MECHANICAL ENGINEERING

M.TECH (ENERGY TECHNOLOGY)

(CBCS)

REGULATIONS, CURRICULUM AND SYLLABUS

(With effect from the Academic Year 2011–12)

PONDICHERRY UNIVERSITY
PUDUCHERRY – 605 014

PONDICHERRY ENGINEERING COLLEGE
PUDUCHERRY – 605 014

REGULATIONS FOR POST GRADUATE PROGRAMME IN MECHANICAL ENGINEERING (CBCS)
(WITH EFFECT FROM JULY 2011)
M.TECH (ENERGY TECHNOLOGY)

1.0 ELIGIBILITY

Candidates for admission to the first semester of four semester M.Tech (Energy Technology) should have passed B.E / B.Tech in Mechanical / Chemical Engineering / Aerospace / Aeronautical /Automobile / Energy Engineering / Marine Engineering/ and Petroleum Engineering through regular course of study from an AICTE approved institution or an examination of any University or authority accepted by the Pondicherry University as equivalent thereto, with at least 55% marks in the degree examination or equivalent CGPA.

Note:

1. Candidates belonging to SC/ST who have a mere pass in the qualifying examination are eligible.

2. There is no age limit for M.Tech. programmes.

2.0 ADMISSION

The admission policy for various M.Tech. programmes shall be decided by the respective institutes offering M.Tech. programmes subject to conforming to the relevant regulations of the Pondicherry University.

3.0 STRUCTURE OF PG PROGRAMME

3.1 GENERAL

3.1.1. The M.Tech. Programmes are of semester pattern with 16 weeks of instruction in a semester.

3.1.2 The programme of instruction for each stream of specialization will consist of:

i. Core courses (compulsory)
ii. Electives
iii. Seminar
iv. Directed study
v. Project work

3.1.3 The M.Tech. Programmes may be of 4 semesters of duration.

3.1.4. Credits will be assigned to the courses based on the following general pattern:

i. One credit for each lecture period
ii. One credit for each tutorial period
iii. Two credits for each practical course
iv. Four credits for directed study
v. Twenty three credits for Project work divided into 9 credits for Phase-I and 14 credits for Phase – II.

One teaching period shall be of 60 minutes duration including 10 for discussion and movement.

3.1.5 Regulations, curriculum and syllabus of the M.Tech. programme shall have the approval of Board of Studies and other Boards/ Committees/ Councils, prescribed by the Pondicherry University. The curriculum has been so drawn up that the minimum number of credits and other requirements for the successful completion of the programme, in any stream, will be as given in Table 1.

Table 1: Minimum credits and other Requirements

Sl. No.	Description	Name of course and requirements
		M Tech (Full Time)
1	No. of Semester	4
2	Min. No. of credits of the programme	72
3	Max. No. of credits of the programme	75
4	Min. Cumulative Grade Point Average for pass	5
5	Min. Successful credits needed for registering in the next semester	I-10 II-25 III-40
6	Min. period of completion of programme (continuous semesters)	4
7	Max. period of completion of programme (continuous semesters)	8
8	No. of core and Elective courses	12
9	Laboratories	2
10	Directed study	1
11	Project work (Two semesters)	2

3.1.6 A core course is a course that a student admitted to a particular programme must complete successfully to receive the Degree. A student shall register in all the core courses listed in the curriculum of his/ her selected area of specialization. Core courses in a particular specialization are offered by the Department concerned.

3.1.7 Elective courses will have to be taken from the courses offered by the Departments in that particular semester from among the approved courses. A Core course of one Department may be taken as an Elective by a student from other Department.

3.1.8 Each student is required to make a seminar presentation on any chosen topic connected with the field of specialization. Preparation and presentation of a seminar is intended to investigate an in-depth review of literature, prepare a critical review and develop confidence to present the material by the student. The seminar shall be evaluated by a department committee constituted for this purpose, based on a report submitted by the candidate and a viva-voce conducted at the end of the semester.

3.1.9 Directed study is a theory course required to be credited by each student under the close supervision of a faculty member of the department. The title of the course and syllabus are to be formulated by the designated faculty member and approved by the vice-chairperson, taking into account the broad area in which the student can enrich his/her knowledge relevant to the area of specialization.

3.1.10 Project work is aimed at training the students to analyze independently any problem posed to them. The work may be analytical, experimental, design or a combination of these. The student can undertake the project work in the department concerned or in an industry/research laboratory approved by the Chairperson/Vice-Chairperson. The project report is expected to exhibit clarity of thought and expression. The evaluation of project work will be a continuous internal assessment based on two reviews, one internal viva-voce and an external viva-voce examination.

3.1.11 A student who has acquired the minimum number of total credits for the award of Degree/ Diploma will not be permitted to register for more courses for the purpose of improving his /her cumulative grade point average (see Table 1).

3.1.12 The medium of instruction, examination, seminars, thesis / dissertation/ project work will be in English.

3.2 GRADING

3.2.1 Based on the performance of each student in a semester letter grades will be awarded in each course at the end of the semester. The letter grades, the corresponding grade point and the description will be as shown in Table 2.

Table 2: Letter Grade and the Corresponding Grade Point

GRADE	POINT	DESCRIPTION
S	10	EXCELLENT
A	9	VERY GOOD
B	8	GOOD

C	7	ABOVE AVERAGE
D	6	AVERAGE
E	4	SATISFACTORY
F	0	FAILURE
FA	0	FAILURE DUE TO LACK OF ATTENDANCE

3.2.2 A student is deemed to have completed a course successfully and earned the appropriate credit if and only if, he /she receive a grade of E and above. The student should obtain 40% of marks in end semester examination in a subject to earn a successful grade. A subject successfully completed cannot be repeated at any time.

3.2.3 The letter grades do not correspond to any fixed absolute mark. Each student is awarded a grade depending on his/her performance in relation to the performance of other students taking or has taken the course. For example, S does not mean he/ she has secured 100% or 95%, but, rather that he /she is in the top 5% of all the students who have taken / are taking the course, in the judgment of the teachers. Grades shall be awarded based on the absolute marks in a meeting of the P.G. Programme Committee to be held not later than 10 days after the last day of semester examination. Normally not more than 5% of the students in any written/ laboratory course shall be awarded the grade S and not more than one – third awarded A grade. Average marks in the class shall normally be C grade excepting in the case of practical /project where it may be B grade.

4.0 REGISTRATION

4.1 Each student, on admission, shall be assigned to a Faculty Advisor, who shall advise the student about the academic programme and counsel him/her on the choice of courses depending on his/her academic background and objective.

4.2 With the advice and consent of the Faculty Advisor, the student shall register for courses he/ she plans to take for the semester before the commencement of classes. No student shall be permitted to register for courses exceeding 30 contact hours per week nor shall any student be permitted to register for any course without satisfactorily completing the prerequisites for the course, except with the permission of the concerned teacher in the prescribed format.

4.3 If the student feels that he/she has registered for more courses than he/she can handle, he/she shall have the option of dropping one or more of the courses he/she has registered for, with the consent of his/her Faculty Advisor, before the end of 3^{rd} week of the semester. However, a student to retain his/her status should register for at least 10 credits/ semester.

4.4 Students, other than those freshly admitted, shall register for the courses of their choice in the preceding semester by filling in the prescribed forms.

4.5 The College shall prescribe the maximum number of students in each course taking into account the physical facilities available.

4.6 The College shall make available to all students a bulletin, listing all the courses offered in every semester specifying the credits, the prerequisites, a brief description or list of topics the course intends to cover, the faculty who will be offering the course, the time and place of the classes for the course.

4.7 In any department, preference shall be given to those students for whom the course is a core-course, if, the demand for registration is beyond the maximum permitted number of students.

4.8 Normally no course shall be offered unless a minimum of 3 students are registered.

5.0 EVALUATION

5.1 Evaluation of theory courses shall be based on 40% continuous internal assessment and 60% end-semester examination. Evaluation of laboratory course shall be based on 50% internal assessment and 50% end-semester examination. In each course, there shall be a 3 hour end-semester examination.

5.2 The total marks for the project work will be 300 marks for Phase-I and 400 marks for Phase-II. The allotment of marks for external valuation and internal valuation shall be as follows:

Project work – (Phase – I): 300 Marks

Internal valuation

Guide		50 marks
First Evaluation		50 marks
Second Evaluation		50 marks
	Total	**150 marks**

External valuation

Evaluation (External Examiner Only)		50 marks
Viva voce (50 for Ext. + 50 for Int.)		100 marks
	Total	**150 marks**

Project work – (Phase – II): **400 Marks**

Internal valuation

Guide		100 marks
First Evaluation		50 marks
Second Evaluation		50 marks
	Total	**200 marks**

External valuation

Evaluation (External Examiner Only)		50 marks
Viva voce (75 for Ext. + 75 for Int.)		150 marks
	Total	**200 marks**

Internal evaluation shall be done by a committee comprising of not less than 3 faculty members appointed by the Vice-Chairperson.

5.3 The directed study shall be evaluated internally and continuously as detailed below:

Test I	: 15 Marks
Test II	: 15 Marks
Assignment	: 10 Marks
Final test covering the whole syllabus	: 60 Marks
Total	: 100 Marks

5.4 The end-semester examination as per the prescribed pattern shall be conducted by the department for all the courses offered by the department. Each teacher shall, in the 4^{th} week of the semester submit to the Vice-Chairman, a model question paper for the end-semester examination. The end-semester question paper shall cover the entire syllabus of the course.

5.5 The department shall invite 2 or 3 external experts to be associated with the end-semester examinations and grading. Each expert will be asked to set the question papers for the courses he/she is competent to examine for the end-semester examination based on the model question paper submitted by the teacher concerned. The teacher and the concerned expert shall evaluate the answer scripts together and award the marks to the student. If, for any reason, no external expert is available for any paper, then, the teacher concerned shall set the question paper(s) for the end-semester examination, and the teacher himself shall evaluate the papers and award the marks.

5.6 In the Department, after the evaluation of all the end-semester examination papers, all the teachers who taught the courses and the external experts together shall meet with the P.G. Programme Committee (see section 7.0) and decide the cut-offs for grades in each of the courses and award the final grades to the students.

5.7 Continuous internal assessment mark of 40 for a theory course shall be based on two tests (15 marks each) and one assignment (10 marks) whereas internal assessment mark of 50 for a laboratory curse shall be based on preparation of record (20 marks), mid-semester examination (20 marks) and internal viva voce (10 marks)

5.8 Every student shall have the right to scrutinize his / her answer scripts, assignments etc. and seek clarifications from the teacher regarding his/her evaluation of the scripts immediately after or within 3 days of receiving the evaluated scripts.

5.9 The Department shall send all records of evaluation, including internal assessment, for safe-keeping to the college administration, as soon as all the formalities are completed.

5.10 At the end of the semester each student shall be assigned a grade based on his her performance in each subject, in relation to the performance of other students.

5.11 A student getting F grade in a core course must repeat that course in order to obtain the Degree. A student getting F grade in an elective course may be permitted to choose another elective against the failed elective course, as the case may be, in consultation with the Faculty Adviser.

5.12 A student shall not be permitted to repeat any course or courses only for the purpose of improving the grade in particular course(s) or the cumulative grade point average (CGPA).

5.13 In exceptional cases, with the approval of the chairman, PG Programme committee, make–up examination(s) may be conducted for a student who misses an end-semester examination(s) due to extreme medical emergency, certified by the college Medical Officer, or due to clash in the end-semester examination between two courses which he/she has registered for, in that semester.

5.14 All eligible students should appear for end-semester examinations.

5.15 No student who has less than 75% attendance in any course shall be permitted to attend the end-semester examinations. However, a student who has percentage attendance between 60-75% in any course and absented on medical grounds has to pay a condonation fee of Rs.200/- for each course and produce a medical certificate from a Government Medical Officer not below the rank of R.M.O. or officer of equal grade to become eligible to appear for the examinations. A student with less than 60% attendance shall be given the grade of FA. He/She shall be asked to repeat that course if it is a core course, when it is offered the next time.

6.0 SUMMER TERM COURSE

6.1 A summer term course (STC) may be offered by the department concerned on the recommendations of P.G. Programme Committee. A summer term course is open only to those students who had taken the course earlier and failed. No student shall be allowed to register for more than two courses during a summer term. Those students who had failed due to lack of attendance will not be allowed to register for the same course offered in summer, unless, certified by the concerned Vice-Chairman and the Principal.

6.2 Summer term course will be announced at the end of even semester. A student has to register within the time stipulated in the announcement by paying the prescribed fees.

6.3 The number of contact hours per week for any summer term course will be twice that of a regular semester course. The assessment procedure in a summer term course will be similar to the procedure for a regular semester course.

6.4 Withdrawal from a summer term course is not permitted.

7.0 PG PROGRAMME COMMITTEE

7.1 The M.Tech. Programme shall be monitored by a committee constituted for this purpose by the college. The committee shall consist of all teachers offering the courses for the programme and two student members or 10% of students enrolled whichever is less. The HOD or a senior faculty in the rank of a Professor shall be the vice-chairman nominated by the Head of the Institution. There shall be a common Chairman in the Rank of Professor nominated by the Head of the Institution. There can be a common coordinator in the rank of Professor nominated by the Head of the Institution.

7.2 It shall be the duty and responsibility of the committee to review periodically the progress of the courses in the programme, to discuss the problems concerning the curriculum and syllabi and conduct of classes. The committee may frame relevant rules for the conduct of evaluation.

7.3 The committee shall have the right to make suggestions to individual teachers on the assessment procedure to be followed in his/her course. It shall be open to the committee to bring to the notice of the Principal any difficulty encountered in the conduct of the classes or any other pertinent matter.

7.4 The committee shall meet at least twice in a semester: one at the beginning of the semester, and another at the end of the semester. In the last meeting the committee excluding the student members but with the external experts invited by the Chairman PG Programme Committee, shall finalize the grades of the students.

8.0 MINIMUM REQUIREMENTS

8.1 To be eligible to continue in the Programme a student must have earned a certain number of successful credits at the end of each semester as given in Table 1. If he /she fails to satisfy this criterion in any semester, he/she shall be placed on scholastic probation in the succeeding semester. If he/she fails to earn the number of credits by the end of that year (including courses taken in summer), then, he/she shall be asked to discontinue the programme.

8.2 Students are expected to abide by all the rules of the college and maintain a decorous conduct. Any deviation will be referred to the Head of the Institution for necessary action.

8.3 No student who has any outstanding amount due to the college, Hostel, Library or Laboratory or against whom any disciplinary action is contemplated/ pending, will be eligible to receive his/her degree.

9.0 DECLARATION OF RESULTS AND ISSUE OF GRADE CARD

9.1 The PG Programme (CBCS) office shall display the grades as soon as possible after the finalization of the grades. The student shall have the right, for a look at the evaluated examination scripts and represent to the M.Tech Programme Committee for review if he/she feels aggrieved by the evaluation within one week from the commencement of succeeding semester classes.

9.2 The College shall issue at the beginning of each semester a grade card to the student containing grades obtained by the student in the previous semester (s) and his/her Grade Point Average (GPA) and his/her Cumulative Grade Point Average (CGPA).

9.3 The grade card shall list:

a) title of the course(s) taken by the student
b) credits associated with the course
c) grade secured by the student
d) total credits earned by the student in that semester
e) GPA of the student
f) total credits earned by the student till that semester and
g) CGPA of the student

9.4 The GPA shall be calculated as the weighted average of the Grade Points weighted by the credit of the course as follows:

The product of the credit assigned to each course and the grade point associated with the grade obtained in the course is totaled over all the courses and the total is divided by the sum of credits of all the courses and rounded off to two decimal places.

For example, a student getting A in 4 credit course, B in 2 credit course, S in a 3 credit course and F in a 3 credit course, will have a GPA as: (9 x 4 + 8 x 2 + 10 x 3 + 0 x 3) / (4+2+3+3)=82 /12=6.83/10.0.

The sum will cover all the courses the student has taken in that semester, including those in which he/she has secured F grade. Grades FA are to be excluded for calculating GPA and CGPA.

9.5 For computing CGPA, the procedure described in 9.4 is followed, except, that the sum is taken over all the courses the student has studied in all the semesters till then. If a student has repeated any course, the grade secured by him/her in the successful attempt only will be taken into account for calculating CGPA.

9.6 To convert CGPA into percentage marks, the following formula shall be used:

% Mark = (CGPA – 0.5) x 10

9.7 A student who satisfies the course requirements for all semesters and passes all the examinations prescribed for all the four semesters within a maximum period of 10 semesters reckoned from the commencement of the first semester to which the candidate was admitted shall be declared to have qualified for the award of degree.

9.8 A student who qualifies for the award of degree shall be declared to have passed the examination in **First Class with Distinction** upon fulfilling the following requirements:

(i) He/she should have passed all the subjects pertaining to semesters 1 to 4 in his/her first appearance in 4 consecutive semesters starting from first semester to which the candidate was admitted.

(ii) He/she should not have been prevented from writing examinations due to lack of attendance.

(iii) He/she should have secured a CGPA of 8.50 and above for the semesters 1 to 4.

9.9 A student who qualifies for the award of the degree by passing all the subjects relating to semesters 1 to 4 within a maximum period of 6 consecutive semesters after his/her commencement of study in the first semester and in addition secures CGPA not less than 6.5 shall be declared to have passed the examination in **First Class.**

9.10 All other students who qualify for the award of degree shall be declared to have passed the examination in **Second Class.**

9.11 A student with CGPA less than 5.0 is not eligible for award of degree.

9.12 For the award of University rank and gold medal, the CGPA secured from 1^{st} to 4^{th} semester should be considered and it is mandatory that the student should have passed all the subjects from 1^{st} to 4^{th} semester in the first appearance and he/she should not have been prevented from writing the examination due to lack of attendance and should not have withdrawn from writing the end-semester examinations.

10.0 PROVISION FOR WITHDRAWAL

A student may, for valid reasons, and on the recommendation of the Vice-Chairperson and Chairperson be granted permission by the Head of the Institution to withdraw from writing the entire semester examination as one unit. The withdrawal application shall be valid only if it is made earlier than the commencement of the last theory examination pertaining to that semester. Withdrawal shall be permitted only once during the entire programme. Other conditions being satisfactory, students who withdraw are also eligible to be awarded DISTINCTION whereas they are not eligible to be awarded a rank/ gold medal.

11.0 TEMPORARY DISCONTINUATION FROM THE PROGRAMME

If a student wishes to temporarily discontinue the programme for valid reasons, he/she shall apply to the Chairperson, PG Programme committee, through the Head of the department in advance and secure a written permission to that effect. A student after temporary discontinuance may rejoin the programme only at the commencement of the semester at which he/she discontinued, provided he/she pays the prescribed fees. The total period of completion of the programme reckoned from the commencement of the first semester to which the candidate was admitted shall not in any case exceed 8 consecutive semesters including the period of discontinuance.

12.0 POWER TO MODIFY

12.1 Notwithstanding anything contained in the foregoing, the Pondicherry University shall have the power to issue directions/ orders to remove any difficulty.

12.2 Nothing in the foregoing may be construed as limiting the power of the Pondicherry University to amend, modify or repeal any or all of the above.

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M.TECH (ENERGY TECHNOLOGY)

CURRICULUM AND SCHEME OF EXAMINATION

(Total number of credits required for the completion of the programme: 72)

SEMESTER – I

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.	ME 901	Energy conversion systems	3	1	0	4	40	60	100
2.	ME 902	Analysis of heat and mass transfer	3	1	0	4	40	60	100
3.	ME 903	Optimization techniques	3	1	0	4	40	60	100
4.		Elective – I	3	0	0	3	40	60	100
5.		Elective – II	3	0	0	3	40	60	100
6.		Elective – III	3	0	0	3	40	60	100
7.	ME907	Energy Engineering Laboratory	-	-	3	2	100	-	100
						23	340	360	700

SEMESTER – II

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.	ME 904	Thermodynamic analysis of energy systems	3	1	0	4	40	60	100
2.	ME 905	Design of thermal equipment	3	1	0	4	40	60	100
3.	ME 906	Computational fluid dynamics	3	1	0	4	40	60	100
4.		Elective – IV	3	0	0	3	40	60	100
5.		Elective – V	3	0	0	3	40	60	100
6.		Elective – VI	3	0	0	3	40	60	100
7.	ME 908	Computational Techniques Laboratory	-	-	3	2	50	50	100
						23	290	410	700

SEMESTER – III

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.	ME 909	Project Phase-I	-	-	18	10	150	150	300
2.	ME 961	Directed Study	-	-	6	4	100	-	100
						14	250	150	400

SEMESTER – IV

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.	ME 910	Project Phase - II	-	-	24	12	200	200	400
						12	200	200	400

<u>**LIST OF ELECTIVES**</u>

Sl. No.	Code	Subject
1.	ME 921	Advanced fluid mechanics
2.	ME 922	Advanced refrigeration and cryogenics
3.	ME 923	Alternate fuels and their applications
4.	ME 924	Biomass conversion systems
5.	ME 925	Cogeneration Technology
6.	ME 926	Energy conservation and management
7.	ME 927	Energy conversion and environmental pollution
8.	ME 928	Micro-Nano Scale Fluid Flow and Heat Transfer
9.	ME 929	Hydrogen energy and fuel cells
10.	ME 930	Modeling and simulation of energy systems
11.	ME 931	Nuclear power engineering
12.	ME 932	Power plant management and economics
13.	ME 933	Thermal Turbomachines
14.	ME 934	Solar power technology
15.	ME 935	Wind energy technology

ME 901 ENERGY CONVERSION SYSTEMS

Unit – I Energy sources

Energy classification – Energy sources – Principal sources of energy: conventional and non-conventional sources – bio-mass, fossil fuels, nuclear fuels, solar energy – Energy conversion – prospecting, extraction, resource assessment and their peculiar characteristics.

Unit – II Thermal energy conversion

Production of thermal energy using bio-mass, fossil fuels, nuclear fuels, solar energy – Conversion of thermal energy, electrical energy, electromagnetic energy and hydraulic energy into mechanical energy – Energy conversion system: steam turbines, hydraulic turbines and wind turbines – Energy conversion system cycles.

Unit – III Electrical energy generation

Production of electrical energy using thermal energy, chemical energy, electromagnetic energy and mechanical energy – Magneto hydrodynamic conversion – introduction – MHD plasmas – analysis of MHD generators – MHD power applications – Batteries – basic concepts – electrochemical principles and reactions – selection and application of batteries – fuel cells – general characteristics – low power fuel cell systems – fuel cell power plants.

Unit – IV Non- conventional energy conversion systems

Production of electrical energy using non-conventional sources: solar energy, wind energy, wave energy, tidal energy and ocean thermal energy. Solar thermal energy conversion system – photovoltaic conversion – optical effects of p-n junction – analysis of PV cells – wave energy conversion system – tidal energy conversion system – wind energy conversion system.

Unit – V Energy storage

Energy storage: requirements and methods – storage of thermal energy – storage of mechanical energy – storage of electrical energy – storage of chemical energy – storage of nuclear energy.

REFERENCE BOOKS:

1. Culp, A.W., - Principles of energy conversion, Tata McGraw Hill, 2000
2. Messerle, Hugo K., - Magnetohydrodynamic Electric Power Generation, John Wiley & Sons, 1995.
3. Linden, D., - Handbook of Batteries and Fuel Cells, McGraw Hill Book Co., 1984.
4. Angrist, S. W., - Direct Energy Conversion, Allyn and Bacon, Boston, 1982.
5. Green, M. A., - Solar Cells, Prentice Hall Inc., Englewood Cliffs, 1982.
6. Appleby, A. J., - Fuel Cell Hand Book, Van Nostrand Reinhold Co., New York, 1989.
7. Considine, D.M., - Energy technology handbook, McGraw Hill, 1977
8. Glasstone, S., and Sessouske, A., - Nuclear reactor engineering, Van Nostrand Reinhold, 1963
9. Russell, C.R., - Elements of energy conversions, Pergamen press, 1967

ME 902 ANALYSIS OF HEAT AND MASS TRANSFER

Unit – I Conductive heat transfer

General differential equations for heat transfer – special forms of differential heat equations – commonly encountered boundary conditions – steady-state one-dimensional heat conduction without and with internal generation of energy – analysis of heat transfer from extended surfaces – two- and three-dimensional systems: governing equations and solution techniques – unsteady heat conduction: differential equations and analytical solutions – temperature-time charts for different geometric shapes – numerical methods for unsteady conduction analysis.

Unit – II Convective heat transfer

Significance of dimensionless parameters in convective heat transfer analysis – theories of boundary layers – governing differential equations – exact analysis of laminar boundary layer – approximate integral analysis of thermal boundary layer – energy and momentum transfer analogies – analysis of turbulent flow – exact solutions – convective heat transfer correlations – free convection from vertical, horizontal and inclined plates – free convection within parallel channels and enclosures – forced convection for internal and external flows. Heat transfer with phase change – condensation and boiling – laminar and turbulent film condensations on vertical plates – film condensation on radial systems and horizontal tubes – heat transfer in flow boiling – heat transfer in two phase flow – heat transfer in high speed flow.

Unit – III Radiative heat transfer

Thermal radiation – radiation intensity – blackbody radiation – Planck's law – Stefan-Boltxmann law – surface emission – emissivity and absorptivity of solid surfaces – Kirchoff's law – gray surface – environmental radiation – blackbody radiative heat exchange – view factor – radiative heat exchange between gray surfaces without and with radiating enclosures – radiation shields – reradiating surfaces – radiative heat exchange between surfaces with volumetric absorption of separating medium – effects of radiation from gasses, vapour, clouds and luminous flames – multimode heat exchange processes and analysis.

Unit – IV Diffusive mass transfer

Differential equations for mass transfer – special forms of differential mass-transfer equation – commonly encountered boundary conditions – steady-state molecular diffusion: one-dimensional mass transfer without and with chemical reaction – two- and three-dimensional mass transfer systems – simultaneous heat, momentum and mass transfer system – unsteady-state molecular diffusion: governing differential equation and analytical solutions – concentration-time charts for mass transfer in different geometric shapes – numerical methods for transient mass transfer analysis.

Unit – V Convective mass transfer

Significance of dimensionless parameters in convective mass transfer analysis – theories of boundary layers – governing differential equations – exact analysis of laminar boundary layer – approximate integral analysis of thermal boundary layer – mass, energy and momentum transfer analogies – models of convective mass transfer coefficients – inter-phase mass transfer – convective mass transfer correlations: mass transfer to plates, cylinders and spheres – mass transfer in wetted-wall columns, packed and fluidized beds – mass transfer involving turbulent flow through pipes.

REFERENCE BOOKS:

1. Eckert, E. R. G. and M. Drake Jr., - Analysis of Heat and Mass Transfer, McGraw Hill Book Co., R. New York, 1973.
2. Frank P. Incropera and David P. Dewitt., - Fundamentals of Heat and Mass Transfer – 4/e, John Wiley & Sons, New York, 2000.
3. Metzgar, D. E. and Afghan, N. H., - Heat and Mass Transfer in Rotating Machinery, Hemisphere Publishing Co., 1984
4. Tong, L. S., - Boiling Heat Transfer and Two Phase Flow, John Wiley & Sons, New York, 1965.
5. Collier, J.G., - Convective Boiling and Condensation, McGraw Hill Book Co., New York, 1972.
6. Sparrow, E. M. and R. D. Cess, Radiation Heat Transfer, Hemisphere Publishing Co., New York, 1978.
7. McAdams, - Heat Transmission, McGraw Hill Book Co., 1972.
8. Bird, R.B., W.E. Stewart and E.N. Lightfoot, - Transport phenomena, John Wiley and Sons, New York, 2007

ME 903 OPTIMIZATION TECHNIQUES

Unit – I Basic Concepts

Mathematical concept of maximization and minimization – Optimal problem formulation: design variables, constraints, objective functions. Single variable optimization: Boundary phase method – Fibonacci search method – Golden section search method – Newton-Raphson method.

Unit – II Multivariable optimization

Simplex search method – Powell's conjugate direction method – Conjugate gradient method – Variable-metric method.

Unit – III Constrained optimization

Kuhn-Trucker conditions – Penalty function method – Frank-Wolfe method – Generalized reduced gradient method – Generalized projection method.

Unit – IV Special cases of optimization

Integer programming: Penalty function method – Branch-and-bound method – Geometric programming – Dynamic programming.

Unit – V Specialized optimization algorithms

Genetic algorithms (GAs): working principle – difference between GAs and traditional methods – GAs for constrained optimization – Simulated annealing – Global optimization: using steepest descent method and GA.

REFERENCE BOOKS:

1. Deb, K., - Optimization for engineering design, Prentice Hall of India, 2005
2. Rao, S.S., - Optimization theory and applications, Wiley Eastern, 1984
3. Reklaitis, G.V., Ravindran, A., Ragsdell, K.M., - Optimization – methods and applications, Wiley, 1983
4. Davis, L., - Handbook of genetic algorithms, Van Nostrand Reinhold, 1991

ME 904 THERMODYNAMIC ANALYSIS OF ENERGY SYSTEMS

Unit – I Thermodynamic properties and relations

Thermodynamic properties: pressure, volume, temperature, specific heats, internal energy, enthalpy and entropy – Thermodynamic relations: Maxwell relations – Clausius Clapeyron equation – Joule-Thomson coefficient – Gibb's function – Helmholtz function – Generalized relations for specific heats, internal energy, enthalpy and entropy.

Unit – II Evaluation of systems with first and second laws

Thermodynamic processes and cycles – First law and its significance – Energy balance equations for closed and open systems – Comparison of work and heat transfer for different processes – First law efficiency – Significance of Second law – Carnot cycle – Second law analysis of reversible and irreversible processes and cycles – Maximum work.

Unit – III Elements of exergy analysis

Control mass analysis – Control region analysis – Reversibility and Irreversibility – Entropy generation – Exergy: Classification – Exergy analysis of processes: Expansion, Compression, Heat exchange, Mixing and separation, Combustion, Chemical reactions – Material and exergy balances of energy systems – Kinds and characteristics of exergy losses – Exergy efficiency – Thermodynamic non-equivalence of exergy and exergy losses

Unit – IV Exergy analysis of thermal and chemical plants

Analysis of thermal power plant: boiler, turbine, condenser, system cycle: Rankine cycle – Analysis of gas turbine plant: compressor, combustor, turbine, system cycle: Brayton cycle – Analysis of refrigeration plant: compressor, condenser, expansion, evaporator – Analysis of Linde air liquefaction system: compressor, heat exchanger, expansion valve – Analysis of sulphuric acid plant.

Unit – V Thermodynamic optimization of thermal systems

Structural coefficients of system elements – Optimization of component geometry – Optimization of systems: Static and dynamic exergy analyses of systems with their elements connected in series and in parallel – Techno-economic optimization: Exergitic and operating costing and optima – Structural method of techno-economic optimization – Autonomous method of techno-economic optimization – Exergitic costing in multi-product plants – Optimization of equipment and operating costs of pro-exergitic and anti-exergitic equipment – Cumulative Exergy–Cost diagram.

REFERENCE BOOKS:

1. Kotas, T. J., - The exergy method of thermal plant analysis, Butterworths, London, 1985
2. Michael, J. Moran and Howard, N. - Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley & Sons, New York, 1993.

3. Francis, F. Huang, - Engineering Thermodynamics - Fundamentals and Application, Macmillan Publishing Co., New York, 1989.
4. Van Wylen and Sonntag, R. E., - Fundamentals of Classical Thermodynamics, John Wiley & Sons, 1994.
5. Barron, Randel F., - Cryogenic Systems, Oxford University Press, 1985
6. Green, Don W.; Perry, Robert H., Perry's - Chemical Engineers' Handbook (8^{th} edition), McGraw Hill Book Co., New York, 2008

ME 905 DESIGN OF THERMAL EQUIPMENT

Unit – I Basic Concepts

Classification – parallel flow – counter flow – cross flow – multi pass – temperature distribution – over all heat transfer co-efficient – log mean temperature distribution – LMTD method – correction for LMTD – NTU method – methodology of heat exchanger calculation – fouling of heat exchanger.

Unit – II Conventional Heat Exchangers

Double pipe heat exchangers – applications and design parameters – types available. Shell and tube heat exchangers with single phase flow – design procedure – flow arrangement for increased heat recovery.

Unit – III Heat Exchangers with phase change

Types of condensers and their selection – design procedures – types of evaporators – shell and tube reboilers – types and thermal design.

Unit – IV Compact heat exchangers and regenerators

Compact heat exchanger – introduction - plate heat exchangers – heat transfer correlations – methods of surface area calculation - finned tube heat exchangers – application of common fin tubes – fin efficiency and temperature distribution in fin tubes – thermal rating of fin tube heat exchangers – regenerators and thermal energy storage – basic concepts and classification – calculation of regenerator thermal performance.

Unit – V Direct contact Heat Exchangers

Types of cooling towers – packing region – features of natural and mechanical draft towers – thermal performance of natural and forced draft cooing towers.

REFERENCE BOOKS:

1. Hewitt, G. F., - et. al., Process Heat Transfer, CRC Press, 1994
2. Kern, D.Q., - Process Heat Transfer, Mc Graw Hill Book Co., New York 1950
3. Schlunder, E.U., - et al., Heat Exchanger Design Hand Book - Vols. 1-5, Hemisphere Publishing Corp., New York, 1983
4. Martin, H., - Heat Exchangers, Hemisphere Publishing Corporation, 1992
5. Kakac, S., R. K. Shah, A. E. Bergles and F. Mayinger, - Heat Exchangers, Hemisphere Publishing Corporation, 19
6. Kakac, S., R. K. Shah, A. E. Bergles - Low Reynolds Number Flow Heat Exchangers, Hemisphere and Publishing Corporation, 1983

ME 906 COMPUTATIONAL FLUID DYNAMICS

Unit – I Introduction

Basics of Computational Fluid Dynamics (CFD) – One dimensional computation: Finite difference methods (FDM) – Finite element method (FEM) – Finite volume method (FVM) – boundary conditions for FDM, FEM, and FVM. Governing equations: Classification of partial differential equations (PDE) – Navier-Stokes system of equations – boundary conditions.

Unit – II FDM

Finite difference methods – Derivation of Finite Difference equation – Simple method – General method Higher order derivatives – Multi Dimensional Finite Difference Formulas – Mixes derivatives – Solution methods – Incompressible viscous flows - Artificial compressibility method – Pressure correction method. – Compressible viscous flows - Euler equations and Potential equations.

Unit – III FEM

Finite element methods – Formulation – Finite element interpolation functions – Linear problems – Non-linear problems – Incompressible viscous flows – Compressible viscous flows – Finite volume methods through finite difference methods – Formulations of finite volume equations: Burgers' equations – Incompressible and compressible flows

Unit – IV Grid generation

Structured grid generation: Algebraic methods – PDE mapping methods – Surface grid generation – Multiblock structured grid generation. Unstructured grid generation: Delaunay-Voronoi methods (DVM) – Advancing front methods (AFM) – Combined DVM and AFM – Three dimensional applications. Adaptive methods: Structured and unstructured adaptive methods.

Unit – V Specialized Techniques

Computing techniques: Domain decomposition methods – Multigrid methods – Parallel processing. Applications of CFD: Turbulence – combustion – acoustics – Heat transfer – Multiphase flows – Electromagnetic flows.

REFERENCE BOOKS:

1. Anderson, D. A., Tannehill, J. C. and Pletcher, R. H., - Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, New York, 1984.
2. Wendt, J. F. (Ed.), -Computational Fluid Dynamics – An Introduction, Springer Verlag, 1992.
3. Zienkiewicz, O. C. and Morgan, K., - Finite Element and Approximation, John Wiley & Sons, 1983.
4. Reddy, J. N., - An Introduction to Finite Element Method, McGraw Hill Book Co., 1984.
5. Gunzburger, M. D., - Finite Element Method for Viscous Incompressible Flows, Academic Press Inc., New York, 1989
6. Chung, T. J., - Computational Fluid Dynamics, Cambridge University Press,2003

7. Hoffmann, K. A., -Computational Fluid Dynamics for Engineers, Engineering Education system, Wichita, Kansas, USA, 1993
8. Muralidhar, K. and Sundararajan, T., -Computational Fluid Flow and Heat Transfer, Narosa Publishing House, N. Delhi, 1995
9. Fletcher, C. A., -Computational Techniques for Fluid dynamics, Vol. 1: Fundamental and general techniques, Spring-Verlag, Berlin, 1998
10. Fletcher, C. A., -Computational Techniques for Fluid dynamics, Vol. 1: Specific techniques for different flow categories, Spring-Verlag, Berlin, 1998
11. Fletcher, J. H., -Computational Techniques for Fluid dynamics, Spring-Verlag, Berlin,

ME 907 ENERGY ENGINEERING LABORATORY

1. Determination of heating/cooling load for the given space to be air-conditioned.
2. Performance test on Air Conditioning/Refrigeration system.
3. Aerodynamic study on Aerofoil and Cylinder (Pressure and Velocity distribution)
4. Energy balance test on given Steam Boiler.
5. Energy balance test on given Petrol engine.
6. Energy balance test on given Diesel engine.
7. Fuel and flue gas analysis using Gas – Chromo graph.
8. Determination of Calorific value of solid/liquid fuel using Bomb Calorimeter.
9. Determination of Calorific value of gaseous fuel using Junkers Gas Calorimeter.
10. Solar radiation – measurement and analysis.
11. Proximate analysis of solid fuel.
12. Ultimate analysis of solid fuel.
13. Pressure Time Diagram using Pressure Transducer and Charge Amplifier of a SI Engine.
14. Emission Testing using Combustion Gas Analyser.

ME 908 COMPUTATIONAL TECHNIQUES LABORATORY

(Programs are to be carried out using FORTRAN/ C languages)

1. Solution to linear algebraic equations using Gauss-Seidel method
2. Solution to linear algebraic equations using Conjugate Gradient method
3. Solution to linear algebraic equations using GMRES method
4. Solution to linear algebraic equations using LU decomposition method
5. Solution to nonlinear algebraic equations using Newton method
6. Determining Eigen value and Eigen vector for a system of equations
7. Finding roots of an equation using Newton-Raphson method
8. Solution to ODEs using Runge-Kutta method
9. Solution to ODEs through Finite Element method
10. Solution to Poisson's equation with Dirichlet and Convective boundary conditions
11. Solution to 2D transient conduction equation using implicit method
12. Solution to one dimensional wave equation
13. Solution to 2D/3D problems using Fluent, Elmer, OpenFOAM etc.

ME 921 ADVANCED FLUID MECHANICS

Unit – I Kinematics and Kinetics

Kinematics of fluid flow - introduction – regimes of fluid mechanics - Lagrangian and Eulerian approach - revision of concepts of different types of fluids, stream lines, path lines, velocity potentials, vorticity – substantial derivative – equations of continuity – Euler's equation – Bernoulli's equations for ideal fluid flow - flow past circular cylinder with and without circulation – flow past an aerofoil.

Unit – II Viscous fluid flow

Viscous flow - stress components in real fluids – stress analysis on fluid motions – Navier Stokes equation of motion – energy equation – properties of Navier Stokes equation – exact solution of Navier Stokes equation for flow between parallel plates – couette flow – flow through pipes – flow between two concentric rotating cylinders.

Unit – III Laminar flow

Laminar boundary layer - laminar boundary layer equation – similarity solution for steady two dimensional flow – approximate integral method – numerical solutions - boundary layer control.

Unit – IV Turbulent flow

Turbulence - introduction to onset of turbulence – physical and mathematical description of turbulence – Reynolds equation for turbulent motion – semi empirical theories of turbulence – turbulent flow through pipes – turbulent boundary layer equations - turbulent flow with zero pressure gradient on smooth flat plate and rough flat plate.

Unit – V Compressible fluid flow

Compressible flow - fundamental equation of flow of compressible viscous and inviscid fluid – plane couette flow – exact solution – steady flow through constant area pipe – laminar boundary layer equation in compressible flow – boundary layer with pressure gradient and with zero pressure gradient – application of moment integral equation to boundary layers – turbulent boundary layer equations in compressible flow – compressible turbulent flow past a flat plate.

REFERENCE BOOKS:

1. White, F. M., - Viscous Fluid Flow – 2/e, McGraw Hill Book Co., 1991.
2. Schlichting, H. and Gersten, K., - Boundary Layer Theory - 8/e, Springer, 2000.
3. Yuan, S. W., 1988. - Foundations in Fluid Mechanics, Prentice Hall of India Pvt. Ltd.,
4. Fox, R. W. and McDonald, A. T., - Introduction to Fluid Mechanics, John Wiley & Sons, 1995.
5. Muralidhar, K. and Biswas, - Advanced Engineering Fluid Mechanics, Narosa Publishing G. House, 1999.

6. Bansal, J. L., - Viscous Fluid Dynamics, Oxford & IBH Publications Co., 1977.
7. Frederick, S. Sherman, - Viscous Flow, McGraw Hill Book Co., 1991.
8. Binder, - Advanced Fluid Mechanics – Vols. I & II , MIR Publications.
9. Kaufmann., - Fluid Mechanics, McGraw Hill Book Co.

ME 922 ADVANCED REFRIGERATION AND CRYOGENICS

Unit – I Vapour compression refrigeration systems

Vapour-compression refrigeration system and cycle – analysis of vapour-compression refrigeration system: system simulation – reciprocating compressor – condenser performance – analysis of condenser unit subsystem – evaporator performance – simulation of complete refrigeration system – performance matching – multi-pressure refrigeration systems: industrial refrigeration systems – removal of flash gases – system with one evaporator and one compressor – system with one evaporator and two compressors – system with two evaporators and one compressor – system with two evaporators and two compressors – refrigeration system with liquid recirculation.

Unit – II Vapour absorption and ejector refrigeration systems

Vapour absorption refrigeration system and cycle – refrigerant-absorbent pairs – actual vapour absorption cycle and its representation on temperature-concentration and enthalpy-composition diagrams – thermal analysis of vapour absorption system – Lithium Bromide-water system: double-effect, half-effect and triple-effect cycles – ammonia-water systems: double-effect, double-lift and two-stage triple-effect systems – GAX cycles: concept, analysis and design considerations – branched GAX cycle – GAX cycle hardware - combined vapour absorption and compression system – commercial absorption units: crystallization – capacity control. Vapour ejector refrigeration system: theory of ejector – refrigerants for ejector system – analysis of ejector refrigeration system.

Unit – III Cryogenics and liquefaction systems

Cryogenic fluids and materials: properties – production of low-temperatures: Joule-Thomson effect – adiabatic expansion – liquefaction systems – analysis of Linde system: pre-cooled and dual-pressure systems – analysis of Claude system: pre-cooled and dual-pressure systems – analysis of Kapitza system – analysis of Heylandt system – analysis of Collins system – analysis of Simon system – classical casecade system – mixed-refrigerant casecade system – critical components of liquefaction systems – heat exchangers – compressors – expanders – expansion valves.

Unit – IV Cryogenic refrigerators

Cryogenic refrigeration systems: thermodynamic analysis – Joule-Thomson refrigeration systems – casecade Joule-Thomson refrigeration systems – expansion-engine refrigeration systems – cold-gas refrigeration systems – Philips refrigerator – Solvey refrigeration systems – A.D. Little refrigeration systems – Vuilleumier refrigerator – Ericsson and Postle refrigerators – pulse tube refrigerator – miniature refrigerators – ultra low-temperature refrigerators: He – He dilution refrigerator – Pomeranchuk cooling system – magnetic cooling systems.

Unit – V Cryogenic-fluid storage and transfer systems, instrumentation and applications

Cryogenic-fluid storage vessels – insulation methods – cryogenic-fluid transfer systems – industrial storage and transfer – cooled-down of storage and transfer systems – instrumentation for low-temperatures: temperature, pressure, flow-rate and liquid-level measurements – applications of cryogenic systems: superconductive devices – cryogenics in space technology – cryogenics in biology and medicine.

REFERENCE BOOKS:

1.	ASHRAE	- Equipment Handbook, The American Society of Heating, Refrigerating and Air-conditioning Engineers Inc., Atlanta, Georgia, Fundamentals and Equipment.
2.	Arora, C. P.,	- Refrigeration and Air-conditioning, Tata McGraw Hill Publishing Co. Ltd., 2000.
3.	Threlkeld, J. L.,	- Thermal Environmental Engineering, Prentice Hall Inc., 1970.
4.	Desrosier, N. W.,	- Technology of Food Preservation, AVT Publishing Co.,
5.	John Stout,	- Home Air Conditioning, Van Nostrand Reinhold Co.
6.	Jones, W. P.,	-Air Conditioning Engineering, Edward Arnold, 1994.
7.	Stoecker, W. F. and Jones, W. P.,.	Refrigeration and Air Conditioning, McGraw Hill Book Co., 1982
8.	Koelet, P. C.,	- Industrial Refrigeration – Principles, Design and Applications, Macmillan, 1992.
9.	Barron, Randel F.,	- Cryogenic Systems, Oxford University Press, 1985.
10.	Klaus D. Timmerhaus and Thomas M. Flynn,	- Cryogenic Process Engineering, Plenum Press, 1989.

ME 923 ALTERNATIVE FUELS AND THEIR APPLICATIONS

UNIT – I Overview

Introduction – Alternative fuels – Potential solid - liquid - and gaseous fuels. – Alcohols – ethanol, methanol, M85, E85 and gashol – properties – SI engine combustion performance and emission characteristics. Alcohols for CI engine – Alcohol fumigation – Dual fuel injection – Surface ignition and spark ignition- storage, dispensing and safety – material compatibility.

UNIT – II Vegetable oils and other similar fuels derived

Vegetable oils- properties – advantages and disadvantages – Biodiesel – trans-esterification - Factors affecting the process – Properties- Biodiesel blends – engine combustion, performance and emission characteristics- material compatibility , other alternative liquid fuels – benzol – acetone – diethyl ether.

UNIT – III Natuaral gas and LPG

Alternative gaseous fuels – natural gas and LPG – production – properties of natural gas and LPG – CNG conversion kits – Advantages and disadvantages of NG and LPG – comparison of gasoline and LPG – CNG and LPG fuel feed system – LPG & CNG for CI engine – methods of fuel induction engine combustion, performance and emission characteristics.

UNIT – IV Hydrogen as alternative fuel

Hydrogen energy – properties , production , thermo- chemical methods – Hydrogen storage – Delivery – conversion – safety – Hydrogen engines, methods of usage in SI and CI engine – Hydrogen injection system – Hydrogen induction in SI engine.

UNIT – V Biogas for IC engines

Biogas – properties – Biogas for running IC engine – Biogas as vehicle fuel – biogas consumption – engine performance and emission- Biomass gasification – producer gas – consumption – dual fuel operation – engine performance and emission.

REFERENCE BOOKS:

1. Ganesan.V, - Internal Combustion Engines, Tata Mc Graw Hill Publishing company Ltd, New Delhi.
2. Ramalingam K.K, - Internal Combustion Engines Theory and practice, Scitech Publications (India) Pvt, Ltd
3. Gupta, H. N., - Fundamentals of internal combustion engines, Prentice Hall India, 2006.
4. Mittal K.M., - Biogas System Principles and application New Age International (P) Ltd, Publishers, 1996
5. Richard L. Bechtold, - Alternative fuels guide book SAE International, Wattendale, 1997.

ME 924 BIOMASS CONVERSION SYSTEMS

Unit – I Biomass definition,classification and properties

Biomass, definition, classification – availability, estimation of availability – biomass resources – consumption and surplus biomass – energy plantations – biomass analysis: Properties, proximate analysis, ultimate analysis, thermo gravimetric analysis and summative analysis – briquetting – pelleting.

Unit – II Biomass combustion

Biomass combustion – biomass stoves, improved chullahs, types, some exotic designs – fixed bed combustors, types, inclined grate combustors – fluidized bed combustors – design, construction and operation of all the above biomass combustors – case studies.

Unit – III Biomass gasification

Biomass gasification, gasifiers – fixed bed system, downdraft and updraft gasifiers – design, construction and operation – fluidized bed gasifiers – gasifier-burner arrangement for thermal heating – gasifier-engine arrangement for electrical power – equilibrium and kinetic consideration in gasifier operation – case studies.
Biomass pyrolysis, types – manufacture of charcoal, yields and application – manufacture of pyrolytic oils and gases, yields and applications.

Unit – IV Bio-diesel

Non-edible vegetable oils – esterification, methods, yields, catalysts – bio-diesel – blends with diesel – use as engine fuel, combustion characteristics and performance of these fuels in engines, power output, efficiency and emissions – case studies.

Unit – V Biogas

Biological conversion of biomass, methods – methanol, ethanol production – fermentation – anaerobic digestion – biogas plants – types of digesters, some exotic designs, factors affecting biogas generation – biogas technology for cooling, lighting and shaft power production – case studies.

REFERENCE BOOKS:

1. Hall, D. O. and R. P. Overend, Biomass - Regenerable Energy, John Wiley & Sons, 1987.
2. Biomass - Thermochemical characterization, Indian Institute of Technology, Delhi, 1997.
3. Challal, D. S., - Food, Feed and Fuel from Biomass, IBH Publishing Co. Pvt. Ltd., 1991.
4. WereKo-Brobby, C. Y. and E. B. Hagan, - Biomass Conversion and Technology, John Wiley & Sons, 1996.
5. Khandelwal, K. C. and Mahdi, S. S., - Biogas Technology - A Practical Hand Book - Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
6. ABETS, - Department of Aerospace Engineering, Biomass to Energy, Indian Institute of Science, Bangalore, 2003.
7. Desai, Ashok V., - Non Conventional Energy, Wiley Eastern Ltd., 1990. ME 925

ME 925 COGENERATION TECHNOLOGY

Unit – I Concepts

Need for Cogeneration – Principle and Concept of Cogeneration – Review on Thermodynamics of conventional power producing plants – Selecting cogeneration technologies and Technical Options for Cogeneration.

Unit – II Performance

Thermodynamics of Cogeneration power plants – performance criteria and effect of irreversibility – Classification of Cogeneration Systems – Factors Influencing Cogeneration Choice

Unit – III Aalysis

Comparative thermodynamic performance of cogeneration plants – Important Technical Parameters for Cogeneration, performance of cogeneration plants – Numerical examples – calculations of typical heat to power ratios and performance parameters.

Unit – IV Design

Design of Cogeneration plant for varying plant heat to power ratio – fuel savings from installation of cogeneration plant – Prime Movers for Cogeneration, Relative Merits of Cogeneration Systems

Unit – V Alternatives

Cogeneration alternatives: Gas turbine – Steam turbine – Diesel engine – bottoming cycles. Industry / utility cogeneration: thermodynamic evaluation, Techno economic evaluation, Environmental evaluation. Cogeneration in sugar and steel industry, Case Studies

REFERENCE BOOKS:

1. Horlock, J. H., - Cogeneration Combined Heat and Power – Thermodynamics and Performance, Pergamon Press, 1986.
2. David Hu, S., - Cogeneration, Reston Publishing Co., USA, 1985
3. Sirchis, J., - Combined Production of Heat and Power, Elservier Applied Science, 1990.
4. Robert Noyes, - Cogeneration of Steam and Electric Power, Noyes Data Corporation, 1986.
5. Spiewak, S. A., - Cogeneration, Fairmont Press Inc., 1991.
6. Kehlhofer, R., - Combined Cycle Gas and Steam Turbine Power Plants, The Fairmont Press Inc., 1991.

ME 926 ENERGY CONSERVATION AND MANAGEMENT

Unit – I Concepts

Concept of energy conservation – Sankey diagram – thermodynamic limitations: first and second laws of thermodynamics of energy transfer – availability analysis of various thermodynamics processes/devices/cycles. Need for energy conservation in domestic, transportation, agricultural and industrial sectors – Lighting and HVAC systems – simple case studies.

Unit – II Thermal energy conservation

Thermal energy conservation: combustion systems and processes – combustion efficiency – boiler performance – methodology of improving the boiler performance – steam turbine and distribution systems: energy conservation in turbines – necessity for maintenance of correct pressure, temperature and quality of steam – condensate recovery – recovery of flash steam – air and gas removal – thermal insulation.

Unit – III Heat exchanger analysis

Heat exchange systems – recuperative and regenerative heat exchangers – compact heat exchangers – fluidized bed heat exchange systems – heat pumps – heat pipes – heat recovery from industrial processes. heat exchange networking – pinch analysis – target setting, problem table approach, composite curves – waste heat recovery and cogeneration schemes.

Unit – IV Energy conservation in industries

Energy conservation in industries - energy conservation in pumps, fans, compressed air systems, refrigeration & air conditioning systems, emergency DG sets, illumination, electrical motors – energy efficient motors and variable speed motors. Case studies for energy conservation in various industries such as cement, iron and steel, glass, fertilizer, food processing, refinery etc.

Unit – V   Energy management

Concept of energy management – Energy demand and supply – Economic analysis of energy options – Duties of energy managers. Energy auditing: definition, necessity and types. Understanding energy costs – bench marking – energy performance – matching energy use to requirement – maximizing system efficiencies – optimizing the input energy requirements. Fuels and energy: supplementing and substitution – energy audit instruments – energy economics: discount rate, pay back period, internal rate of return, life cycle costing – energy conservation systems analysis for safety, health and pollution.

REFERENCE BOOKS:

1. Patrick, D. and Fardo, S. W., - Energy conservation and management, Prentice-Hall Inc., 1990
2. Witte, Larry C., - Industrial energy management and utilization, Hemisphere publishers, Washington, 1988
3. Reiter, S., - Industrial and Commercial Heat Recovery Systems, Van Nostrand Reinhold Co., 1983
4. Wayn C. Turner, - Energy management handbook, The Fairmount press, 1998

5. Chiogioji, M. H., - Industrial Energy Conservation, Marcel Dekker, 1985
6. Kenney, W. F., - Energy Conservation in Process Industries, Academic Press, 1983
7. O' Callaghan, P., - Energy Management, McGraw Hill Book Company, 1993
8. Sirchis, J., - Energy Efficiency in Industry, Elsevier Applied Science, London, 1988.
9. Gottschalk, C. M., - Industrial Energy Conservation, John Wiley & Sons, 1996
10. Bisio, A. and Sharon Boots (Eds.)., - Encyclopedia of Energy Technology and Environment, John Wiley & Sons, New York, 1996
11. Tyagi, A. K., -Handbook of energy audits and management, TERI
12. PCRA Booklets.

ME 927 ENERGY CONVERSION AND ENVIRONMENTAL POLLUTION

Unit – I

Principal sources of energy: conventional and non-conventional sources - availability of energy sources, trade–off between energy and environment-green house effect- consequences of global warming – Pollution: indoor pollution-outdoor pollution-pollutants and their harmful effects on health and environment

Unit – II

Fuels used in thermal power plants – pollutants from thermal power plants -Gaseous emissions, particulate matter and smoke emissions – formation of pollutants – monitoring and analysis-flue gas analyzer -control techniques for different pollutants – Emission regulations – waste water treatment and disposal – ash handling system.

Unit – III

Pollution from automobiles-marine engines- diesel engine power plants – Pollutants from non-conventional fuels like natural gas, LPG, biogas, biodiesel, ethanol, methanol etc. – factors causing the formation of pollutants – control techniques-Emission regulations – Emission instrumentation: NO_X analyzers, HC/CO analyzer, smoke analyzer-noise pollution

Unit – IV

The nuclear fuel cycle – Waste classification – Spent fuel storage – Transportation – Reprocessing – High-Level waste disposal – low-level waste generation and treatment – Low-level waste disposal – Biological and Environmental Effects – radiation dose – Basic for limits of exposure – Sources of radiation dosage – Protective measures – Environmental radiological impact – radiation standards

Unit – V

Environmental Pollution from gas turbine power plants – Environmental Impact of renewable energy sources: Biomass energy – wind energy – OTEC – geothermal – tidal – solar photovoltaic energy conversion systems

REFERENCE BOOKS:

1. Jeffrey, P. J., R. F. Weiner P. A. Vesilind, - Environmental pollution and control, , Butterworth- and Heinemann, 4th edition , 1997.
2. Rao, C.S., - Environmental Pollution Control Engineering, New Age International Ltd,, 1992.
4. Martin Crawford, - Pollution Control Theory, McGraw Hill, 1976
5. Marshall, W., - Nuclear Power Technology, Vol. I &II, Clarendon press, Oxford, 1985.
6. Ganesan, V., - Internal Combustion Engines, Tata McGraw Hill, New Delhi, 1995
7. Khan, B.H., - Non-conventional energy sources-, Tata McGraw Hill, New Delhi

ME 928 MICRO-NANO SCALE FLUID FLOW AND HEAT TRANSFER

Unit – I

Introduction - Scaling issues in heat transfer and fluids, Derivation of governing equations of mass, momentum and energy, Fluid flow properties, Applications

Unit – II

Gas flows - Elements of kinetic theory of gases, Rarefied gas phenomena, Tangential momentum accommodation coefficient, solution in microchannel

Unit – III

Liquid flows - Introduction, Challenges in mixing at microscales, Electrokinetic effects Analysis

Unit – IV

Two-phase flows – Capillary effects, Gas bubbles, Droplet and Digital Microfluidics

Unit – V

Heat Transfer - Forced convection with slip, Thermal effects at microscales, Nanofluidics and Molecular dynamics, Direct simulation Monte-Carlo, Lattice Boltzmann method

REFERENCE BOOKS:

1. Karniadakis, G., Beskok, A., Aluru, N., - Microflows and Nanoflows – Fundamentals and and Simulation, Springer, New York, 2005.
2. Rogers, B., Pennathur, S., and Adams, J., - Nanotechnology – Understanding Small Systems, CRC Press, New York, 2008.
3. Probstein, R. F., - Physicochemical Hydrodynamics – An Introduction, Wiley, New York, 1994.
4. Nguyen, N. T., and Wereley, S. T., - Fundamentals and Applications of Microfluidics, Artech House, Boston, 2006.
5. Gomez, F. A. (Ed.), Wereley, S. T., - Biological Applications of Microfluidics, Wiley, New Jersey, 2008.
6. Bruus, H., -Theoretical Microfluidics, Oxford University Press, New York, 2008.

ME 929 HYDROGEN ENERGY AND FUEL CELLS

Unit – I Hydrogen Energy

Hydrogen as an energy source – Properties of hydrogen – Combustion methods and devices – Economics of hydrogen energy – Production of hydrogen: natural resource – biological source - electrolytic process – thermal decomposition – biochemical method – photochemical method – photo-catalytic method.

Unit – II Hydrogen Energy Storage, Transportation and Applications

Selection of storage: Gaseous, liquid – Method of storage: Gaseous hydrogen, cryogenic method, metal hydrides, carbon nano-tubes, sea as a source of deuterium – Transportation: methods of transport – cryo-cooled systems – Fuel cells – Applications of hydrogen energy in land and space vehicles – Hydrogen power technologies.

Unit – III Safety and environmental aspects of hydrogen

Hydrogen sensing and detection: hydrogen measuring principles – traditional sensing methods: thermal conductivity, gas chromatography, mass spectroscopy, laser gas analysis – solid-state sensing techniques – operation mechanisms of solid-state sensors – hydrogen sensors for industrial processes – sensors in hydrogen fuel applications – hydrogen safety: hydrogen hazards – hazards in hydrogen storage facilities – hazards in using hydrogen as fuel in transport sectors – hydrogen codes and standards: national codes – national templates – selected highlights of national templates – key issues: performance based versus prospective standards – coordination of international and domestic standards.

Unit – IV Fuel cells

Fuel cell operation – low-to-medium temperature fuel cells: phosphoric acid fuel cell, alkaline fuel cell, direct borohydride fuel cell, proton-exchange membrane fuel cell, direct methanol fuel cell, miniature fuel cells – high-temperature fuel cells: Molten carbonate fuel cell, direct carbon fuel cell, solid oxide fuel cell – fuel cell efficiencies.

Unit – V Fuel cell applications and economics

Applications of fuel cells – prognosis for fuel cells - Fuel cells in Dispersed Energy Systems (Utility use) - Fuel cells in On-Site Integrated Energy Systems and Industrial Co-generation.

REFERENCE BOOKS:

1. Veziroglu, T. N. and Barbir, F., - Hydrogen Energy Technologies, UNIDO Emerging Technologies Series, UNIDO, Vienna, 1998
2. Jamasb, T., Pollitt,M.G. Nuttall, W. J., -Future Electricity Technologies and Systems, Cambridge and University Press, 2006
3. Ryan O'Hare, Colella, Fritz B.Prinz., - Fuel Cell Fundamentals, John Wiley & Sons Inc., 2nd Edition, Suk-Won Cha, Whitney 2009
4. Karl V. Kordesch, Dr. Günter R. Simader, - Fuel Cells: and their Applications, Wiley Publications, 1996
5. Ram B.Gupta, -Hydrogen Fuel: Production, Transport and Storage, CRC Press, 2009

ME 930 MODELLING AND SIMULATION OF ENERGY SYSTEMS

Unit – I

Mathematical modeling – interpolations – polynomial and Lagrangian – solution of simultaneous linear equations – curve fitting – regressions analysis – solution of transcendental equations – modeling of thermal equipment – heat exchangers – turbo machines.

Unit – II

System simulation – classes of simulation – information flow diagram. Methods used in simulation – successive substitution – Newton Raphson methods. Examples of energy systems – gas turbines – refrigeration – pumps.

Unit – III

Optimization – objectives and constraints – problem formulation – unconstrained optimization – constrained optimization using Lagrange multiplier equations – Kuhn-Tucker conditions.

Unit – IV

Optimization using search methods – univariate search methods – constrained optimization using penalty functions – conjugate gradient method. Introduction to genetic algorithms and simulated annealing.

Unit – V

Steady state simulation of large systems – convergence and divergence in successive substitution – partial substitution in successive substitution – characteristics of Newton-Raphson method – quasi Newton method – application in simulation of energy systems. Application of optimization techniques to energy systems.

REFERENCE BOOKS:

1. Stoecker, W. F., Design of Thermal Systems, McGraw Hill Book Co., 1989.
2. Bejan, A., G. Tsatsaronis and M. Moran, Thermal Design and Optimization, John Wiley & Sons, 1996.
3. Rao, S. S., Optimization Theory and Applications, Wiley Eastern Ltd., 1990.
4. Hodge, B. K., Analysis and Design of Energy Systems, Prentice Hall Inc., 1990.
5. Press, W. H., et al., Numerical Recipes in Fortran – 2/e, Cambridge University Press, 1996.

ME 931 NUCLEAR POWER ENGINEERING

Unit – I

Radioactivity – nuclear reactions – binding energy – neutron interaction – cross sections – fission – power from fission – fission chain reactions – criticality – conversion and breeding – nuclear fuel performance.

Unit – II

Nuclear power reactors – nuclear fuel cycles – fuel enrichment – fuel assembly – fuel reprocessing – decommissioning of power plants – radioactive waste disposal and its management.

Unit – III

Neutron flux – diffusion theory applications – ficks law – solution to diffusion equation for point source – plannar source and bare slab – diffusion length – energy loss in scattering collisions – moderators.

Unit – IV

One group reactor equation – one group criticality equation – thermal reactors – criticality calculations – homogeneous and heterogeneous reactors – reactor kinetics and safety – prompt neutron life time – reactor with and without delayed neutrons – prompt criticality – control rods – principles of nuclear rector safety.

Unit – V

Heat generation in reactors – thermal constraints – heat transfer to coolants – thermal design of reactor.

REFERENCE BOOKS:

1. Lamarsh, J. R., - Introducation to Nuclear Engineering, Addison-Wesley, New York, 1983.
2. Marshall, W., - Nuclear Power Technology - Vol. I, II & III, Clarendon Press, Oxford, 1985.
3. Samuel Glasstone, -Principle of Nuclear Reactor Engineering, Van Nostrand Reinhold Co., New York, 1963.
4. Culp, Archie W., - Principles of Energy Conversion, McGraw Hill Book Co., 1991.

ME 932 POWER PLANT MANAGEMENT AND ECONOMICS

Unit – I

Power Plant Economics and Tariffs: Load curve, load duration curve, different factors related to plants and consumers, Cost of electrical energy, depreciation, generation cost, effect of load factor on unit cost. Fixed and operating cost of different plants, role of load diversity in power system economy. Objectives and forms of Tariff: Causes and effects of low power factor, advantages of power factor improvement, different methods for power factor improvements.

Unit – II

Economic Operation of Power Systems: Characteristics of steam and hydro-plants, Constraints in operation, Economic load scheduling of thermal plants Neglecting and considering transmission Losses, Penalty factor, loss coefficients, Incremental transmission loss.

Unit – III

Demand Side Load Management: Concepts, Barriers, Planning and Implementation methods etc., management philosophy- leadership- work environment- delegation-organization – human resources – policies – common tasks – communications – finance – taxation/depreciation – legal aspects – quality control – Insurance

Unit – IV

Organizational design of power plant – plant operation – quality control – maintenance schedule – log books – production records

Unit – V

Plant business units: strategic, operating and resource, management roadmaps and attributes – general/plant management – business management- accounting management – fuels, energy and emissions management – profit-centered maintenance management – engineering management – operations management – planning & scheduling management – human resources management – environmental management – health & safety management – quality management

REFERENCE BOOKS:

1. Stevenson, W. D., - Elements of Power System Analysis, McGraw Hill, 1994
2. Soni Gupta and Bhatnagar,- A text book on Power System Engineering, Dhanpat Rai & Co.
3. Murthy, P. S. R., -Operation and control of Power System" BS Publications, Hyderabad, 2007

ME 933 THERMAL TURBOMACHINES

UNIT – I

Introduction to Thermal Turbomachines – Principle of operation – energy equation – classifications – work done, Losses and efficiencies – performance characteristics

UNIT – II

Flow through nozzles and diffusers – Steam turbines – impulse turbine and reaction turbines – velocity triangles – compounding – considerations in design of nuclear steam turbines – governing of steam turbines

UNIT – III

Gas turbine- classification – Thermodynamics of axial and radial flow gas turbines- Degree of reaction-Design procedure for turbine stage - stage efficiency – Performance – Gas turbine cycle – simple cycle and cogeneration cycle – effect of operating variables on thermal efficiency – application of gas turbines: aircraft-surface vehicles-electric power generation.

UNIT – IV

Compressors – classification – Axial flow Compressor – Stage Velocity triangles – Enthalpy Entropy diagram – Flow through blade rows-stage losses and efficiency – Work done factor – Performance characteristics – Centrifugal Compressors – elements of a centrifugal compressor stage- – Stage Velocity triangles – Enthalpy-Entropy diagram – nature of impeller flow – slip factor – volute casing – stage losses and efficiency – Performance Characteristics.

UNIT – V

Axial fans – Principle of operation – types of axial fan stages – performance of axial fans – applications – Centrifugal fans – types – fan stage parameters – drum type and partial flow fans – losses and performance.

REFERENCE BOOKS:

1. Yahya, S.M., - Turbines Compressors and Fans, Tata McGraw-Hill Company, 2002
2. Shephard, D.G., - Principles of Turbomachines, Macmillan Company, 1984
3. Cohen, H., G.F.C. Rogers and H.I.H. Saravanamuttoo, - Gas Turbine Theory, 5th edition., Prentice Hall, 2001
4. Kerten, W.J., Steam Turbine - Theory and Practice, CBS Publishing 1988

ME 934 SOLAR POWER TECHNOLOGY

Unit – I

Solar energy, geometry, solar radiation – availability, measurement and estimation – solar tracking – Isotropic and anisotropic models – empirical relations

Unit – II

Solar thermal devices – liquid flat plate collectors, materials, selective surfaces, cover plates – thermal analysis of collector – solar air heaters – construction, performance and analysis.
Concentrating collectors: types – heliostats — solar ponds

Unit – III

Solar thermal energy storage – sensible heat storage - latent heat storage- Thermo chemical storage - water, packed bed storages – storage in phase change materials, performance and analysis.

Unit – IV

Solar cells – photovoltaic principle – materials for photovoltaic cells – design and fabrication of photovoltaic cells – performance analysis of photovoltaic cells – thermoelectric generator solar cells – photochemical solar cells – solar photovoltaic power plants – terrestrial and space applications.

Unit – V

Applications: Solar lighting – solar cooling – heat pump – solar drying – solar cooking - solar passive buildings – solar power plants – performance and analysis – case studies.

REFERENCE BOOKS:

1. Duffie, J. A. and Beckmann, W.,- Solar Thermal Process, John Wiley & Sons, 1980.
2. Sukhatme, S. P., - Solar Energy- Principles of Thermal collection and Storage, Tata McGraw Hill Publishing Co. Ltd., 1994.
3. Magal, B.S., - Solar Power Engineering, Tata McGraw Hill Publishing Co. Ltd., 1990.
4. Bansal, N. K., Manfred Kleeman and Michael Meliss, - Renewable Energy Sources and Conversion Technology, Tata McGraw Hill Publishing Co. Ltd., 1990.
5. Jiu Sheng Hsieh, - Solar Energy Engineering, Prentice Hall Inc., 1991.
6. Mani, A. and Rangarajan, S., - Solar Radiation over India, Allied Publishers Pvt. Ltd., 1982.

ME 935 WIND ENERGY TECHNOLOGY

Unit – I Wind resource

Wind characteristics: meteorology of wind – Francis Beaufort scale – wind speed distribution across the world and India – wind speed variation with height – wind speed characteristics – atmospheric turbulence – Gust wind speeds – extreme wind speeds – wind speed prediction and forecasting – wind measurements: Eolian features – biological indicators – rotational anemometers – pressure plate and tube anemometers – hot wire anemometer – Doppler acoustic radar – wind direction measurements – Classification of wind energy conversion systems: HAWT, VAWT – Wind energy scenario in India – Wind energy applications: stand-alone system – grid and hybrid connected systems.

Unit – II Principle of Wind Energy Conversion

Aerodynamics of horizontal axis wind turbines: actuator disc concept – momentum theory – power coefficient – Betz limit – rotor disc theory – vortex cylinder theory – rotor blade theory – break-down momentum theory – aero-foils and their characteristics – blade geometry – effect of number of blades: solidity – aerodynamics of wind turbine in steady yaw – acceleration potential – stall delay – unsteady flow – aerodynamics of vertical axis turbines – Momentum theories

Unit – III Performance of Wind turbines, loading estimation

Assessment of performance: power output – constant rotational speed operation – variable-speed operation – estimation of energy capture – wind turbine field testing – wind turbine performance measurement – design loads: basis for loading – national and international standards – turbulence and wakes – extreme loads – fatigue loading – stationary blade loading – blade dynamic loading – hub and low-speed shaft loading – nacelle loading – tower loading

Unit – IV Design of wind turbines and control, safety and electrical systems

Design: blades, pitch bearings, rotor hub, gear box, mechanical brake, nacelle, yaw drive, tower and foundation – Stall control – pitch control – yaw control – braking systems – electrical and electronic controllers – electrical power generators: asynchronous generators – DC shunt generator – permanent magnet generator – AC generators – self-excitation of induction generators – power collection systems – lightning protection – power quality assessment – electrical protection – embedded wind power generation

Unit – V Wind turbine plant installation and economics

Selection of plant size – selection of site – project assessment – site investigation – visual and landscape assessment – noise assessment – ecological assessment – electromagnetic interference – financial assessment – concept of economics – capital costs – revenue requirements – value of wind generated electricity – hidden costs – economic factors

REFERENCE BOOKS:

1. Freris, L. L., - Wind Energy Conversion Systems, Prentice Hall, 1990
2. Spera, D. A., - Wind Turbine Technology: Fundamental concepts of wind turbine engineering, ASME Press
3. Johnson, G. L., - Wind Energy Systems, Prentice Hall, 1985
4. Walker, J. F., - Wind Energy Technology, John Wiley, 1997
5. Anna Mani & Nooley, - "Wind Energy Data for India", 1983.

ME 961 DIRECTED STUDY

Each candidate is required to make a study on a relevant topic connected with the field of specialization. The topic shall be chosen in consultation with the concerned Faculty Guide and Head of the Department. It would be such as to develop investigative and creative ability of the candidate. A presentation shall be given after a thorough investigation of the literature and other data relevant to the topic.

ME 909 MAJOR PROJECT (PHASE – I)

The project work is to acquaint the student in the analysis of problems posed to him, in the method of conducting a detailed literature survey and reviewing the state of art in the area of the problem. If the major project (Phase–I) which is not purely theoretical, student is also expected to design, conduct and develop skills of experimental work, in some of them and to analyse the results obtained. An Internal Examiner will examine the project report written at a viva-voce.

ME 910 MAJOR PROJECT (PHASE – II)

The student will take up the Major Project (Phase–II) in the fourth semester. This is aimed at exposing the students to analyze independently his project work. The work may be purely analytical or completely experimental or combination of both. In few cases, the project can also involve a sophisticated design work. The major project report is expected to show clarity of thought and expression, critical appreciation of the existing literature and analytical and/or experimental or design skill. The dissertation work should be of relevant nature for the current and the future needs of the country. The dissertation report will be examined at the time of viva-voce.

INFRASTRUCTURE AND FACULTY REQUIREMENT FOR M.TECH (PRODUCT DESIGN AND MANUFACTURING)

1. INFRASTRUCTURE:

(i) Building Infrastructure

Sl.No.	Building Details	Area (Sq.m)
1.	Class/Tutorial Room	**34**
2.	Laboratory	**80**
3.	Project Lab	**50**

(ii) Equipment Infrastructure

Sl.No.	Facilities/Equipment/Accessories	Qty.
1.	Gas – Chromo graph.	**1**
2.	Proximate analysis of solid fuel.	**1**
3.	Bomb Calorimeter.	**1**
4.	Emission Testing using Combustion Gas Analyser	**1**
5.	Junkers Gas Calorimeter.	**1**
6.	Steam Boiler	**1**
7.	Solar radiation – measurement and analysis.	**1**
8.	FFT Analyser	**1**
9.	Gas Analyser	**1**
10.	Computer Systems connected with LAN	**25**
11.	CATTIA 12 version	**15 Licence**
12.	ANSYS 12 version	**15 Licence**
13.	AUTO CAD 2002	**15 Licence**
14.	UTM Machine	**1**
15.	Plotter 450	**1**
16.	HP Laser Printer 1000	**1**
17.	HP Laser Printer 1023	**1**

2. LIBRARY:

Number of books : **100**

Titles : **As required by the curriculum**

Journals : **5 related International journals**

3. FACULTY REQUIREMENT:

S.No.	Cadre	No.	Qualification	Specialization
1.	Professor	**1**	As per AICTE norms	Energy Technology/ Thermal Engineering/ Energy Engineering
2.	Associate Professor	**1**	As per AICTE norms	Energy Technology/ Thermal Engineering/ Energy Engineering
3.	Assistant Professor	**1**	As per AICTE norms	Energy Technology/ Thermal Engineering/ Energy Engineering

4. TEACHER TO STUDENT RATION : 1:15

5. STUDENT TO COMPUTER RATIO : 1:1