Vector analysis: Triple product of vectors, differentation.Operatiors-gradient. divergent and cur 1, Integration of vector fields. Green, Stokes and Gauss theorems.

Functions of complex variables : Analytic functions, Harmonic conjugate. Conformal mapping, Cauchy integral theorem, Residue theorem.

Special functions; Beta and Gamma functions, Bessel functions; Legendre functions/polynomials.

Partial differential equations.

Statistics and probability theory; Mathematical Statistics, graphical representation of samples, mean and variance. Random processes, random variables, mean, variance, expectation, Various distributions-Binomial, Poisson, Several random variables - co-relations.

Theory of sampling and sampling distributions.

Optimization involving single and multiple variables. Introduction to Operation Research. Linear Programming - graphical and Simplex method. Queuing theory. Dynamic Programming.

Numeral analysis; Solution of linear equations, algebraic eigenvalue problem, polynomial equation, differentiation and integration.
Calculus of variations.

MA 214 **MANUFACTURING PROCESS II** 3 0 0 4

Review of metal cutting.

Turning : Taper turning. Turret and Caps ton lathes, autos

Milling : Vertical, horizontal and universal milling machines, indexing, gear cutting; milling cutters-geometry and specifications.

Grinding : Surface and cylindrical grinding, centre less grinding, grinding wheels, construction and specifications; mechanics of grinding; tool grinding.

Drilling : Drilling tool geometry, drilling machines.

Special Machines

(a) Gear hobbing Gear geometry, gear generation and hobbing, gear grinding.

. (b) Boring machines : Cylindrical boring and lapping.-

(c) Profile cutting and machinery.

Mechanics of Metal Cutting : Review, cutting forces, factors affecting cutting forces, tool dynamometers, geometry and characteristics.

Tool Materials: Effect of alloying materials, tool life-factors affecting tool life, selection of tool material.

Unconventional Machining : Limitation of conventional machining processes - chemical, electric discharge, electron beam, laser beam, ion beam, plasma, explosive.

Automation and NC machines.

MA 215 **MANAGEMENT OF MANUFACTURING SYSTEMS** 3 10 4

Introduction : production functions, productivity and quality management conforming to ISO - 9000 systems.

Plant organization : organization, principles of organization, organization structure - line and staff organizations.

Plant location, layout: process layout, product layout and combination layout - methods of layout, economics of layout.

Production planning and control : types of products, demand, demand forecasting, marketing strategies. Scheduling and control of scheduling; production control.

Inspection and quality control: objectives, kinds of inspection of raw *material* and finished product; SQM, sampling; control charts and their applications.

Work and method study : definition and concepts; method study - procedures, symbols, advantages. Flow process charts. Motion study - micro motion, SIMO charts, procedures system concepts value and ABC analysis : system concepts, classification, analysis, techniques.

Industrial maintenance - types, organization of maintenance department. Breakdown and preventive maintenance.

Inventory control and replacement analysis : introduction, replacement policy and methods adopted; EOQ.

Management concepts - development of management principles, scientific management, human relations aspects.

Industrial psychology, personnel management, and labour relations, methods of remuneration.
Project Management - CPM and PERT

SEMESTER IV

EXAMINATIQN PRACTICAL

Paper I PR 1 MA 216 **KINEMATICS & DYNAMICS LAB** 0 0 2 2

Based on the course work corresponding to **MA** 211-Kinematics & Dynamics of Machinery.

Paper II PR 2 MA 217 **CONTROL SYSTEMS LAB** 0 0 22

Based on the course work corresponding to **MA** 212-Control Systems.

Paper III PR 3 MA 218 **MANUFACTURING PROCESSES II LAB** *0022*

Based on the course work corresponding to MA 214-Manufaduring Processes II.

Paper IV PR 4 MA 219 **PRACTICAL TRAINING** - - - 2

At the end of third semester. Evaluation based on the Visits to the industries and its report.

EXAMINATION SESSIONAL

Paper I PR 1 VS 1 MA 220 **REPORT WRITING** **0 0 11**

Report writing sessional. Paper

II PR 1 VS 2 MA 221 **PROGRAMMING (I** 0 0 21

programming in the Institute Computer Center during the Semester based on the numerical methods.

MA 301 **MACHINE TOOLS, CNC AND AUTOMATION** 3 10 4

Conceptualization of mechanical systems and general requirements.

Analysis of machine system from different points of view - kinematic, strength, rigidity, dynamics, fatigue, wear, reliability, and economy.

Drives - pulley, friction, gear; design aspects of gear drives. Hydraulic drives.

Machine tool structures - static and dynamic analysis. Analysis of spindles, bearings; slides and guides.

Control systems for machine tools

Conventional machine tools

C N. C. :

Introduction and impact of programmable machines, histroy of development.

N. C. system - components

Machine control Unit (M C U), - hardware and software.

N C programming: changing faceof programming, N. C. instruction generation.

CAD/CAM : geometric modelling

Automation:

Introduction : networks and DNC -$_L$ networks and CAD/CAM integration with other CAD/CAM elemenfs ; future trends in CIM.

MA 302 TRANSDUCERS AND MEASUREMENTS 3 10 4

Performance characteristics : accurarcy, sensitivity, precision, linearity, resolution, hysteresis. Static and dynamic characteristics.

Basicprinciples of operation of voltmeter, ammeter. Digital voltmeter, A.C. and RMS measurements. Multimeters-analog and digital. Digital phase meters. Counters-pulse counters.

CRO and its applications. Multichannel oscilloscopes. Frequency response measurement. Spectrum analyser.

Resistance transducers, Straingages. Capacitance

transducers and theri applications.

Piezoelectric Phenomenon, crystals, its applicatios. Configurations, sensitivity, coefficients, ferroelectic and applications.

Feedback transducers - applications, advantages

Elastic transducers - springs, bellows, diaphragms, thin plates, membranes, Bourdon tubes - special features and applications.

LVDT, capacitive pick ups, Hot wire anemometers, thermo emf transducers, temperature transducers. Hall effect transducers, Optical Pyrometers.

Accelerometers and vibration pickups.

MA 303 **TOOL DESIGN** **3 10 4**

Tool Design

General considerations in tool design. Tool design methods and procedures.

Tool making practices : tools of toolmakers, hand finishing and polishing, screws and dowels, hole location, jig boring practice installation of bushes; punch and die manufacturing.

Review of tool materials and heat treatments. Plastics as tool material.

Design of cutting tools; review of cutting processes, cutting forces. Single point cutting tool, cutters - milling, drills, reamers, tapes.

Die Design

Locating and clamping methods

Design of sheet metal blanking and piercing dies; review of processes, fundamentals; clearance, types of die construction.

Design of bending, forming and drawing dies : factors affecting material flow; blank size, draw force; single and double action dies.

Tool design for NC machine tools : cutting tools, holding methods, automatic tool changes and tool positioning, tool presetting.

Automatic screw cutting machines : cutting tools. **Jigs**

and Fixtures

Design Procedure and practice.

Design of drill jigs : definition, chip forming in drilling; general considerations, drill bushings, method of construction, drill jigs and modern manufacturing.

Study of two drill jigs and design of one drill jig.

Design of fixtures --; introduction, fixture and its effect on mass production, ; fixtures - vice, milling, boring, broaching, lathe, grinding, welding.

One case study and design of a fixture.

MA 304 **INDUSTRIAL CONTROL SYSTEMS** 3 10 4

Review of control systems with appropriate industrial system examples for open - loop and closed - loop control systems. Case Studies. Application of On-Off controls, Proportional. Control, Integral Control, Derivative control, combinations of these controls and finally the RID controller. Electronic, Pneumatic and Hydraulic realization of these controllers. An overview of Actuators such as, Valves, Servomotors, Stepper-motors, Hydraulic and Electro-hydraulic motors etc.

Modeling of first order, second order, and higher order systems with examples from industrial systems. Open-loop and Closed-loop transient response of these systems incorporating controllers and the effect of time delay. Interacting control systems and realization of decoupled control systems. Stability of industrial controls. An overview of various stability techniques. Introduction to industrial control systems-Application of Ratio control, Split range control, Cascade control, Feed forward control, Selector control, Inverse Derivative control, Antireset control and Multivariable controls.

Modeling of process and distributed control loops giving appropriate industrial examples.

Microprocessor based control systems. Realization of sequence control and relay logics with examples using programmable Logic controllers (PLC). Ladder diagrams and appropriate programming languages. Supervisory control and Data acquisition (SCADA) as applied to industrial systems with examples. Microprocessors for the realization of PID controllers to computer control with application for industrial systems.

MA 304 **INFORMATION SYSTEMS AND DATA MANAGEMENT** **3104**

Date processing concepts and file systems : Definitions, Auxiliary storage devices and its parameters, File types organisation and access methods, Sequential, Indexed-Sequential, Direct Ring, Tree structured.

Structured programming : Programming structure, Structured flow chart, Structured programming logic.

Management information System : introduction, Elements of MIS, Structure of MIS.

Data Base Concepts: Data management-file system approach and data base approach, Design of Data base model, Querry system, Security, Privacy, integrity considerations.

OR

MA 304 **COMMUNICATIONS PRINCIPLES AND CIRCUITS** 3 1 0 4

Review of parallel RLC circuits and transistor amplifiers.

General theory of amplified modulation, maximum allowable modulation, modulators and balance modulators S.S.B., Vestigial side band. Compatible single side band.

General theory of frequency modulation and phase modulation, relation between phase and frequency modulation, Spectrum of an FM ' and PM signal. (NBFM & WBFM), FM generation, varactor diode and reactance circuit, indirect method of FM generation.

AM detection, Envelope detector analysis and circuit, different types of clipping coherent detector, application of PLL in AM detection.

FM detection : Ratio & Foster Seely discriminiator, Application of PLL in FM detection, frequency compressor, L circuits.

RF amplifiers, Tuned R.F. amplifiers, IF amplifiers, analysis and circuit, stagger tuned RF amplifiers, frequency convertors and mixers, class C amplifiers, Neutralisation.

Radar : Principles of radars, range equation, detection of radar signals.

Transmitter : AM and FM transmitters, Transmitters matching circuit, AFC class amplifiers.

MA 305 **MICROPROCESSORS AND APPLICATIONS** 3 2 0 4

Introduction to Microprocessors and microcomputers Study of 8 bit **Microprocessors,** its internal architecture, addressing modes. Microprocessor programming, System timing. Various data transfer schemes. Interfacing memory (ROM, SRAM, DRAM etc.) Cache controller and cache memory system. Input/Output interface (Chips like 8212, 8255, 8155, 8253,8279,8237 etc.) Interrupts and their processing 8259 PIC, Interrupt interface circuits using 8259. Interfacing techniques with A/D, D/A, stepper motor, printer, key board, output displays etc. Various bus standards like RS 232, IEEE 488, etc. Introduction to 16 bit and 32 bit Processors.

Introduction to Micro-Controller.

SEMESTER V

EXAMINATION PRACTICAL

Paper I PR 1 MA 306 **MACHINE TOOLS LAB** 0 0 2 2

Based on the course work corresponding to MA 301-Machine Tools.

Paper II PR 2 MA307 **TOOL DESIGN LAB** 0 0 22

Based on the course work corresponding to MA 303-Tool Design.

Paper III PR 3 MA 308 **LAB** 0 0 22

Based on the course work corresponding to MA 304.

Paper IV PR 4 MA 309 **TRANSDUCERS & MEASUREMENTS LAB** **0 0 22**

Based on the course work corresponding to MA 302-Transducers & Measurements.

EXAMINATION SESSIONAL

Paper I VS I MA 310 **PROGRAMMING III** 0 0 2 1

Exercises based on advanced data structure.

MA 311 ROBOTICS & CAM I 3 10 **4**

Overview : historical perspective, classifications, applications, components.

Development: industrial and technical development

Mechanical considerations: physical configurations, robot motions; **end** effectors.

,. : Drive methods : principles and characteristics, Selection criterion.

Sensors : sensory requirements, evaluation and selection and available techniques.

Review of Control Methods.

Kinematics analysis and control.

Computer hardware for robot systems: Logic circuits and computer **elements;** peripheral system organization, input and output operations **and** control.

Robot software: requirements; functions performed by programming; present robot languages.

Robot vision: capturing the image, frame grabbers; interfacing and controls, examples.

Review of numerical control for CNC and DNC Machines.

Group Technology : Merits and demerits, Organization, Classification; Guidelines for implementation of group Technology.

Computer aided Process Planning.

Computer aided production planning and control, Flexible Manufacturing and Computer integrated manufacturing systems.

MA 312 **COMPUTER GRAPHICS** 3 1 0 4

Graphics display devices (monochrome and colour), Interactive devices, Line & circle plotting using Breshenham' s algorithm; Windowing and clipping, Sutherland Cohen approach, CyrusBeck method, Mid point subdivision algorithm; Curve drawkig using Hermite polynomial, Bezier curves, B-splines; Picture transformation- translation, rotation, scaling, mirror images, 3D graphics, coordinate system, 3D transformatiorv, rotation about an arbitrary axis, orthogonal projections, multiple views, isometric projection, perspective projections (one, two and three vanishing points), 3D clipping, Hidden surface removal, curved surface generation, Generation of solids, sweep method, interpolation, CSG modeling, Rendering, Introduction to Virtual Reality, Graphics standards, GKS, PHIGS, X windows, Use of graphics (simulation, CAD) animation.

OR—

MA 312 TELEMETRY AND DATA TRANSMISSION 3 1 0 4

Introduction to telemetry and telecontrol-telemetry links-telemetry error.

Classification of Signals-their suitability for telemetry-analog and digital telemetry.

Landline telemetry-mechanical, pneumatic and electrical systems-industrial telemetry.

Application of negative feedback for pneumatic and wire telemetry systems.

Telemetry and carriercommunication systems-distinction and design criteria-modulation techniques-AM, FM and PM suitability for wire and wireless telemetry power-line carrier communication.

Information carrying capacity-bandwidth and noise considerations-merits of each modulation technique.

AM, FM and PM modulators and demodulators-V to f and f-to-V converters-phase locked loop and its application.

Pulse modulation, PAM, PWM and PPM signals-relative merits-sampling theorems, sampling frequency and sampling techniques-reconstruction of data.

Pulse-code modulation-binary and many signals coding formated-digital data transmission.

Multiplexing techniques-FDM and TDM systems-relative merits-tRIG standards.

Remote control and telecontrol-mechanical and electronic systems-special considerations.

Typical telemetry and telecontrol schemes related to industry and pace exploration.

MA 313 **APPLIED PLASTICITY** **3 1 0 4**
(Forming Processes)

Review of tensile test, Yield phenomenon, Baushinger effect, strain hardening, effect of carbon and temperature on steel properties.

Stress-strain relation - idealized.

Review of fundamentals of mechanics of solids - stress analysis, co-ordinate transformation, principal stresses, maximum shear stress, equilibrium equations, stress - strain relations, constitutive relations, plane stress and plane strain problems.

yield criteria - Tresca and Von Mises, Flow rules, Incremental and deformation theories.

Plane strain problems, slip-line theory and its application to indealized problems of indentation and forming processes, limit analysis and its applications.

Forming processes - rolling, forging, drawing, deep drawing, bending and extrusion, punching and blanking; operations, practices and machines; other processes like coining, thread rolling, tube piercing, spinning, stretch forming.

Mechanics of forming processes :

Rolling - Modeling, rolling pressure, roll separating force, driving torque and power, power loss in bearings.

Strip forging - Mechanics, pressure distribution, total force, forging of a disc.

Drawing - Modelling, drawing force, power, maximum allowable reduction.

Deep drawing - Mechanics, stress distribution, effect of friction, blank holding force.

Bending - Mechanics, work load, spring back.

Extrusion - Stress analysis, work load, frictional power loss.

Effect of different parameters on the processes, theory and practice, operations and machines.

Introduction to dies, material wear. Explosive

forming, electro hydraulic forming. Hot and cold

forming.

Friction and lubrication in forming machines : defects, inspection and steps to reduce them.

MA314 **MECHANICAL DESIGN** 3 1 0 4

Introduction to machine design-types of loading, material selection, shape and geometry of machine elements, design criteria, factor of safety. Design of simple components such as levers couplings, riveted joints, beams, shafts.

Design for strength, stiffness, resilience, production, maintenance. Iso-strength and Iso-rigidity analysis.

Design for fatigue loading : S-N curve, stress concentration, modified Goodman' s diagram; design of simple elements like fasteners, shafts subjected to cyclic loading.

Design of fasteners : bolts, studs, nuts, locknuts, couplings- rigid and flexible. Cotter and pin joints. Riveted joints, power screws.

Design of. welded joints : Welded frames and structures, pressure Vessels.

Design of springs : Closed coiled helical springs, leaf springs.

Design of power-transmission : Shafts, keys and spines, coupling, friction drives, belting, chains, clutches and brakes.

Design of gears and gear drives : review of gear geometry, analysis and design of spur gears, helical and bevel gears.

Design of bearings: classification ;hydrodynamic lubrication, journal bearing. Antifriction bearings, ball bearings, roller and needle bearings, design for combined axial and radial loading.

Introduction to design of machine frames, guides and guide ways.

Design process: Introduction to engineering design, need analysis, conceptual design, design for technical viability economical and financial viability, detailed design, optimal design. Interactive design process and morphology of design systems.

Belt Conveyor and EOT Cranes.

MA 315 METROLOGY AND STATISTICAL QUALITY CONTROL 3 2 0 4

Metrology and inspection : principles of measurements,-line, end wavelength standards; linear and angular measurements; comparators; flatness and straightness testing; surface roughness measurement; screw and gear measurements; limit gauging.

Limits and fits standards.

Gauges and gauge design : fixed gauges, gauge tolerances; Selection; indicating and automatic gauges.

Quality Control and Production Systems. Systems approach. ISO -9000 and quality assurance. Basic concepts in quality and reliability. Economics of quality production, control charts.

Elements of on - line inspection and control of quality parameters. Principles of automatic inspection, test and assembly. Assembly and inspection under Computer Supervision.

SMESTER VI

EXAMINATION PRACTICAL

Paper I PR 1 MA 316 **ROBOTICS & CAM-I LAB** 0 0 22

Based on the course work corresponding to MA 311 Robotics & CAM-I

Paper II PR 2 MA317 **LAB** 0 0 22

Based on the course work corresponding to MA 312

Paper III PR 3 MA 318 **FORMING PROCESSES LAB** 0 0 22

Based on the course work corresponding to MA 313-Applied Plasticity.

Paper IV PR 4 MA 319 **MECHANICAL DESIGN** 0 0 22

Based on the course work corresponding to MA 314-Mechanical Design-

EXAMINATION SESSIONAL

Paper I VS 1 MA 320 **PRACTICAL TRAINING** -----1

Training for3 Weeks in industry manufacturing Electrical/Electronics components after fifth Semester.

Paper II VS 2 MA 321 **PROGRAMMING IV (AUTOCAD)** ------**1**

MA 401 **INTRODUCTION TO CAD & PRODUCT DESIGN** **3 10 4**

Fundamentals of CAD - design process^ Review of solid modelling and computer aided design of some elements/ components.

Review of interactive graphics; simulation and modelling, animation; introduction to the elements of ergonomics; case studies, designing' and analysing graphs, dealing with maps, coast lines etc. 3 dimensional problems, geometric modelling for mechanical parts, display and analysis of data defined on grids; strategic factors in product design; Simultaneous engineering; design for assembly; functional tolerances, Robust design for product, Taguchi loss function.

Introduction to concurrent design, Hardware description languages (AHDL) like Mast, CITA.

MA 402 **MODERN METHODS OF MANUFACTURING** **3 10 4**

Systems of manufacturing : batch, mass, cellulor and flexible. Concepts of computer integrated manufacturing system. Use of robots in manufacturing and assembly. Needs and roles of newer processes. Evaluation of processes and their relation to productivity. Metal cutting, joining, coating; Process based on concentration of energy in the forms of beams etc. Metal forming; Processes involving sophisticated control of metallurgical parameters, Processing environment, deformation rate etc; Processes based on chemical interactions, solid phase bonding and joining operations.

MA 403 **INDUSTRIAL ELECTRONICS** 3104

Introduction to power semiconductor devices: SCR, G.T.O., I.G.B.T. Power MOSFET etc.

Rectifying circuits : Uncontrolled and Controlled rectifiers (Single phase and three phase), Electroplating, Converter controlled D.C. motors.

Forced commutations in SCR.

inverters: Series and parallel inverters, Three phase bridge inverters (180 Mode, 120 Mode), Inverter fed A.C. Motors.

High frequency inverters and their applications, high frequency heating and welding.

Chopper circuits, Chopper controlled D.C. Motors.

UPS, SMPS, PLC, Electronic timers with their applications.

P L L and its applications, Voltage Regulators, P C B Fabrication.

SEMESTER VII

EXAMINATION PRACTICAL

Paper I	PR 1	MA 406	**CAD LAB**	0 0 3 2

Based on course work corresponding to **MA** 401-Introduction to CAD and Product Design.

Paper II	PR 2	MA 407	**MODERN METHODS OF MANUFACTURING LAB**	**0 0 3 2**

Based on course work corresponding to MA 402-Modern Methods of Manufacturing.

Paper III	PR 3	MA 4,08	**INDUSTRIAL ELECTRONICS LAB**	0 0 22

Based on course work corresponding to MA 403. Industrial Electronics.

Paper IV	PR 4	MA 409	**PRACTICAL TRAINING**	**------**2

Training for 8 Weeks after sixth semester

EXAMINATION SESSIONAL

Paper I	VS 1	MA 410	**PPROGRAMMING (AUTOCAD)**	0 0 2 1

MA 411 **MECHATRONICS** **3104**

Introduction, general characteristics of transducers and sensors including sensitivity, resolution, accuracy, repeatability, range, response time and hysteresis, linearity etc. Transducers applications and selections.

Mechanical, hydraulic and pneumatic actuation systems, operational characteristics and performance of hydraulic and pneumatic based actuation systems including linear devices, rotary devices, flow control valves, pressure control valves, direction control valves, ancillary devices (accumulators, amplifiers, etc.)

Synthesis of systems with respect to fluid pressure, direction and flow control.

Electrical Actuation Systems : operational characteristics and applications of electrical actuation components for applications like. AC/ DC motors, Stepper motors, hydraulic motors, relays, push buttons, switches, etc.

identification of control systems and their inter relationship. Behavior of mechatronic systems (First and Second order response).

Programmable logic controllers and applications: PLC structures, PLC languages, Programming of PLC, Interfacing PLC with actuators, open loop and closed loop control using PLC.

OR--

MA 411 ARTIFICIAL INTELLIGENCE 3104

Kinds of systems, production systems. Heuristics and their role. Search strategies. Knowledge representation systems: declarative and procedural approaches. First order systems, proof systems. Resolution approach. Closed World Assumption. Natural Language processing : Non deterministic and Deterministic parsing semantics and pragmatics. Expert systems and their application. Basic learning approaches.

SEMESTER VIII

EXAMINATION PRACTICAL

Paper I-PR 1 MA 414	**LAB**		0 0 3 2

Based on course work corresponding to MA 411.

Paper II PR 2 MA415	**LAB**		0 0 3 2

Based on course work corresponding to MA 412/MA 413.

Paper III PR 3 MA416	**PROJECT**		0 0 10 8 r

Based on the project assigned to the student involving investigations, design, development, fabrication etc.

Paper IV PR 4 MA 417	**PRACTICAL TRAINING**	-	----- 2

Based, on the training in industry for 8 weeks after seventh semester.

EXAMINATION SESSIONAL

Paper I VS 1 MA418	**SEMINAR & REPORTS**		**00 11**

MA 404/MA 405 **INDUSTRIAL ECONOMICS** 3 10 4

Introduction, Fundamental concepts - incremental/marginal reasoning, opportunity cost, contribution costs and revenues, time value of money.

Demand and supply: demand analysis, market structure, elasticity, consumer behavior. Supply, supply analysis, Business conditions - measurement; macro-model, forcasting with macromodels. Forecasting industry demand and capacity. Market demand and the firm' s share.

Resource allocation, marginal productivity of a single input, allocation of input, product mix problem, sensitivity analysis. Cost minimization. Estimation of production cost and functions - engineering approach, statistical estimates of production and cost functions.

Analysis of profitability : cost analysis, accounting costs and economic costs, break-even analysis, profit-volume analysis. Discrete production runs.

Analysis of price and non-price competition - price theory, theory of price with varying demand, demand shifting, oligopoly. Pricediscriminatiop, peak-load pricing, public utility rate regulation, multiple-product pricing.

Decision process - Theory and analysis.

Long-range planning : forecasting and strategy formulation, social forecasting, technological forecasting, resource forecasting. Input-output analysis.

Capital budgeting - corporate strategy, capital budgeting, cash flow, measuring profitability, cost of capital. Decision process and capital planning.

Applications & Case Studies.

MA 404/405 **RELIABILITY** 3 10 4

Review : probability, concepts, Boolean algebra, Venn diagrams, logic diagram, networks, representations. Random processes-continuous and discrete distributions - normal, lognormal, Weibull, Gamma, exponential etc.,-moments of distributions, cumulative distribution functions, conditional distribution functions. Combination of distribution-sum, difference, product and quotient.

Introduction, concepts, reliability data and analysis, high reliability systems. Reliability assessment, system reliability, performance-capacity, variability, requirement.

Performance-requirement conditions, overall requirement. Achievement-concept, functional capability. Various transfer function approaches. Transfer characteristics- concepts, Laplace transform of function. Laplace transforms of first and second order systems.

Simulation and reliability. Quality and reliability. Reliability and safety.

Reliability of systems-concepts, co-relation process, change of state. Synthesis-two-element system, non-redundant elements, parallel redundant elements. Complex systems-exclusive elements, simple common elements, cross-linked common elements, majority-vote elements.

Replacement policy and reliability; reliability management. Applications, case studies.

MA 404/MA 405 **OPTIMIZATION TECHNIQUES** 3 10 **4**

introduction : historical development, engineering applications; statement of problem-objective function, constraints, classification, techniques.

Classification: Single variable optimization, multivariable optimization with equality and inequality constraints.

Linear programming: graphical method, simplex method, simplex algorithm. Duality, decomposition principle, transportation problem.

Non-linear programming : one dimensional minimization methods, unrestricted search, golden search method, interpolation methods, unconstrained optimization techniques-direct search method, univariate method. Constrained optimization method-penalty function method.

Geometric programming, dynamic programming, integer programming.

MA 404/405 **PREVENTIVE MAINTENANCE & CONDITION MONITORING** **3 10 4**

Introduction-objective, Corrective/Breakdown maintenance, preventive maintenance, condition monitoring, Health and Usage monitoring Maintenance policy.

Condition monitoring-objective, basic principles, Vibration and Signature analysis, level measurement, transducers and their selection, instrumentation, Data analysis. Strategies for monitoring. Economics of condition based monitoring.

Diagnostic maintenance Methods of examination, Visual/ultra sound, Vibration, Non-destructive testing, wear debris, lubricating oil, Gas Chromatography.

Case Studies.

MA 404/405 **ROBOTICS** & **CAM II** 3 10 **4**

Robot systems; present status and future trends, Review

of physical configurations and motions; mobility

Sensors; techniques and evaluation; analyzing sensor data; special applications of sensors.

Matrix algebra of coordinate transformation, kinematics analysis; geometric and dynamic analysis of robot manipulators.

Robot control. Robot Vision.

Robot controlled CNC. Path

planning. Obstruction

avoidance.

Computer aided Materials Management-inventory control, Materials requirement planning.

Computer Controlled parts handling and equipments, Manufacturing Automation protocol, Cross functional implementation Technology for system integration.

MA 404/405 **MANUFACTURING INFORMATION SYSTEMS** 310 **4**

Introduction to Data Processing and information Systems. Fundamentals of Information Technology.

Data Bank concepts, CAD/CAM databases.Data-Bank-Information storage and retrieval. Data life cycle. Desirable characteristics df Data processing systems. Level of Decision Making and Information requirements. Data Dictionaries in Manufacturing. Integrated Information System. Object Oriented Models.

Structured Query Languages. Implementation of an Information System.

Distributed databases. Information processing systems. Use of computer networks. Elements of Computer Communication Networks. Elements of Automated Manufacturing Systems. Networks in Manufacturing. Local Area Networks - Architectures and Protocols. Manufacturing Message Specification. Manufacturing Automation Protocol. Network and Protocol Implementation. LAN design and performance. Sensor level network. Machine level network. Cell level network. Network performance evaluation.

Multimedia information systems, management of Multimedia databases.

MA 404/405 **FINITE ELEMENT METHOD**

Introduction to FEM, Variational principle, Relationship with other methods, Development of Finite Element Method with emphasis on energy principles, virtual work, potential energy, Application to line elements, beams, plane stress, plane strain and three dimensional stress.

MA 412/413 **PERSONNEL MANAGEMENT** 3104

Nature, Scope, Objective and Growth of Personnel programme, personnel department and its Functions; profile of a Good Personnel Manager; Formulation of personnel policy manpower planning; Recruitment and Selection-Traditional and Scientific approach; Job change-Promotion, Transferand Separation; Training and Development-Counselling and Succession Planning; Performance Appraisal and Merit Rating; Wage and Salary Administration-equitable wage structure; wage Disparties and Differentials-job evaluation; Motivation in actual practice; Motivation Research; Communication Channel, Media and Forms of Communication; Barriers; How to issue Instructions; industrial Relations-Wleaning and Scope-Role ot Employer, Machinery; Welfare Activities; Employee Benefits and Services-Statutory and Non-Statutory.

Concept, objectives, manpower data bank., supply forecast, reconciling demand & supply, budgetting S control, audii S improvement, acquisition 8. redeployment, reporting, performance evaluation 8. appraisal, training, compensation. Counseling policies. Safety & Health, Carrier development, Test & interviews.

Applications & Case studies.

MA 412/413 **FINANCIAL MANAGEMENT** 3104

Aims and objectives of Financial Management, Financial Analysis and Planning. Valuation of Securities. Cost-Volume-profit Analysis. Operating and Financial Leverage. Investment and capital Structure Decision. Methods of Capital Budgeting. Cost of Different sources of Raising capital. Weighted Average Cost of capital, Optimum Capita! Structure. Inventory, Accounts payable. Effect of Inflation on working capital Management, InstrumentsofLong-Term Finance. Internal financing and Divided Policy.'

Finance Function as Business; Approach to Financial Planning; Analysis of financial statements; Limitations of Financial statements; Ration Analysis; Flow of Funds Analysis; Sources of Long and Short Term Finance; Management of Components of Current Assets-Inventory Management; Accounts Receivables; Cash; Blls payable. Financial policies likeworking capital policy, Credit policy. Cash policy, Determinants; basic Features of Indian Money and Capital Markets; Financial Structure of Indian companies and Liberltzation policy.

Applications *&* Case Studies.

MA 412/413 **COMPOSITE MATERIALS** 3 1 0 4

Introduction, definition; classification; structures and method of preparation of fibers and fiber reinforced composites.

Micromechanics of fiber and particle reinforced composites.

Prediction of elastic constants, strength and stiffness, factors affecting strength and stiffness. Tensile and impact strength of composites.

Analysis of lamina; constitutive classical laminate therory. Analysis of composite laminated beams.

Thermal stresses

Design considerations for composite materials.

Introduction to fracture mechanics. Failure mechanics, crack propagation.

Experimental characteristics of composites-static and dynamic loading.

Performance of composites under fatigue, impact and adverse environment applications.

MA 412/413 **INDUSTRIAL DRIVES** 3 10 **4**

Introduction to electric drives, Selection of drives, drive characteristics. Thyristor controlled drives. Basic of variable speed drives, D.C. drives : Analytics of fully/half controlled/converter controlled D.C. devices. Dual converter fed D!C. drives. Reversing and braking of thyristor controlled D.C. drives. Analysis and control of inverter fed A.C. drives, Vector controlled Induction motor drives. Braking of A.C. drives. Switch reluctance motors, PMDC drives.

MA 412/MA 413 **MACHINE TOOL VIBRATIONS** 3 10 **4**

Introduction, elements of vibrating systems.

Sinusoidal functions and their properties. Review of harmonic fund ions and Fourier series. Review of Hamilton' s principle and LaGrange's formulation.

Vibration of single degree of freedom system : idealization of physical systems, free vibration-undamped and damped; damping-viscous, Coulomb, material.

Forced Vibration, ground excitation, whirling of shafts magnification factor, transmissibility of viscously damped systems.

Transients, time domain and frequency dome in.

Instrumentation and measurement.

Vibration of two and multidegree freedom systems : natural frequencies and modes. Response to harmonic excitation, dynamic absorber.

Matrix formulation-stiffness and mass matrices, decoupling; natural frequencies and modes; modal analysis.

Vibration of continuous systems : longitudinal vibration of slender bars, torsinonal vibration of circular shafts, transverse vibration of beams.

Approximate methods :

Machine tool chatter; Dynamics of metal cutting-chatter in machine tools. Effect of flexible mounting in chatter. Chatter in coupled machine tool systems. Theory of chatter with several degrees of freedom. Theory of impact damper.

Dynamic stress analysis.

MA 412/413 ADVANCED PHYSICS 3 10 4

Elements of quantum Physics: Black body radiation, photoelectric and Compton effect, Wave nature of electron; Schrödinger Wave equation and its simple applications, Energy levels and emission of light.

Characterization of materials : X-ray diffraction with emphases on atomic from factor, Electron microscopy for testing, I-R spectroscopy, Auger spectroscopy and spectrophotometer.

Crystallography : Crystal energy, different types of bonds and calculation of Madeline's constant, Simple idea of Crystal dislocation.

Semiconductors : Band theory of solids, semi conducting materials, Doping, Elementary compounds : Ceramic/Amorphous semiconductors and their electrical properties.

Magnetic properties: Dia, para, ferro and antiferro-ferrimagnetism, soft-hard magnet, Ferrites & magnetic sensors.

Dielectric properties : Ferro piezo & phroelectric materials and their sensors. Superconductivity and its future applications.

Laser : Einstein transition coefficient, population inversion, Classification of Lasers : Gas Laser (He-Ne Laser, CO2 masers) and solid state lasers (semiconductor) coherence, Q-Switching, Modulation of laser light, Elements of holography, phase contrast microscope, reference wave length and testing wave length, concept of a hologram and its applications, optical fibers. Applications of laser in Engineering and Medicine.

Nuclear Physics: Binding energy-Liquid drop model, properties of slow and fast neutrons, particle detectors and .accelerators, artificial radioactivity, nuclear reactors.

Ultrasonic: Production, Divergence of beam, Mode conversion, Acoustic Impedance matching, Ultrasonic flow detector, Ultrasonic sensors, Acoustic emission.

MA412/413 **PRIME MOVERS** 3 **1 0 4**

Review ot power cycles-Rankine, Carnot, Otto, Diesel and Brayton,

Energy sources, availability and demand : fossil fuels-energy conversion, calorific value of fuels : Nuclear power materials, energy available.

I.C. engines - spark ignition and compression ignition engines, turboprop, turbojet. Indicator diagrams, volumetric efficiency, performance characteristics and testing; energy balance, gas power engines regeneration.

Actual Rankine cycle regeneration,

Turbo machines : application of thermodynamic laws to turbo machines, efficiency. Energy conversion in turbo machines, classification of turbo machines -impulse and reaction. Flow through nozzles. Characteristics, flow of wet steam. Impulse turbine, velocity and pressure compounding, reheat, performance characteristics.

Hydraulic turbines: classification, Pellton wheels, velocity triangles, turbine efficiency and volumetric efficiency; reaction turbines : velocity triangles and efficiencies, propeller and Kaplan turbine characteristics.

Axial and centrifugal pumps characteristics.

Selection of prime movers.

Non-conventional energy sources.