CIRCULAR:-

A reference is invited to the syllabi relating to the Master of Engineering (Mechanical) Energy System and Management degree course vide this office Circular No.UG/10 of 2013-14, dated 26th April, 2013 and the Principals of affiliated Colleges in Engineering are hereby informed that the recommendation made by Ad-hoc Board of Studies in Electrical Engineering at its meeting held on 8th July, 2016 has been accepted by the Academic Council at its meeting held on 14th July, 2016 vide item No. 4.19 and that in accordance therewith, the revised syllabus as per Choice Based Credit System for Master of Engineering (Mechanical) Energy System and Management (Sem. I to II), which is available on the University’s web site (www.mu.ac.in) and that the same has been brought into force with effect from the academic year 2016-17.

MUMBAI – 400 032 (Dr.M.A.Khan)
November, 2016 REGISTRAR

To,

The Principals of affiliated Colleges in Engineering.

A.C/4.19/14/07/2016.

********************

Copy forwarded with compliments for information to:-

1. The Dean, Faculty of Technology,
2. The Chairman, Ad-hoc Board of the Studies in Electrical Engineering
3. The Director, Board of College and University Development,
4. The Controller of Examinations,
5. The Co-Ordinator, University Computerization Centre.

(Dr.M.A.Khan)
REGISTRAR

... PTO
UNIVERSITYOFMUMBAI

Revised Syllabus for the M. E. Program

Program: M. E. (Mechanical)

ENERGY SYSTEMS AND MANAGEMENT

(As per Choice Based Credit System with effect from the academic year 2016–2017)
From Co-ordinator’s Desk:-
To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this, Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meetings unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEOs), give freedom to Affiliated Institutes to add few (PEOs), course objectives course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth of approach of course to be taught, which will enhance learner’s learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry are to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology and developed curriculum accordingly. In addition to outcome based education, **Choice Based Credit System** is also introduced to ensure quality of engineering education.

Choice Based Credit and Grading System enables a much-required shift in focus from teacher-centric to learner-centric education, since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes. Faculty of Technology has devised a transparent credit assignment policy, adopting a ten point scale to grade learner’s performance. Choice Based Credit and Grading System is implemented for Master of Engineering from the academic year 2016-2017.

**Dr. S. K. Ukarande**
**Co-ordinator,**
**Faculty of Technology,**
**Member - Academic Council**
**University of Mumbai, Mumbai**
Chairman’s Preamble:

Engineering education in India is expanding and is set to increase manifold. The major challenge in the current scenario is to ensure quality to the stakeholders along with expansion. To meet this challenge, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student will have at the time of graduation from the program. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating the philosophy of outcome based education in the process of curriculum development.

As the Chairman, Board of Studies in Mechanical Engineering of University of the Mumbai, I am happy to state here that, the Program Educational Objectives for Postgraduate Program were finalized in a brain storming session, which was attended by more than 20 members from different affiliated Institutes of the University. They are either Heads of Departments or their senior representatives from the Department of Mechanical Engineering. The Program Educational Objectives finalized for the postgraduate program in Mechanical Engineering are listed below;

1. To prepare the Learner with a sound foundation in the mathematical, scientific and engineering fundamentals.
2. To prepare the Learner to use modern tools effectively in order to solve real life problems.
3. To prepare the Learner for a successful career in Indian and Multinational Organisations
4. To encourage and motivate the Learner in the art of self-learning.
5. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social responsibilities in the Learner’s thought process.

In addition to the above, 2 to 3 more program educational objectives of their own may be added by affiliated Institutes.

In addition to Program Educational Objectives, for each course of postgraduate program, objectives and expected outcomes from a learner’s point of view are also included in the curriculum to support the philosophy of outcome based education. I strongly believe that even a small step taken in the right direction will definitely help in providing quality education to the major stake holders.

Dr. S. M. Khot

Chairman, Board of Studies in Mechanical Engineering, University of Mumbai
## Program Structure for

**ME Mechanical Engineering (Energy Systems and Management)**  
*Mumbai University*  
*(With Effect from 2016-2017)*

### Semester I

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Teaching Scheme (Contact Hours)</th>
<th>Credits Assigned</th>
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<td>ESMC101</td>
<td>Energy Scenario, Policy and Environment</td>
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<td>ESMC102</td>
<td>Energy Efficiency in Thermal Systems</td>
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### Examination Scheme

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University of Mumbai, ME (Mechanical) Energy Systems and Management, Rev 2016 6
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# Common with Energy Systems and Management and Thermal Engineering
& Common with Energy Systems and Management and Heat Power Engineering
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### Semester III

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*Seminar of Semester III and Dissertation II of Semester IV should be assessed jointly by the pair of Internal and External Examiners*

**Note:** The Contact Hours for the calculation of load of teacher are as follows
- Seminar - 01 Hour / week / student
- Project I and II - 02 Hour / week / student

### Semester IV

<table>
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Course Code | Course Name | Credits  
---|---|---
ESMC101 | Energy Scenario, Policy and Environment | 04

Objectives
1. To understand and compare global and Indian energy profile.
2. To compare global and Indian energy policies.
3. To analyze energy impact on environment.

Outcomes: Learner will be able to…
1. Assess role of energy in global economic development.
2. Analyze energy consumption pattern in India and its effect on economic development.
3. Determine impact of International energy policy on national energy growth.
4. Understand relationship between energy, ecology and environment.

<table>
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<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
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<tbody>
<tr>
<td>01</td>
<td><strong>Global Energy Scenario</strong>&lt;br&gt;Role of energy in economic development and social transformation, Energy &amp;GDP, GNP and its dynamics. Energy sources and overall energy demand and availability, Energy Consumption in various sectors and its changing pattern, Exponential increase in energy consumption and projected future demands. Non-Conventional and Conventional Energy Resources: Coal, Oil, Natural Gas, Nuclear Power and Hydroelectricity, Solar, wind and other renewable etc. Depletion of energy sources and impact on exponential rise in energy consumption on economies of countries and on international relations. Energy Security, Energy Consumption and its impact on environmental climatic change.</td>
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| 05 | **Industrial Energy and Environment Analysis**  
Energy and the environment, Energy in manufacture, Hazardous waste management in Chemical/Petrochemical/Cement industries and Power Plants, Contamination of ground water, Treatment & disposal, Pollution from combustion and atmospheric pollution control methods. |
|---|---|
| 06 | **Energy, Ecology and Environment**  

**Assessment:**

**Internal:**
Assessment consists of two tests out of which; one should be compulsory class test (**on minimum Two Modules**) and the other is either a class test or assignment on live problems or course project.

**End Semester Theory Examination:**
Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

**References:**

8. J K Parikh, Modeling approach to long term demand and energy implication, IIASA Professional Paper
9. TEDDY Year Book Published by Tata Energy Research Institute (TERI),
10. S Rao, Energy Technology, Khanna Publishers
11. International Energy Outlook -EIA annual Publication
13. Frank P Lees, Loss Prevention in Process Industries Volume 1, 2 & 3, Elsevier
   Butterworth Heinemann
Objectives
1. To understand conventional and nonconventional fuels & combustion technology.
2. To discover energy conservation (ENCON) opportunities in thermal systems.
3. To know alternatives for waste energy recovery from energy systems.

Outcomes: Learner will be able to…
1. Define the reasons of incomplete combustion and attempt to reduce the subsequent impact.
2. Determine ENCON opportunities in thermal systems.
3. Measure and improve the quality of recovered waste energy.

<table>
<thead>
<tr>
<th>Module</th>
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<th>Hrs.</th>
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| 01     | Fuel and Combustion Technology  
Introduction to Fuels, Properties of Fuel oil, Coal and Gas, Storage, handling and preparation of fuels, Principles of Combustion, Combustion of Oil, Coal, and Gas, Biomass. Calculation of theoretical air quantity, Excess air and CO₂ in flue gas. | 08 |
| 02     | Steam Systems and ENCON opportunities  
Properties of steam, Steam distribution losses, Steam leakages, Steam Pipe Sizing and Design, Selection, Operation, Maintenance & Testing of Steam Traps, Condensate and flash steam recovery, Energy conservation (ENCON) opportunities in steam systems | 10 |
| 03     | Boilers and ENCON Opportunities  
IBR boiler specifications, Fire tube, water tube, packaged, stoker fired boiler, Combustion in boilers, Direct & Indirect Method to find boiler efficiency, Blow down types & performance calculations, Feed water treatment, ENCON opportunities, Case study, Fluidized bed combustion (FBC) boiler types and advantages | 10 |
| 04     | Furnace and ENCON Opportunities  
Types of furnace, Heat transfer, Losses in furnace, Direct & Indirect Method to find Efficiency of furnace, Excess air, Heat distribution, Temperature control, Draft control General fuel economy measures in furnaces, Case study | 08 |
| 05     | Insulation and Refractories  
Types of furnace, Heat transfer, Losses in furnace, Direct & Indirect Efficiency, Excess air, Heat distribution, Temperature control, Draft control General fuel economy measures in furnaces, Case study | 10 |
| 06     | Cogeneration (CG) & Waste Heat Recovery (WHR)  
Definition, need & principle of CG, technical options of CG, CG cycles, Selection of CG systems, Performance evaluation of CG, Case study, Need of WHR, Waste sources and Quality, Benefits of WHR. | 06 |

Assessment:

Internal:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum Two Modules) and the other is either a class test or assignment on live problems or course project.
End Semester Theory Examination:
Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
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<tr>
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<td>Energy and Power, Principal types of power plants, Power plant cycles and their classification, Performance Evaluation of Power plant cycles.</td>
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<tr>
<td>02</td>
<td><strong>Steam Power Plants</strong></td>
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<td>Classification, Layout, Essential requirements of Power Station Design, Site Selection, Capacity, Plant arrangement, Useful life of SPP components, SPP pumps, Advantages and Disadvantages, Cost and Economics of SPP</td>
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<tr>
<td>03</td>
<td><strong>Gas Turbine Power Plants</strong></td>
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<tr>
<td></td>
<td>General aspects, Advantages and Disadvantages of GTPP over SPP, Site selection, Classification of GTPP, GTPP fuels, Operation of GTPP, GTPP layout, Effect of operating variables on thermal efficiency, Combined GT and SPP</td>
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<td><strong>Hydro-Electric Power Plants (HePP)</strong></td>
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<tr>
<td></td>
<td>Advantages and disadvantages, Site selection, Essential features/elements of HePP, Classification, Plant layout, Average life of HePP components, Electrical and Mechanical components, Comparison of HePP and SPP, Underground HePP, Advanced HePP, Safety measures and preventive maintenance, Cost of HePP and hydroelectric power</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td><strong>Nuclear Power Plants</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General aspects, Nuclear power systems, Main components of NPP, Advantages of NPP, Site selection, Applications, Economics of NPP, Safety measures for NPP, Future of NPP, Nuclear Power Plants in India, Useful byproducts of Nuclear power generator and their uses</td>
<td>07</td>
</tr>
<tr>
<td>06</td>
<td><strong>Combined Operation of Plants</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General aspects, Advantages of COP, Load division and power stations, Coordination of different power plants, Cost comparison and cost analysis of SPP, GTPP, HePP and NPP</td>
<td>08</td>
</tr>
</tbody>
</table>
Assessment:

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End Semester Theory Examination:
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3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

References:

3. P K Nag, Power Plant Engineering, TMH, New Delhi, 1998
4. A K Raja, Amit Praksh Shrivastava, Manish Dwivedi, Power Plant Engineering, New Age International Publishers
Course Code | Course Name     | Credits
---|-----------------|-------
ESMDLO 1011 | Utilization of Solar Energy | 04

**Objectives**
1. To understand Solar Geometry and basic idea of solar energy collection
2. To learn different utilities of solar energy
3. To summarise economics of solar energy collection systems

**Outcomes:** Learner will be able to…
1. Estimate and quantify available solar radiation
2. Judiciously design the solar energy collection system
3. Understand basic economics of solar energy systems

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td>Description of Solar Radiation and its application for thermal utilities as well as PV utilities, availability, measurement and estimation; Isotropic and anisotropic models; empirical relations</td>
<td>10</td>
</tr>
<tr>
<td>02</td>
<td>Flat plate collector, concentrating collector, thermal energy storage: steady state and dynamic analysis, process economics</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td>Solar water heating: active and passive, building heating and cooling, solar drying, solar desalination, Solar Ponds, Industrial Process heating</td>
<td>08</td>
</tr>
<tr>
<td>04</td>
<td>Simulation in solar process design, limitations of simulation, design of active systems by f-chart, utilisability method</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td>Solar photovoltaic systems, PV generators: characteristics and models, load characteristics and direct coupled systems, maximum power point trackers, applications, design procedure, applications of nano materials/technology in solar energy</td>
<td>10</td>
</tr>
<tr>
<td>06</td>
<td>Solar Economics: Application of economic methods to analyze the feasibility of solar systems to decide project/policy alternatives, Net energy analysis and cost requirements for active and passive heating and cooling, electric power generation and for industrial process heating</td>
<td>08</td>
</tr>
</tbody>
</table>

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4. Only Four questions need to be solved.

References:

Objectives
1. To understand cogeneration and waste heat recovery techniques
2. Learn to check viability of cogeneration and waste heat recovery
3. To summarise economics of such systems

Outcomes: Learner will be able to...
1. Estimate and quantify available waste heat
2. Tap opportunities of waste heat recovery
3. Understand economics of cogeneration and waste heat recovery systems

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
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</thead>
<tbody>
<tr>
<td>02</td>
<td>Application &amp; Techno Economics Of Cogeneration: Cogeneration Application in various process industries. Sizing of waste heat boilers - Performance calculations, Part load characteristics selection of Cogeneration Technologies – Financial considerations - Operating and Investments - Costs of Cogeneration</td>
<td>14</td>
</tr>
<tr>
<td>05</td>
<td>Applications &amp; Techno Economics of Waste Heat Recovery Systems: Applications in industries, selection of waste heat recovery technologies - financial considerations, saving potentials of different waste heat sources - operations and investment costs of waste heat recovery</td>
<td>07</td>
</tr>
<tr>
<td>06</td>
<td>Introduction to tri-generation and quad-generation</td>
<td>04</td>
</tr>
</tbody>
</table>

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4. Only Four questions need to be solved.

References:

7. BEE Reference Book No 2 and 4, BEE India
Course Code: ESMDLO 1013
Course Name: Alternative Fuels
Credits: 04

Objectives
1. To understand socioeconomic and environment aspects of alternative fuels.
2. To get knowledge of production of alternative fuels.
3. To learn the need for fuel substitution and subsequent benefits.

Outcomes: Learner will be able to…
1. To distinguish between types of alternative fuels.
2. To determine the quality of biofuels.
3. To analyse the impact of alternative fuels on environment.

Module | Detailed Contents | Hrs.
--- | --- | ---
01 | **Fossil Fuels to Alternative Fuels**
Reserves of Fossil fuels in India and globe, Disadvantages of Fossil fuels, Need of Alternative fuels, Types, Advantages, Sources of Alternative fuels. | 10
02 | **Advanced Liquid Biofuels**
Raw material for biofuel production, Biomass and Waste, First and next generation biofuels, Conversion of lignocellulosic, algal biomass, and waste into biofuels and chemicals, Production of Biodiesel, Bio alcohol, Jatropha Fuel Applications. | 12
03 | **Advanced Gaseous Biofuels**
Bio-CNG from sugarcane, Synthetic gas SynGas, generation of SynGas through plasma gasification of plastic waste, Applications. | 08
04 | **Hydrogen Technology**
Hydrogen as Alternative fuel, Hydrogen storage, hydrogen liquefaction, ortho and para hydrogen, Non-fossil Natural gas and methane, Applications. | 08
05 | **Fuel Cells**
Principle & operation of Fuel cells, Thermodynamics of fuel cells, types of fuel cells, comparison of fuel cell technologies, stack configurations and fuel cell systems, Applications. | 08
06 | **Alternative Fuels and Environmental Impact**
Climate change, Benefits of alternative fuel to environment, Environmental impact assessment. | 06

Assessment:

**Internal:**
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4. Only Four questions need to be solved.

References:

8. Prabir Basu; *Biomass gasification and pyrolysis: Practical design and theory*; Elsevier, 2010
10. H S Mukunda, *Understanding Clean Energy and Fuels from Biomass*, Wiley India
### Course Code

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<tr>
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<th>Course Name</th>
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<tbody>
<tr>
<td>ESMDLO 1014</td>
<td>Energy Systems Modeling and Analysis</td>
<td>04</td>
</tr>
</tbody>
</table>

#### Objectives
1. To model and simulate the energy systems for performance improvement analysis.
2. To apply quantitative techniques for optimization of operating parameters in energy system.
3. To use economic techniques for energy model development.

#### Outcomes: Learner will be able to…
1. Understand model development process and its application in energy systems.
2. Apply quantitative technique in energy systems planning, operation and maintenance.
3. Simulate the conventional and sustainable energy systems.

#### Module | Detailed Contents | Hrs.
---|------------------|-------
01 | **Modeling overview** | Levels of analysis, steps in model development, examples of models, Need for Energy System Modeling. | 06 |
02 | **Quantitative techniques** | Interpolation-polynomial, Lagrangian, Curve fitting, regression analysis, solution of transcendental equations. | 08 |
05 | | Case studies of optimization in Energy systems problems. Dealing with uncertainty-probabilistic techniques. Trade-offs between capital & energy using Pinch Analysis | 08 |
06 | | Energy- Economy Models: Scenario Generation, Input Output Model | 06 |

#### Assessment:

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4. Only Four questions need to be solved.

References:

Course Code  
ILO 1011

Course Name  
Product Life Cycle Management

Credits  
03

Objectives:
1. To familiarize the students with the need, benefits and components of PLM
2. To acquaint students with Product Data Management & PLM strategies
3. To give insights into new product development program and guidelines for designing and developing a product
4. To familiarize the students with Virtual Product Development

Outcomes: Learner will be able to…
1. Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
2. Illustrate various approaches and techniques for designing and developing products.
3. Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
4. Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

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<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
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</table>
| 01     | **Introduction to Product Lifecycle Management (PLM):** Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications  
**PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy, Change management for PLM | 10 |
| 03     | **Product Data Management (PDM):** Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation | 05 |
| 04     | **Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies | 05 |
Assessment:

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REFERENCES:
### Objectives:
1. To familiarize the students with various aspects of probability theory
2. To acquaint the students with reliability and its concepts
3. To introduce the students to methods of estimating the system reliability of simple and complex systems
4. To understand the various aspects of Maintainability, Availability and FMEA procedure

### Outcomes:
Learner will be able to…
1. Apply the concept of Probability to engineering problems
2. Apply various reliability concepts to calculate different reliability parameters
3. Estimate the system reliability of simple and complex systems
4. Carry out a Failure Mode Effect and Criticality Analysis

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<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Probability theory:</strong> Probability: Standard definitions and concepts; Conditional Probability, Baye’s Theorem. <strong>Probability Distributions:</strong> Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. <strong>Measures of Dispersion:</strong> Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.</td>
<td>08</td>
</tr>
<tr>
<td>02</td>
<td><strong>Reliability Concepts:</strong> Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. <strong>Failure Data Analysis:</strong> Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions. <strong>Reliability Hazard Models:</strong> Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>System Reliability:</strong> System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.</td>
<td>05</td>
</tr>
<tr>
<td>04</td>
<td><strong>Reliability Improvement:</strong> Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td><strong>Maintainability and Availability:</strong> System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.</td>
<td>05</td>
</tr>
<tr>
<td>06</td>
<td><strong>Failure Mode, Effects and Criticality Analysis:</strong> Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fault tree analysis and Event tree Analysis</td>
<td>05</td>
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4. Only Four question need to be solved.

REFERENCES:
Objectives:
1. The course is blend of Management and Technical field.
2. Discuss the roles played by information technology in today’s business and define various technology architectures on which information systems are built.
3. Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage.
4. Identify the basic steps in systems development.

Outcomes: Learner will be able to…
1. Explain how information systems Transform Business.
2. Identify the impact information systems have on an organization.
4. Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making.
5. Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses.

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<tr>
<th>Module</th>
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<th>Hrs</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td>Introduction To Information Systems (IS): Computer Based Information Systems, Impact of IT on organizations, Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS.</td>
<td>4</td>
</tr>
<tr>
<td>02</td>
<td>Data and Knowledge Management: Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management. Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results</td>
<td>7</td>
</tr>
<tr>
<td>03</td>
<td>Ethical issues and Privacy: Information Security. Threat to IS, and Security Controls</td>
<td>7</td>
</tr>
<tr>
<td>05</td>
<td>Computer Networks Wired and Wireless technology, Pervasive computing, Cloud computing model.</td>
<td>6</td>
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REFERENCES:
1. Kelly Rainer, Brad Prince, Management Information Systems, Wiley
Course Code  | Course Name  | Credits
--- | --- | ---
ILO 1014  | Design of Experiments  | 03

Objectives:
1. To understand the issues and principles of Design of Experiments (DOE)
2. To list the guidelines for designing experiments
3. To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization

Outcomes: Learner will be able to…
1. Plan data collection, to turn data into information and to make decisions that lead to appropriate action
2. Apply the methods taught to real life situations
3. Plan, analyze, and interpret the results of experiments

<table>
<thead>
<tr>
<th>Module</th>
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</thead>
</table>
| 01 | Introduction  
1.1 Strategy of Experimentation  
1.2 Typical Applications of Experimental Design  
1.3 Guidelines for Designing Experiments  
1.4 Response Surface Methodology | 06 |
| 02 | Fitting Regression Models  
2.1 Linear Regression Models  
2.2 Estimation of the Parameters in Linear Regression Models  
2.3 Hypothesis Testing in Multiple Regression  
2.4 Confidence Intervals in Multiple Regression  
2.5 Prediction of new response observation  
2.6 Regression model diagnostics  
2.7 Testing for lack of fit | 08 |
| 03 | Two-Level Factorial Designs and Analysis  
3.1 The 2² Design  
3.2 The 2³ Design  
3.3 The General 2^k Design  
3.4 A Single Replicate of the 2^k Design  
3.5 The Addition of Center Points to the 2^k Design  
3.6 Blocking in the 2^k Factorial Design  
3.7 Split-Plot Designs | 07 |
| 04 | Two-Level Fractional Factorial Designs and Analysis  
4.1 The One-Half Fraction of the 2^k Design  
4.2 The One-Quarter Fraction of the 2^k Design  
4.3 The General 2^k-p Fractional Factorial Design  
4.4 Resolution III Designs  
4.5 Resolution IV and V Designs  
4.6 Fractional Factorial Split-Plot Designs | 07 |
| 05 | Conducting Tests  
5.1 Testing Logistics  
5.2 Statistical aspects of conducting tests  
5.3 Characteristics of good and bad data sets  
5.4 Example experiments  
5.5 Attribute Vs Variable data sets | 07 |
Assessment:

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REFERENCES:
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T.Voss
Objectives:
1. Formulate a real-world problem as a mathematical programming model.
2. Understand the mathematical tools that are needed to solve optimization problems.
3. Use mathematical software to solve the proposed models.

Outcomes: Learner will be able to…
1. Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
2. Perform sensitivity analysis to determine the direction and magnitude of change of a model’s optimal solution as the data change.
3. Solve specialized linear programming problems like the transportation and assignment problems, solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
4. Understand the applications of integer programming and a queuing model and compute important performance measures.

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<thead>
<tr>
<th>Module</th>
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</table>
| 01     | **Introduction to Operations Research:** Introduction, , Structure of the Mathematical Model, Limitations of Operations Research  
**Linear Programming:** Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method,  
**Duality, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis  
**Assignment Problem:** Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem  
**Integer Programming Problem:** Introduction, Types of Integer Programming Problems, Gomory’s cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms. | 14 |
| 02     | **Queuing models:** queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population | 05 |
| 03     | **Simulation:** Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation | 05 |
| 04     | **Dynamic programming.** Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothing, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems. | 05 |

Inventory Models: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model.

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REFERENCES:
Objectives:
1. To understand and identify different types cybercrime and cyber law
2. To recognized Indian IT Act 2008 and its latest amendments
3. To learn various types of security standards compliances

Outcomes: Learner will be able to…
1. Understand the concept of cybercrime and its effect on outside world
2. Interpret and apply IT law in various legal issues
3. Distinguish different aspects of cyber law
4. Apply Information Security Standards compliance during software design and development

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<tbody>
<tr>
<td>01</td>
<td><strong>Introduction to Cybercrime:</strong> Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.</td>
<td>4</td>
</tr>
<tr>
<td>03</td>
<td><strong>Tools and Methods Used in Cyberline</strong> Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)</td>
<td>6</td>
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<tr>
<td>05</td>
<td><strong>Indian IT Act.</strong> Cyber Crime and Criminal Justice: Penalties, Adjudication and Appeals Under the IT Act, 2000, IT Act. 2008 and its Amendments</td>
<td>6</td>
</tr>
<tr>
<td>06</td>
<td><strong>Information Security Standard compliances</strong> SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.</td>
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REFERENCES:
1. Nina Godbole, SunitBelapure, Cyber Security, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White Publications, Mumbai
5. Nina Godbole, Information Systems Security, Wiley India, New Delhi
8. Websites for more information is available on : The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
9. Website for more information , A Compliance Primer for IT professional : https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer-professionals-33538
### Course Information

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ILO 1017</td>
<td>Disaster Management and Mitigation Measures</td>
<td>03</td>
</tr>
</tbody>
</table>

#### Objectives:
1. To understand physics and various types of disaster occurring around the world
2. To identify extent and damaging capacity of a disaster
3. To study and understand the means of losses and methods to overcome/minimize it.
4. To understand role of individual and various organization during and after disaster
5. To understand application of GIS in the field of disaster management
6. To understand the emergency government response structures before, during and after disaster

#### Outcomes: Learner will be able to:
1. Get to know natural as well as manmade disaster and their extent and possible effects on the economy.
2. Plan of national importance structures based upon the previous history.
3. Get acquainted with government policies, acts and various organizational structure associated with an emergency.
4. Get to know the simple do’s and don’ts in such extreme events and act accordingly.

### Module Details

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
</tr>
</thead>
</table>
| 01     | **Introduction**  
1.1 Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change. | 03  |
| 02     | **Natural Disaster and Manmade disasters:**  
2.1 Natural Disaster: Meaning and nature of natural disaster, Flood, Flash flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion  
2.2 Manmade Disasters: Chemical, Industrial, Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters. | 09  |
| 03     | **Disaster Management, Policy and Administration**  
3.1 Disaster management: meaning, concept, importance, objective of disaster management policy, disaster risks in India, Paradigm shift in disaster management.  
3.2 Policy and administration:  
Importance and principles of disaster management policies, command and coordination of in disaster management, rescue operations-how to start with and how to proceed in due course of time, study of flowchart showing the entire process. | 06  |
| 04     | **Institutional Framework for Disaster Management in India:**  
4.1 Importance of public awareness, Preparation and execution of emergency management program. Scope and responsibilities of National Institute of Disaster Management (NIDM) and National disaster management authority (NDMA) in India. Methods and measures to avoid disasters, Management of casualties, set up of emergency facilities, importance of effective communication amongst different agencies in such situations.  
4.2 Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard. | 06  |
Financing Relief Measures:
5.1 Ways to raise finance for relief expenditure, role of government agencies and NGO’s in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO’s and the works they have carried out in the past on the occurrence of various disasters, Ways to approach these teams.
5.2 International relief aid agencies and their role in extreme events.

Preventive and Mitigation Measures:
6.1 Pre-disaster, during disaster and post-disaster measures in some events in general
6.2 Structural mapping: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication
6.3 Non Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans.
6.4 Do’s and don’ts in case of disasters and effective implementation of relief aids.

Assessment:

Internal:
Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:
Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.
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3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

REFERENCES:
5. ‘Disaster management & rehabilitation’ by RajdeepDasgupta, Mittal Publications, New Delhi.
6. ‘Natural Hazards and Disaster Management, Vulnerability and Mitigation – R B Singh, Rawat Publications
(Learners are expected to refer reports published at national and International level and updated information available on authentic web sites)
Objectives:
1. To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
2. To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management.
3. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Outcomes: Learner will be able to…
1. To identify and describe present state of energy security and its importance.
2. To identify and describe the basic principles and methodologies adopted in energy audit of an utility.
3. To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
4. To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities.
5. To analyze the data collected during performance evaluation and recommend energy saving measures.

<table>
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<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
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</thead>
<tbody>
<tr>
<td>02</td>
<td><strong>Energy Audit Principles:</strong> Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Benchmarking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring &amp; targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>Energy Management and Energy Conservation in Electrical System:</strong> Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings. <strong>Energy efficiency measures in lighting system, Lighting control:</strong> Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.</td>
<td>10</td>
</tr>
<tr>
<td>04</td>
<td><strong>Energy Management and Energy Conservation in Thermal Systems:</strong> Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.</td>
<td>10</td>
</tr>
<tr>
<td>05</td>
<td><strong>Energy Performance Assessment:</strong> On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.</td>
<td>04</td>
</tr>
</tbody>
</table>
Assessment:

Internal:
Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:
Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. **In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.**

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four question need to be solved.

REFERENCES:

1. Handbook of Electrical Installation Practice, Geoфry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
8. www.energymanagertraining.com
9. www.bee-india.nic.in
Simulation study using mathematical simulation software (or any programming language)

1. Study of Different Modeling Techniques practiced in Power Plant Engineering
2. Simulation study using Mathematical Simulation Software (or any programming language) on any two conventional power plants
3. Simulation study of any two non conventional power plant
4. Visit to Power Plant Control Room to Understand Automated Control System in Power Plant and prepare visit report.

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners
The following experiments are performed and readings must be entered in the energy audit report format.

1. Finding energy saving potential from specific power consumption and EER of Air conditioner.
2. Illuminance calculation and lighting design for an interior.
3. Centrifugal Pump efficiency calculation and ENCON opportunities.
4. 3-Φ/1- Φ motor loading calculation and ENCON opportunities.
5. Fan/Blower efficiency calculation and ENCON opportunities.
6. Performance testing of Air compressor and ENCON opportunities.
7. Leakage testing of Air compressor and ENCON opportunities.
8. Study of an Electricity bill and ENCON opportunities.

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners
Objectives
1. To collect and analyze the energy audit data effectively
2. To understand the mechanism of PAT cycle.
3. To become certified energy manager and auditor.

Outcomes: Learner will be able to...
1. Understand detailed energy auditing procedure and Distinguish between energy auditing stages.
2. Monitor and setting target of energy consumption.
3. Know the framework of PAT cycle and understand M&V audit
4. Carry out commercial energy audits.

<table>
<thead>
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<th>Hrs.</th>
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<tbody>
<tr>
<td>02</td>
<td><strong>Categories of Energy Manager and Auditor</strong>&lt;br&gt;Energy Manager (EM), Energy Auditor (EA) certification in India, Duties and responsibilities of EM and EA, Accredited Energy Auditor (AEA), Empanelled AEA, BEE (The manner and intervals of time for conduct of energy audit) Regulations, 2008.</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>Energy Monitoring and Targeting (EMT)</strong>&lt;br&gt;Definition of EMT, Elements of EMT system, Decision Making of EMT, Data information sources, Data analysis, Statistical representation of Energy consumption and Production, Least square method, Correlation &amp; regression, CUSUM technique.</td>
<td>10</td>
</tr>
<tr>
<td>04</td>
<td><strong>Perform, Achieve &amp; Trade (PAT) Cycle</strong>&lt;br&gt;Brief description of PAT (Perform, Achieve &amp; Trade) Cycle, Designated Consumer, Institutional framework for PAT, Role of each entity in PAT cycle, Activities and Responsibilities for PAT cycle, EScerts Issuance flow chart, Trading of EScerts.</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td><strong>Energy Audits in PAT cycle</strong>&lt;br&gt;Baseline Energy Audit, Definition of (Monitoring &amp; Verification) M &amp; V, Team formation for M&amp;V audit, Appointment and Role of Empanelled AEA, Documents required for M &amp; V, Gate to Gate Diagram for various industries, Verification process, Concept of Normalization in PAT, Need for Mandatory Energy Audit.</td>
<td>10</td>
</tr>
<tr>
<td>06</td>
<td><strong>Energy Audit in Commercial Sectors</strong>&lt;br&gt;Need of energy auditing in commercial sectors, energy audit in corporate buildings, educational institutes, Hospitals, Banks, Resorts, government buildings, Estimation of building load, steady state method, network method, numerical method, correlations, Calculation of energy saving potential by ENCON opportunities.</td>
<td>10</td>
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Assessment:

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University of Mumbai, ME (Mechanical) Energy Systems and Management, Rev 2016

ESMC201  Advances in Energy Management & Audit  04
End Semester Theory Examination:
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3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

References:

1. BEE Reference books: no.1/2/3/4
2. [http://beenet.gov.in](http://beenet.gov.in)
3. PAT booklet, BEE India
6. AmlanChakrabarti, Energy engineering and management, PHI Learning, New Delhi 2012
7. ShaligramPokharel, Energy Analysis for Planning and Policy, CRC Press, 2014
Objectives
1. To learn electrical and power systems.
2. To understand working principle of electrically assisted systems.
3. To identify saving potential in electrically assisted systems.

Outcomes: Learner will be able to…
1. Calculate losses in electrical and power systems and improve its energy efficiency.
2. Determine ENCON opportunities in electrical motor systems.
3. Determine ENCON opportunities in fluids handling systems.
4. Determine ENCON opportunities in lighting systems.

<table>
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<th>Module</th>
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<tbody>
<tr>
<td>01</td>
<td><strong>Electrical and Power System</strong>&lt;br&gt;Electric power supply, Transmission and Distribution Losses, Electricity Billing, Electrical Load Management, Power Factor Improvement, Transformers, Harmonics, Analysis of Electrical Power Systems, Maximum demand controllers. Automatic power factor controllers, Energy efficient transformers, Case study.</td>
<td>08</td>
</tr>
<tr>
<td>02</td>
<td><strong>Electrical Motors</strong>&lt;br&gt;Types, Characteristics &amp; Efficiency of Motors, Selection, Factors Affecting Energy Efficiency, Rewinding, Motor Load Survey Methodology, Energy efficient motors, Soft starters with energy saver, Variable speed drives, ENCON opportunities, Case study.</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>Fans, Blowers and Compressors</strong>&lt;br&gt;Difference between Fans, Blowers and Compressors, types, Flow control methods in fan, Fan performance evaluation, Types of compressor, Compressor Performance Evaluation, Compressed Air Systems &amp; their efficient operation, Compressor Capacity Assessment, ENCON opportunities, Case study.</td>
<td>12</td>
</tr>
<tr>
<td>04</td>
<td><strong>Refrigeration and HVAC system</strong>&lt;br&gt;Types of refrigeration system, components, Chilling plant, Selection and performance assessment of refrigeration plants, Factors affecting energy efficiency of refrigeration plants, ENCON opportunities, Case study.</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td><strong>Centrifugal Pumps &amp; Cooling Towers</strong>&lt;br&gt;Pump types, System &amp; pump characteristics, Pump Performance evaluation, Energy efficient pumping system operation, ENCON opportunities by Flow control methods in pumps, Use &amp; types of cooling tower, Performance evaluation, Energy efficient operation, Flow control methods, Case study.</td>
<td>10</td>
</tr>
<tr>
<td>06</td>
<td><strong>Lighting Systems</strong>&lt;br&gt;Terms in Lighting System, Lamp Types &amp; features, Recommended luminance Levels, Lighting Design calculations for Interiors, Lighting System Energy Efficiency Study Methodology, Energy Efficient Replacement Options, Electronic ballast, Occupancy sensors, Energy efficient lighting controls, Case Study.</td>
<td>06</td>
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4. Only Four questions need to be solved.

References:

2. Energy performance assessment for equipment & utility systems, Book 4, Bureau of Energy Efficiency India
3. Electrical energy conservation modules of AIP-NPC, Chennai
4. PCRA Publications on Compressed Air System
5. Technology Menu for Energy Efficiency (NPC)
6. ASHRAE Hand Book
7. British Pump Manufacturers' Association Catalogue
Objectives
1. To understand the concept of sustainable development.
2. To know the economics of renewable energy and financing options.
3. To determine role of renewable energy in upcoming projects.

Outcomes: Learner will be able to...
1. Know sustainability initiatives for reducing energy impacts on environment.
2. Understand the role of renewable energy in climate change.
3. Determine the efficient solar and wind energy technology.
4. Know the current trends in sustainable and renewable energy.

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<tr>
<td>01</td>
<td><strong>Sustainable Energy &amp; Environment</strong>&lt;br&gt;Sustainable Development, Energy technologies promoting sustainability, Environmental impacts, Economic and social considerations, Financing mechanisms, Carbon credits, clean development mechanisms, Climate change, COP21.</td>
<td>08</td>
</tr>
<tr>
<td>02</td>
<td><strong>Renewable Energy</strong>&lt;br&gt;Potential of renewable energy sources, renewable electricity and key elements, Global climate change, CO2 reduction potential of renewable energy.</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>Solar Energy Technology</strong>&lt;br&gt;Solar thermal power plants (Concentrators, solar chimney etc.), Solar thermal conversion devices, Economics and social considerations, Design considerations of component selection, CSP (Concentrated Solar Power) advanced materials. Solar photovoltaic power plants, photovoltaic technology, Design of a photovoltaic system, economics and costing, Application as a distributed power supply strategy.</td>
<td>12</td>
</tr>
<tr>
<td>04</td>
<td><strong>Wind Power Technology</strong>&lt;br&gt;Wind energy potential measurement, wind mill component design, economics and demand side management, energy wheeling, and energy banking concepts.</td>
<td>07</td>
</tr>
<tr>
<td>05</td>
<td><strong>Biogas Energy</strong>&lt;br&gt;Aerobic and anaerobic bio-conversion processes, microbial reactions purification, properties of biogas. Storage and enrichment, Biogas energy economics.</td>
<td>07</td>
</tr>
<tr>
<td>06</td>
<td><strong>Current Trends in Renewable &amp; Sustainable Energy</strong>&lt;br&gt;Fuel cell based power plants, tidal and wave energy plant design, OTEC power plants. Geothermal energy: hot springs and steam ejection site selection, Renewable energy Financing criteria, Net Metering, Solar cities, Role of energy in smart cities.</td>
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References:

**Objectives**

1. To understand the working principle of energy storage systems.
2. To identify and select the efficient energy storage systems.
3. To find suitable application of storage system.

**Outcomes:** Learner will be able to...

1. Distinguish between different modes of energy storage.
2. Know the working principle and selection of Energy Storage System.

<table>
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<tr>
<th>Module</th>
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<th>Hrs.</th>
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</table>
| 01     | **Energy Storage**
Need of energy storage; Different modes of Energy Storage.
Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels. Hydrogen for energy storage. Solar Ponds for energy storage. | 12   |
| 02     | **Electrochemical Energy Storage Systems**
Batteries: Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon Nano-tubes in electrodes. | 08   |
| 03     | **Magnetic and Electric Energy Storage Systems**
Superconducting Magnet Energy Storage(SMES) systems; Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor(EDLC), principle of working, structure, performance and application, role of activatedCarbon and carbon Nano-tube (CNT). | 09   |
| 04     | **Sensible Heat Storage**
SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers; Heat storage in SHS systems; Aquifers storage. | 08   |
| 05     | **Latent Heat Thermal Energy Storage**
Phase Change Materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and air-conditioning systems; Enthalpy formulation; Numerical heat transfer in melting and freezing process. | 09   |
| 06     | **Application of Energy Storage**
Food preservation; Waste heat recovery; Solar energy storage; Greenhouse heating; Power plant applications; Drying and heating for process industries. | 06   |
Assessment:

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<tbody>
<tr>
<td>ESMDLO2022</td>
<td>Fuels Combustion and Emission Control</td>
<td>04</td>
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</tbody>
</table>

**Objectives**
1. To give an idea about types of fuels, origin, reserves and their processing.
2. To define the combustion and conversion process of fuels.
3. To analyze the impact of incomplete combustion, emission on environment.

**Outcomes:** Learner will be able to…
1. Distinguish between conventional, non-conventional and nuclear fuels.
2. Understand the types and production process of fuels.
3. Determine the requirements for complete combustion process.
4. Analyse the effects of emission control

<table>
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<tbody>
<tr>
<td>01</td>
<td><strong>Introduction to Fuels</strong></td>
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<tr>
<td></td>
<td>Types of fuels, commercial and non-commercial fuels, Principle fuels for energy conversion: Fossil fuels, Nuclear fuels, RDF, Bio-fuels</td>
<td>05</td>
</tr>
<tr>
<td>02</td>
<td><strong>Solid Fuels</strong></td>
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<tr>
<td></td>
<td>Different types of solid fuels, Family of coal, origin of coal, composition of coal, analysis and properties of coal, action of heat on coal, oxidation of coal, hydrogenation of coal, classification of Indian coal, Storage of coal, carbonization, gasification and liquefaction and pulverization of solid fuels.</td>
<td>09</td>
</tr>
<tr>
<td>03</td>
<td><strong>Liquid Fuels</strong></td>
<td></td>
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<tr>
<td></td>
<td>Introduction to Petroleum, origin of petroleum, petroleum production, composition and classification, processing of petroleum, Important petroleum products, properties of petroleum products, liquid fuels from sources other than petroleum, storage and handling of liquid fuels, gasification of liquid fuels, petroleum refining in India.</td>
<td>09</td>
</tr>
<tr>
<td>04</td>
<td><strong>Gaseous Fuels</strong></td>
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<td></td>
<td>Classification of gaseous fuels based on mode of occurrence and method of production, cleaning and purification of gaseous fuels. Hydrogen as energy carrier</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td><strong>Combustion of Fuels</strong></td>
<td></td>
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<tr>
<td>06</td>
<td><strong>Emission control</strong></td>
<td></td>
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<tr>
<td></td>
<td>Introduction, atmosphere, Emission control methods. Quantification of emissions.</td>
<td>06</td>
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**Assessment:**

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4. Only Four questions need to be solved

**References:**

Objectives
1. To identify and select the correct instruments for related parameters
2. To learn the operation of automatic control systems.
3. To train about the handling and maintenance of energy measurement instruments

Outcomes: Learner will be able to…
1. To understand the basic measurement concepts and principles.
2. To learn the methods of measuring the process parameters.
3. To understand techniques of measuring energy system parameters.
4. To learn selection of proper instrument for concerned measurement.

<table>
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<tr>
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<tbody>
<tr>
<td>01</td>
<td>Measurement Concepts</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Introduction to measurements for scientific and engineering application need and goal. Broad category of methods for measuring field and derived quantities. Principles of measurement, parameter estimation, regression analysis, correlations, error estimation and data presentation, analysis of data</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>Process Parameter Measurement</td>
<td>09</td>
</tr>
<tr>
<td></td>
<td>Measurement of field quantities, measurement of force, pressure, temperature, flow rate, velocity, humidity, noise, vibration, measurement by probe and non-destructive techniques, Name, Make and Specification of Instruments.</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>Measurement of derived quantities, torque, power, thermo physical properties, radiation and surface properties, Name, Make and Specification of Instruments.</td>
<td>09</td>
</tr>
<tr>
<td>04</td>
<td>Automatic Control Systems</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Control Room Equipment, PLCs and other logic devices, Analytical instrumentation,</td>
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<tr>
<td>05</td>
<td>Instrument Selection and Commissioning</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>General considerations, Control valve selection and sizing, Regulators and final control elements, Limits, Margins and their Relevance to Instrumentation and control, Control Centers, Fire and Safety Instruments</td>
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</tr>
<tr>
<td>06</td>
<td>Instruments in Energy Auditing</td>
<td>04</td>
</tr>
<tr>
<td></td>
<td>Need of measurement, electrical, mechanical, thermal, chemical, fluid measurement, types of instruments, handling of instruments on site and off site, care of instruments, calibration.</td>
<td></td>
</tr>
</tbody>
</table>

Assessment:

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2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved

References:

5. Johnson C.D., Process Control Instrumentation
Objectives
1. To understand impact of energy systems on environment.
2. To know the pollution control techniques.
3. To recite energy and environment policies.

Outcomes: Learner will be able to…
1. Determine the impact of pollutants on atmosphere.
2. Propose the pollution control systems in energy systems.
3. Understand International and Indian environment policies.
4. Calculate the effect of energy efficiency on global climate change.

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Effect of Energy Systems on Environment</strong> Environmental degradation due to energy production and utilization, Primary and Secondary pollution such as SOx, NOx, SPM in air, Depletion of ozone layer, global warming, Physiological and health problems due to energy plants. Methods of Environmental Impact Assessment.</td>
<td>08</td>
</tr>
<tr>
<td>02</td>
<td><strong>Water, Air and Land Pollution</strong> Sources of Pollution in thermal power plant, Water, air, land pollution due to estimation for thermal power plant. Environmental pollution limits guidelines for thermal power plant pollution control, Water pollution in thermal power plant, physical and chemical methods of pollution control, Measurement and effects of land pollution, Pollution control systems. Hydrothermal plant environmental assessment, Nuclear power plants and environmental pollution, pollution control measures.</td>
<td>10</td>
</tr>
<tr>
<td>03</td>
<td><strong>Pollution due to Automobile &amp; Utilities</strong> Pollution due to automobile and utilities, Methods to Control emission from Vehicle, Boilers &amp; Furnaces., International Standards for Quality of air and norms for exhaust gases. Software advantage &amp; disadvantage in automobile pollution inspection.</td>
<td>08</td>
</tr>
<tr>
<td>04</td>
<td><strong>Energy Recovery from Industrial and Urban Waste</strong> Industrial waste, Waste and effluent treatment plants, Industrial, domestic and solid waste as a source of energy, Water treatment plant in housing societies.</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td><strong>Environmental and Pollution Control Policies</strong> United Nations Framework Convention on Climate Change (UNFCC), IPCC, Conference of Parties (COP), COP 21 Accord, Clean Development Mechanism (CDM), Prototype Carbon Funds (PCF) Carbon Credits and it’s trading, Benefits to developing countries, Building a CDM project in India.</td>
<td>08</td>
</tr>
<tr>
<td>06</td>
<td><strong>Energy Efficiency and Global Climate Change</strong> Global Environmental Issues, Acid rain, Loss of Biodiversity, Ozone layer depletion, Global Warming Potential (GWP), Global warming &amp; Climate change Impact, India’s Green House Gases Emission.</td>
<td>10</td>
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4. Only Four questions need to be solved

References:

2. Energy Management and Control Systems M.C.Macedo Jr. (John Wiley and Sons)
6. BEE Reference book: no.1
10. http://beeindia.gov.in
## Course Details

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILO 2021</td>
<td>Project Management</td>
<td>03</td>
</tr>
</tbody>
</table>

### Objectives:
1. To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.
2. To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.

### Outcomes:
Learner will be able to…
1. Apply selection criteria and select an appropriate project from different options.
2. Write work breakdown structure for a project and develop a schedule based on it.
3. Identify opportunities and threats to the project and decide an approach to deal with them strategically.
4. Use Earned value technique and determine & predict status of the project.
5. Capture lessons learned during project phases and document them for future reference.

### Detailed Table

<table>
<thead>
<tr>
<th>Module</th>
<th>Project Management Foundation:</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical &amp; atypical) Project phases and stage gate process. Role of project manager. Negotiations and resolving conflicts. Project management in various organization structures. PM knowledge areas as per Project Management Institute (PMI).</td>
<td>5</td>
</tr>
<tr>
<td>02</td>
<td>Initiating Projects: How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development &amp; growth (forming, storming, norming &amp; performing), team dynamics.</td>
<td>6</td>
</tr>
<tr>
<td>03</td>
<td>Project Planning and Scheduling: Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart. Introduction to Project Management Information System (PMIS).</td>
<td>8</td>
</tr>
<tr>
<td>05</td>
<td>5.1 Executing Projects: Planning monitoring and controlling cycle. Information needs and reporting, engaging with all stakeholders of the projects. Team management, communication and project meetings. 5.2 Monitoring and Controlling Projects: Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep. Project audit. 5.3 Project Contracting: Project procurement management, contracting and outsourcing.</td>
<td>8</td>
</tr>
<tr>
<td>06</td>
<td>6.1 Project Leadership and Ethics: Introduction to project leadership, ethics in projects. Multicultural and virtual projects. 6.2 Closing the Project: Customer acceptance; Reasons of project termination, Various types of project</td>
<td>6</td>
</tr>
</tbody>
</table>
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References:
1. Jack Meredith & Samuel Mantel, Project Management: A managerial approach, Wiley India, 7th Ed.
4. Gopalan, Project Management, , Wiley India
### Course Details

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<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILO 2022</td>
<td>Finance Management</td>
<td>03</td>
</tr>
</tbody>
</table>

**Objectives:**

1. Overview of Indian financial system, instruments and market
2. Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
3. Knowledge about sources of finance, capital structure, dividend policy

**Outcomes:** Learner will be able to…

1. Understand Indian finance system and corporate finance
2. Take investment, finance as well as dividend decisions

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
</tr>
</thead>
</table>
| 01     | **Overview of Indian Financial System:** Characteristics, Components and Functions of Financial System.  
       | **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills.  
       | **Financial Markets:** Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market  
       | **Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges | 06 |
| 02     | **Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio.  
       | **Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting. | 06 |
| 03     | **Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision.  
       | **Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis. | 09 |
| 04     | **Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value (NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR)  
       | **Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity’s Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities. | 10 |
| 05     | **Sources of Finance:** Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance.  
       | **Capital Structure:** Factors Affecting an Entity’s Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure | 05 |
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<tbody>
<tr>
<td>ILO2023</td>
<td>Entrepreneurship Development and Management</td>
<td>03</td>
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</tbody>
</table>

#### Objectives:

1. To acquaint with entrepreneurship and management of business
2. Understand Indian environment for entrepreneurship
3. Idea of EDP, MSME

#### Outcomes:

1. Understand the concept of business plan and ownerships
2. Interpret key regulations and legal aspects of entrepreneurship in India
3. Understand government policies for entrepreneurs

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<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
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<tbody>
<tr>
<td>01</td>
<td>Overview Of Entrepreneurship: Definitions, Roles and Functions/Values of</td>
<td>04</td>
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<td></td>
<td>Entrepreneurship, History of Entrepreneurship Development, Role of</td>
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<td></td>
<td>Entrepreneurship in the National Economy, Functions of an Entrepreneur,</td>
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<td></td>
<td>Entrepreneurship and Forms of Business Ownership</td>
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<td></td>
<td>Role of Money and Capital Markets in Entrepreneurial Development: Contribution of</td>
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<td>Government Agencies in Sourcing information for Entrepreneurship</td>
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<tr>
<td>02</td>
<td>Business Plans And Importance Of Capital To Entrepreneurship: Preliminary and</td>
<td>09</td>
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<tr>
<td></td>
<td>Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as</td>
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<td></td>
<td>Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks,</td>
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<td></td>
<td>Assumptions and Conclusion, Capital and its Importance to the Entrepreneur</td>
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<td></td>
<td>Entrepreneurship And Business Development: Starting a New Business, Buying an</td>
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<td></td>
<td>Existing Business, New Product Development, Business Growth and the Entrepreneur</td>
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<td></td>
<td>Law and its Relevance to Business Operations</td>
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<tr>
<td>03</td>
<td>Women’s Entrepreneurship Development, Social entrepreneurship-role and need,</td>
<td>05</td>
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<tr>
<td></td>
<td>EDP cell, role of sustainability and sustainable development for SMEs, case studies,</td>
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<td></td>
<td>exercises</td>
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<td>04</td>
<td>Indian Environment for Entrepreneurship: key regulations and legal aspects,</td>
<td>08</td>
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<td>MSMED Act 2006 and its implications, schemes and policies of the Ministry of</td>
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<td>MSME, role and responsibilities of various government organisations, departments,</td>
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<td></td>
<td>banks etc., Role of State governments in terms of infrastructure developments and</td>
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<td>support etc., Public private partnerships, National Skill development Mission,</td>
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<td>Credit Guarantee Fund, PMEGP, discussions, group exercises etc</td>
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<td>05</td>
<td>Effective Management of Business: Issues and problems faced by micro and small</td>
<td>08</td>
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<td></td>
<td>enterprises and effective management of M and S enterprises (risk management,</td>
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<td></td>
<td>credit availability, technology innovation, supply chain management, linkage with</td>
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<td>large industries), exercises, e-Marketing</td>
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<tr>
<td>06</td>
<td>Achieving Success In The Small Business: Stages of the small business life cycle,</td>
<td>05</td>
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<td>four types of firm-level growth strategies, Options – harvesting or closing small</td>
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<td></td>
<td>business Critical Success factors of small business</td>
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References:
1. PoornimaCharantimath, Entrepreneurship development- Small Business Enterprise, Pearson
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr CN Prasad, Small and Medium Enterprises in Global Perspective, New century Publications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. MaddhurimaLall, ShikahSahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
10. LaghuUdyogSamachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in
Objectives:
1. To introduce the students with basic concepts, techniques and practices of the human resource management.
2. To provide opportunity of learning Human resource management (HRM) processes, related with the functions, and challenges in the emerging perspective of today’s organizations.
3. To familiarize the students about the latest developments, trends & different aspects of HRM.
4. To acquaint the student with the importance of inter-personal & inter-group behavioral skills in an organizational setting required for future stable engineers, leaders and managers.

Outcomes: Learner will be able to…
1. Understand the concepts, aspects, techniques and practices of the human resource management.
2. Understand the Human resource management (HRM) processes, functions, changes and challenges in today’s emerging organizational perspective.
3. Gain knowledge about the latest developments and trends in HRM.
4. Apply the knowledge of behavioral skills learnt and integrate it with in inter personal and intergroup environment emerging as future stable engineers and managers.

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td>Introduction to HR</td>
<td>5</td>
</tr>
</tbody>
</table>
|        | • Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions.  
        | • Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues. |     |
| 02     | Organizational Behavior (OB) | 7   |
|        | • Introduction to OB Origin, Nature and Scope of Organizational Behavior, Relevance to Organizational Effectiveness and Contemporary issues  
        | • Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness  
        | • Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behavior.  
        | • Motivation: Theories of Motivation and their Applications for Behavioral Change (Maslow, Herzberg, McGregor);  
        | • Group Behavior and Group Dynamics: Work groups formal and informal groups and stages of group development. Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team.  
        | • Case study |     |
| 03     | Organizational Structure &Design | 6   |
|        | • Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress.  
        | • Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership.  
        | • Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies. |     |
| 04     | Human resource Planning | 5   |
|        | • Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale. |     |
Training & Development: Identification of Training Needs, Training Methods

Emerging Trends in HR
Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development, managing processes & transformation in HR. Organizational Change, Culture, Environment
Cross Cultural Leadership and Decision Making: Cross Cultural Communication and diversity at work, Causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation.

05

HR & MIS
Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries
Strategic HRM
Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals
Labor Laws & Industrial Relations
Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act

06

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<tbody>
<tr>
<td>ILO2025</td>
<td>Professional Ethics and Corporate Social Responsibility (CSR)</td>
<td>03</td>
</tr>
</tbody>
</table>

**Objectives:**
1. To understand professional ethics in business
2. To recognized corporate social responsibility

**Outcomes:** Learner will be able to…
1. Understand rights and duties of business
2. Distinguish different aspects of corporate social responsibility
3. Demonstrate professional ethics
4. Understand legal aspects of corporate social responsibility

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Professional Ethics and Business:</strong> The Nature of Business Ethics; Ethical Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business</td>
<td>04</td>
</tr>
<tr>
<td>02</td>
<td><strong>Professional Ethics in the Marketplace:</strong> Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy <strong>Professional Ethics and the Environment:</strong> Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>Professional Ethics of Consumer Protection:</strong> Markets and Consumer Protection; Contract View of Business Firm’s Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy <strong>Professional Ethics of Job Discrimination:</strong> Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.</td>
<td>06</td>
</tr>
<tr>
<td>04</td>
<td><strong>Introduction to Corporate Social Responsibility:</strong> Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India</td>
<td>05</td>
</tr>
<tr>
<td>05</td>
<td><strong>Corporate Social Responsibility:</strong> Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India</td>
<td>08</td>
</tr>
<tr>
<td>06</td>
<td><strong>Corporate Social Responsibility in Globalizing India:</strong> Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.</td>
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References:

1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer.
**Course Code**: ILO2026  
**Course Name**: Research Methodology  
**Credits**: 03

### Objectives:
1. To understand Research and Research Process  
2. To acquaint students with identifying problems for research and develop research strategies  
3. To familiarize students with the techniques of data collection, analysis of data and interpretation

### Outcomes:
1. Prepare a preliminary research design for projects in their subject matter areas  
2. Accurately collect, analyze and report data  
3. Present complex data or situations clearly  
4. Review and analyze research findings

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs</th>
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</table>
| 01     | **Introduction and Basic Research Concepts**  
|        | 1.1 Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology  
|        | 1.2 Need of Research in Business and Social Sciences  
|        | 1.3 Objectives of Research  
|        | 1.4 Issues and Problems in Research  
|        | 1.5 Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical | 09 |
| 02     | **Types of Research**  
|        | 2.1. Basic Research  
|        | 2.2. Applied Research  
|        | 2.3. Descriptive Research  
|        | 2.4. Analytical Research  
|        | 2.5. Empirical Research  
|        | 2.6 Qualitative and Quantitative Approaches | 07 |
| 03     | **Research Design and Sample Design**  
|        | 3.1 Research Design – Meaning, Types and Significance  
|        | 3.2 Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors | 07 |
| 04     | **Research Methodology**  
|        | 4.1 Meaning of Research Methodology  
|        | 4.2. Stages in Scientific Research Process:  
|        | a. Identification and Selection of Research Problem  
|        | b. Formulation of Research Problem  
|        | c. Review of Literature  
|        | d. Formulation of Hypothesis  
|        | e. Formulation of research Design  
|        | f. Sample Design  
|        | g. Data Collection  
|        | h. Data Analysis  
|        | i. Hypothesis testing and Interpretation of Data  
|        | j. Preparation of Research Report | 08 |
| 05     | **Formulating Research Problem**  
|        | 5.1 Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis | 04 |
| 06     | **Outcome of Research**  
|        | 6.1 Preparation of the report on conclusion reached  
|        | 6.2 Validity Testing & Ethical Issues  
|        | 6.3 Suggestions and Recommendation | 04 |
Assessment:
Internal:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum Two Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:
Some guidelines for setting up the question paper. Minimum 80% syllabus should be covered in question papers of end semester examination. In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of total six question
2. All question carry equal marks
3. Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

References:
Course Code | Course Name | Credits
---|---|---
ILO2027 | IPR and Patenting | 03

**Objectives:**
1. To understand intellectual property rights protection system
2. To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures
3. To get acquaintance with Patent search and patent filing procedure and applications

**Outcomes:** Learner will be able to…
1. understand Intellectual Property assets
2. assist individuals and organizations in capacity building
3. work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

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<tr>
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<tbody>
<tr>
<td>01</td>
<td><strong>Introduction to Intellectual Property Rights (IPR):</strong> Meaning of IPR, Different category of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc.</td>
<td>05</td>
</tr>
<tr>
<td>02</td>
<td><strong>Importance of IPR in Modern Global Economic Environment:</strong> Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development</td>
<td>07</td>
</tr>
<tr>
<td>03</td>
<td><strong>Enforcement of Intellectual Property Rights:</strong> Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) active in IPR enforcement</td>
<td>05</td>
</tr>
<tr>
<td>04</td>
<td><strong>Indian Scenario of IPR:</strong> Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.</td>
<td>05</td>
</tr>
<tr>
<td>05</td>
<td><strong>Emerging Issues in IPR:</strong> Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.</td>
<td>05</td>
</tr>
<tr>
<td>06</td>
<td><strong>Basics of Patents:</strong> Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent</td>
<td>07</td>
</tr>
<tr>
<td>07</td>
<td><strong>Patent Rules:</strong> Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)</td>
<td>08</td>
</tr>
<tr>
<td>09</td>
<td><strong>Patent databases:</strong> Important websites, Searching international databases</td>
<td>05</td>
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<tr>
<td>1</td>
<td>Introduction to Digital Business- Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts. Difference between physical economy and digital economy, Drivers of digital business- Big Data &amp; Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things(digitally intelligent machines/services) Opportunities and Challenges in Digital Business,</td>
<td>09</td>
</tr>
<tr>
<td>2</td>
<td>Overview of E-Commerce E-Commerce- Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals Other E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC</td>
<td>06</td>
</tr>
<tr>
<td>3</td>
<td>Digital Business Support services: ERP as e –business backbone, knowledge Top Apps, Information and referral system Application Development: Building Digital business Applications and Infrastructure</td>
<td>06</td>
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References:
2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
6. Trend and Challenges in Digital Business Innovation, Vinocenzo Morabito, Springer
7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan
8. E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance
Objectives:
1. Understand and identify environmental issues relevant to India and global concerns
2. Learn concepts of ecology
3. Familiarise environment related legislations

Outcomes: Learner will be able to…
1. Understand the concept of environmental management
2. Understand ecosystem and interdependence, food chain etc.
3. Understand and interpret environment related legislations

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<td>01</td>
<td>Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities. Environmental issues relevant to India, Sustainable Development, The Energy scenario.</td>
<td>10</td>
</tr>
<tr>
<td>02</td>
<td>Global Environmental concerns: Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.</td>
<td>06</td>
</tr>
<tr>
<td>03</td>
<td>Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.</td>
<td>05</td>
</tr>
<tr>
<td>04</td>
<td>Scope of Environment Management, Role &amp; functions of Government as a planning and regulating agency. Environment Quality Management and Corporate Environmental Responsibility</td>
<td>10</td>
</tr>
<tr>
<td>05</td>
<td>Total Quality Environmental Management, ISO-14000, EMS certification.</td>
<td>05</td>
</tr>
<tr>
<td>06</td>
<td>General overview of major legislations like Environment Protection Act, Air (P &amp; CP) Act, Water (P &amp; CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.</td>
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4. Only Four questions need to be solved.
References:
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
The laboratory will focus on the following,

1. Measurement of solar radiation and sunshine hours
2. Measurement of albedo, UV & IR radiation
3. Measurement of emissivity, reflectivity, transmittivity
4. Performance testing of solar flat plate water heater (forced flow & thermosyphon systems)
5. Performance testing solar air heater & dryer & desalination unit
6. Performance testing of solar thermal concentrators
7. Characteristics of photovoltaic devices & testing of solar PV operated pump
8. Testing of Gasifier or Wind machines or Fuel cell

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners
Course Code | Course Name | Credits
--- | --- | ---
ESML202 | Measurement & Virtual Instrumentation Lab | 01

**Topic**

I. Study of sensor characteristics, selection, calibration and measurement of minimum 05 mechanical parameters such as flow, load, pressure, speed and temperature

II. **Virtual Instrumentation (VI)**

   a. Simulation of any system with Virtual Instrumentation environment using any suitable software

   b. Interfacing of sensors used for measuring above mentioned parameters in I with VI software and measurement of these parameters on any laboratory model or actual working system

III. **Demonstration of interfacing of VI software with suitable generic hardware**

**Assessment:**

**End Semester Examination:** Practical/Oral examination is to be conducted by pair of internal and external examiners
Guidelines for Seminar
  o Seminar should be based on thrust areas in Mechanical Engineering (Energy Systems and Management aspect is appreciated)
  o Students should do literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor. Students should use multiple literature and understand the topic and compile the report in standard format as per University Guidelines for report writing and present in front of Panel of Examiners appointed by the Head of the Department/Institute of respective Programme.
  o Seminar should be assessed jointly by the pair of Internal and External Examiners
  o Seminar should be assessed based on following points
    ▪ Quality of Literature survey and Novelty in the topic
    ▪ Relevance to the specialization
    ▪ Understanding of the topic
    ▪ Quality of Written and Oral Presentation
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<tbody>
<tr>
<td>ESMD301/ESMD401</td>
<td>Dissertation (I and II)</td>
<td>12 + 15</td>
</tr>
</tbody>
</table>

**Guidelines for Dissertation**

- Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format.

**Guidelines for Assessment of Dissertation I**

- Dissertation I should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization
  - Clarity of objective and scope

- Dissertation I should be assessed through a presentation by a panel of internal examiners appointed by the Head of the Department/Institute of respective Programme.

**Guidelines for Assessment of Dissertation II**

- Dissertation II should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization or current Research / Industrial trends
  - Clarity of objective and scope
  - Quality of work attempted
  - Validation of results
  - Quality of Written and Oral Presentation

- Dissertation II should be assessed through a presentation jointly by Internal and External Examiners appointed by the University of Mumbai

Students should publish at least ONE paper based on the work in reputed International / National Conference/Journal (desirably in Refereed Journal).

**Dissertation Report has to be prepared strictly as per University of Mumbai report writing guidelines.**