Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Semester-VI

Third Year Sixth Semester							
Sl. No.	**Category**	**Subject Code**	**Subject Name**	**Total Number of contact hours**			**Credits**
				L	**T**	**P**	
Theory							
1	Professional Core courses	PC-ME601	Manufacturing Technology	4	0	0	4
2	Professional Core courses	PC-ME602	Design of Machine Elements	3	1	0	4
3	Professional Elective courses	PE-ME601	Elective-I	3	0	0	3
4	Professional Elective courses	PE-ME602	Elective-II	3	0	0	3
5	Humanities and Social Sciences including Management courses	HM-HU601	Humanities II (Operations Research)	3	0	0	3
6	Mandatory courses	MC601	Constitution of India	-	2	-	0
	Total Theory			**16**	**3**	**0**	**17**
Practical/ Sessional							
1	Professional Core courses	PC-ME691	Mechanical Engineering Laboratory (Design) II	0	0	3	1.5
2	Project (or Summer internship)	PW-ME681	Project-II (90 hrs. Total)	0	0	4	2
	Total Practical			**0**	**0**	**7**	**3.5**
	Total of Sixth Semester			**16**	**3**	**7**	**20.5**

Two papers for (Professional Elective Courses- Elective I and II, that is, PE-ME601 and PE-ME602) are to be chosen among the List of Professional Elective Papers.

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Subject Code : PC-ME601	**Category:** Professional Core Courses
Subject Name : Manufacturing Technology	**Semester**: Sixth
L-T-P: **4-0-0**	**Credit: 4**
Pre-Requisites: Primary Manufacturing Processes	

Course Objectives:

To impart knowledge to make students able to demonstrate the tooling needed for manufacturing, the dimensional accuracy and tolerances of products, assembly of different components. Also students will be able to understand the principles of working of NC, CNC machine tools and rapid prototyping.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Tooling for conventional and non-conventional machining processes: Mould and die design, Press tools, Cutting tools; Holding tools: Jigs and fixtures, principles, applications and design; Press tools: Configuration, design of die and punch; principles of forging die design.	12
2	Metrology: Metrology in tool wear and part quality including surface integrity, alignment and testing methods; tolerance analysis in manufacturing and assembly. Process metrology for emerging machining processes such as micro-scale machining, Inspection and workpiece quality.	8
3	Assembly practices: Manufacturing and assembly, process planning, selective assembly, Material handling and devices.	6
4	**NC/CNC Machine Tools and Systems** Types of automation: Fixed (or hard) and programmable (or flexible); need, advantages and applications of flexible automation over fixed automation. **Components and Their Functions in NC/CNC Machines** MCU, DPU and CLU, Feed drives using stepper/ servo motors and recirculating ball screw-nut system, Automatic Tool Changers- Tool Turret and Tool Magazine, Automatic pallet Changer. **Basic systems of NC and CNC machines** Coordinate system, Control– open loop and closed loop, Dimensioning– absolute and incremental, Point–to–point and contour motion, Linear and circular Interpolation. **CNC Machine Tools and Integrated Automation** Structure and working principle of CNC lathe, milling machine,	8

	Examples and use of CNC machines, Machining Centre (Vertical and Horizontal), Integrated Automation systems (DNC- Direct and Distributed or BTR and Dedicated system, FMS- FFMS, FMC and FMM)– characteristics and applications.	
5	**Part Programming for CNC machines** Manual Part Programming using ISO G and M Codes in CNC lathe and milling machine for simple jobs, Canned cycle. Computer Aided Part Programming using MACRO statements in APT for simple jobs in CNC lathe and milling machine.	8
6	**Rapid Prototyping** Overview of Rapid Prototyping, Basic Process- CAD Model Creation, Conversion to STL format, Slicing the STL File, Layer by layer construction. Use of CMM and 3-D Camera for making virtual model. Principles, systems, relative advantages and applications of the common RP methods, such as Stereo lithography (SLG), Selective laser sintering (SLS), Fused deposition modelling (FDM), Laminated objects manufacturing (LOM), 3-D Printing**.**	6

Course Outcomes:

1. To describe machines and related tools for manufacturing various components.
2. To understand the relationship between process and system in manufacturing domain.
3. To experiment on CNC machine tools.
4. To demonstrate rapid prototyping methods.

Learning Resources:

1. S. Kalpakjian and S.R. Schmid, Manufacturing Processes for Engineering Materials, 5th Edition, Pearson India, 2014.
2. R.K. Jain, Engineering Metrology, 21st Edition, Khanna Publication, New Delhi, 1984.
3. P.N. Rao, N.K. Tewari and T.K. Kundra, Computer Aided Manufacturing, McGraw Hill, 2017.
4. Y. Koren, Computer Control of Manufacturing Systems, McGraw Hill, 1986.
5. M.P. Grover, Fundamentals of Modern Manufacturing, 3rd Edition, Wiley.
6. M.P. Groover, Automation, Production Systems and CIM, Prentice Hall.
7. A. Ghosh & A.K. Mullick, Manufacturing Science, EW Press.
8. A. Ghosh, Rapid Prototyping, EW Press.

Maulana Abul Kalam Azad University of Technology, West Bengal

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : PC-ME602	**Category:** Professional Core Courses
Subject Name : Design of Machine Elements	**Semester** : Sixth
L-T-P : 3-1-0	**Credit: 4**
Pre-Requisites: Strength of materials, Machine Drawing	

Course Objectives:

This course seeks to provide an introduction to the design of machine elements commonly encountered in mechanical engineering practice, through

1. a strong background in mechanics of materials based failure criteria underpinning the safety-critical design of machine components
2. an understanding of the origins, nature and applicability of empirical design principles, based on safety considerations
3. an overview of codes, standards and design guidelines for different elements
4. an appreciation of parameter optimization and design iteration
5. an appreciation of the relationships between component level design and overall machine system design and performance

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Objective and scope of Mechanical Engineering Design; Design considerations; Review and selection of materials and manufacturing processes; codes and standards;	4
2	Modes of failure; Design/allowable stress; Factor of safety (FoS); Theories of failure – maximum normal stress theory, maximum shear stress theory, Distortion energy theory. Choice of Failure criteria; Design for stability : buckling analysis – Johnson and Euler columns	4
3	Fatigue in metals; S-N curve; Endurance limit and fatigue strength; Stress concentration factors – effect of discontinuity, fillets and notches; Effect of size, surface finish, stress concentration and degree of reliability on endurance limit; Design for finite and infinite life; Goodman, modified Goodman and Soderberg diagrams with respect to fatigue failure under variable stresses; Cumulative fatigue damage – Miner's equation.	5
4	Design of (i) Cotter joint; (ii) Knuckle joint and (iii) Fillet Welded joint of brackets under different types of loading.	6
5	Bolted joints : Metric thread, standard sizes, use of lock nuts and washers; Applications in structures including brackets, turn buckle; Pre-stressed bolts; Riveted joints : Unwin's formula; Brief discussion on single, double and triple row lap joints, butt joints with single or double strap / cover plate; simple strength design; joint efficiencies.	6

6	Design of : (i) Solid and hollow shafts, strength design of shafts, design based on torsional rigidity; (ii) Shaft coupling-rigid, pin-bush and geared flexible type, alignment of coupling; **(iii)** Belt drives-geometrical relations, derivation of torque and power transmission by flat and V-belt drives, selection of belt from manufacturers' catalogues, **pulley** (iv) **Chain drives – roller chains, polygonal effect, power rating, sprocket wheel, silent chain**	10
7	Design of: (i) Transmission screw, Screw jack, (ii) Helical compression spring - stress and deflection equations, stiffness, curvature effect : Wahl's factor, springs in parallel and series; **(iii) Multi-leaf springs : load-stress and load-deflection equations, Nipping**	8
8	Analysis and design of sliding and rolling contact bearings, Design of transmission elements: spur, helical, bevel and worm gears; Analysis of clutches and brakes	5

Course Outcomes:
Upon completion of this course, students will get an overview of the design methodologies employed for the design of various machine components.

Learning Resources:
1. J.E. Shigley and C.R. Mischke, Mechanical Engineering Design, 5th Edition, McGraw Hill International, 1989.
2. D. Deutschman, W.J. Michels and C.E. Wilson, Machine Design Theory and Practice, Macmillan, 1992.
3. R.C. Juvinal, Fundamentals of Machine Component Design, John Wiley, 1994.
4. M.F. Spottes, Design of Machine elements, Prentice-Hall India, 1994.
5. R. L. Norton, Mechanical Design– An Integrated Approach, Prentice Hall, 1998.
6. V. B. Bhandari, Design of Machine Elements by, McGraw Hill Publishing Co. Ltd., 2007.
7. P. Kannaiah, Machine Design, 2nd Edition, Scitech Publications.

Maulana Abul Kalam Azad University of Technology, West Bengal

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: HM-HU601	**Category:** Humanities and Social Sciences including Management Courses
Subject Name: Humanities II (Operations Research)	**Semester**: Sixth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites:	

Course Objectives:

1. To study the various Operations Research tools,
2. To study to apply an appropriate model to the given situation.
3. To formulate the problem.
4. To solve and analyze the problems on Operations Research.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to Operations Research:** Introduction, Historical Background, Scope of Operations Research, Features of Operations Research, Phases of Operations Research, Types of Operations Research Models, Operations Research Methodology, Operations Research Techniques and Tools, Structure of the Mathematical Model, Limitations of Operations Research	2
2	**Linear Programming:** Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Case Studies of LPP, Graphical Methods to Solve Linear Programming Problems, Applications, Advantages, Limitations. Graphical Analysis of Linear Programming Problems: Introduction, Graphical Analysis, Some Basic Definitions, Graphical Methods to Solve LPP, Some Exceptional Cases, Important Geometric Properties of LPP. Simplex Method: Introduction, Standard Form of LPP, Fundamental theorem of LPP, Solution of LPP - Simplex Method, The Simplex Algorithm, Penalty Cost Method or Big M-method, Two Phase Method, Solved Problems on Minimisation. Duality in Linear Programming Problem: Introduction, Importance of Duality Concepts, Formulation of Dual Problem, Economic Interpretation of Duality, Sensitivity Analysis.	8

3	**Transportation Problem:** Introduction, Formulation of Transportation Problem (TP), Transportation Algorithm (MODI Method), the Initial Basic Feasible Solution, Moving Towards Optimality.	3
4	**Assignment Problem:** Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Travelling Salesman Problem	3
5	**Project Management Using CPM-PERT:** Project Scheduling and PERT-CPM: Introduction, Basic Difference between PERT and CPM, PERT/CPM Network Components and Precedence Relationship, Project Management – PERT, Float calculation and its importance. Cost reduction by Crashing of activity	5
6	**Queuing Theory:** Basis of Queuing theory, elements of queuing theory, Operating characteristics of a queuing system, Queue discipline, Service Mechanism, Classification of Queuing models, [M/M/1]:{//FCFS} Queue System, numerical	3
7	**Inventory Management:** Inventory classification, Different costs associated to Inventory, Inventory models with deterministic demands (EOQ, EPQ and price discount models), inventory classification systems	4
8	**Job Sequencing:** Introduction to sequencing and scheduling models: n job two machines problem, n job 3 machines problem	2
9	**Decision Theory:** Introduction, Decision under certainty, Decision under risk, Decision under uncertainty: Laplace criterion, MaxiMin criterion, MiniMax criterion, savage MiniMax regret criterion, Hurwicz criterion, Decision tree	3
10	**Replacement Theory:** Introduction, Replacement of capital equipment which depreciated with time, replacement by alternative equipment, Group and individual replacement policy.	3

Course Outcome:

At the end of this course students will be able to

1. Apply forecasting methods for predicting demands.
2. Make decisions under certainty, uncertainty and conflicting situations.
3. Apply linear programming tools for optimal utilization of resources in various types of industries.
4. Solve transportation problems to minimize cost and understand the principles of assignment of jobs and recruitment polices.
5. Understand the basic elements of a Queuing model

6. Apply PERT/CPM for project scheduling and resource allocation in an optimal way.
7. Manage inventory with cost effectiveness.

Learning Resources

1. F.S. Hillier, G.J. Lieberman, B. Nag and P. Basu, Introduction to Operation Research, 10th Edition, McGraw Hill, 2017.
2. C. Mohan and K. Deep, Optimization Techniques, New Age, 2009.
3. N.D. Vohra, Quantitative Techniques in Management, 5th Edition, McGraw-Hill.
4. K.V. Mittal and C. Mohan, Optimization Methods in Operations Research and Systems Analysis, New Age, 2003.
5. H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002.
6. A. Ravindran, D.T. Phillips and J.J. Solberg, Operations Research: Principles and Practice, 2nd Edition, John Willey and Sons, 2009.
7. K. Bedi, Production and Operations Management, Oxford University Press, 2004.
8. S.J. Chandra and A. Mehra, Numerical Optimization with Applications, Narosa, 2009.
9. J.K. Sharma, Operation Research: Theory and Applications, 5th Edition, Macmillan Pub., 2013.
10. L.W. Wayne, Operations Research Applications and Algorithms, 4th Edition, Brooks/Cole, USA.

Maulana Abul Kalam Azad University of Technology, West Bengal

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : MC601	**Category:** Mandatory Courses
Subject Name : Constitution of India	**Semester** : Sixth
L-T-P : 0-2-0	**Credit: 0**
Pre-Requisites:	

Course Objectives:

The objectives of this course help the students to

1. To provide basic information about Indian constitution.
2. To identify individual role and ethical responsibility towards society.
3. To understand human rights and its implications.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to the Constitution of India, The Making of the Constitution and Salient features of the Constitution. Preamble to the Indian Constitution Fundamental Rights & its limitations.	4
2	Directive Principles of State Policy & Relevance of Directive Principles State Policy Fundamental Duties. Union Executives – President, Prime Minister Parliament Supreme Court of India.	5
3	State Executives – Governor, Chief Minister, State Legislature High Court of State. Electoral Process in India, Amendment Procedures, 42nd, 44th, 74th, 76th, 86th & 91st Amendments.	5
4	Special Provision for SC & ST Special Provision for Women, Children & Backward Classes Emergency Provisions. Human Rights –Meaning and Definitions, Legislation Specific Themes in Human Rights-Working of National Human Rights Commission in India Powers and functions of Municipalities, Panchyats and Co - Operative Societies.	5
5	Special Provision for SC & ST Special Provision for Women, Children & Backward Classes Emergency Provisions. Human Rights –Meaning and Definitions, Legislation Specific Themes in Human Rights-Working of National Human Rights Commission in India Powers and functions of Municipalities, Panchyats and Co - Operative Societies.	5

Course Outcomes:

On completion of the course student will

1. Have general knowledge and legal literacy and thereby to take up competitive examinations.
2. Understand state and central policies, fundamental duties.
3. Understand Electoral Process, special provisions.
4. Understand powers and functions of Municipalities, Panchayats and Co-operative Societies,

5. Understand Engineering ethics and responsibilities of Engineers
6. Understand Engineering Integrity & Reliability

Learning Resources:

1. D.D. Basu, Introduction to the Constitution on India, 19th/ 20th Students Edition, Prentice Hall EEE, 2001.
2. C.E. Haries, M.S. Pritchard and M.J. Robins, Engineering Ethics, Thompson Asia, 2003.
3. M.V. Pylee, An Introduction to Constitution of India, Vikas Publishing, 2002.
4. M. Govindarajan, S. Natarajan and V.S. Senthilkumar, Engineering Ethics, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
5. B.K. Sharma, Introduction to the Constitution of India, PHI Learning, New Delhi, 2011.
6. Latest Publications, Indian Institute of Human Rights, New Delhi.

Maulana Abul Kalam Azad University of Technology, West Bengal

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : PC-ME691	**Category:** Professional Core Courses
Subject Name : Mechanical Engineering Laboratory (Design) II	**Semester** : Sixth
L-T-P : 0-0-3	**Credit: 1.5**
Pre-Requisites:	

Course Objectives:

To understand the measurement of mechanical properties of materials
To understand the deformation behaviour of materials
To understand the kinematic and dynamic characteristics of mechanical devices

Course Contents (12 experiments/ problems/ studies are to perform):

1. Uniaxial tension test on mild steel rod
2. Torsion test on mild steel rod
3. Impact test on a metallic specimen
4. Brinnell/ Vickers and Rockwell hardness tests on metallic specimens
5. Bending deflection test on beams
6. Strain measurement using Rosette strain gauge, or like.
7. Microscopic examination of heat-treated and untreated metallic samples
8. Determination of velocity ratios of simple, compound, epicyclic and differential gear trains
9. Studying kinematics of four bar, slider crank, crank rocker, double crank, double rocker and oscillating cylinder mechanisms
10. Studying kinematics of typical mechanisms like pantograph, some straight line motion mechanisms, wiper, drafter, etc.
11. Motion studies of different cams & followers
12. Single degree of freedom Spring-mass-damper system: determination of natural frequency and damping coefficient
13. Determination of torsional natural frequency of single and double rotor systems- undamped and damped natural frequencies
14. Studying machine vibration using sensor
15. Solving simple balancing problems experimentally

Course Outcomes:

Students who have undergone the course will be able to understand the measurement of mechanical properties of materials and will be able to characterize the dynamic behavior of mechanical system.

Subject Code : PW-ME681	**Category:** Project (Summer Internship)
Subject Name : Project-II	**Semester** : Sixth
L-T-P : 0-0-4	**Credit: 2**
Pre-Requisites:	

Course Objectives:

This course is aimed to provide more weightage for project work. The project work could be done in the form of a summer project or internship in the industry or even a minor practical project in the college. Participation in any technical event/ competition to fabricate and demonstrate an innovative machine or product could be encouraged under this course.

Course Outcomes:

Students will be able to understand the procedure to carry out practical projects related to any technical event/ competition to fabricate and demonstrate an innovative machine or product, etc.

Maulana Abul Kalam Azad University of Technology, West Bengal

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Fourth Year Seventh Semester							
Sl. No.	**Category**	**Subject Code**	**Subject Name**	**Total Number of contact hours**			**Credits**
				L	**T**	**P**	
Theory							
1	Professional Core courses	PC-ME701	Advanced Manufacturing Technology	3	0	0	3
2	Professional Elective courses	PE-ME701	Elective III	3	0	0	3
3	Professional Elective courses	PE-ME702	Elective-IV	3	0	0	3
4	Open Elective courses	OE-ME701	Open Elective- I	3	0	0	3
5	Humanities and Social Sciences including Management courses	HM-HU701	Economics for Engineers	2	0	0	2
	Total Theory			**14**	**0**	**0**	**14**
Practical/ Sessional							
1	Professional Core courses	PC-ME791	Mechanical Engineering Laboratory III (Manufacturing)	0	0	3	1.5
2	Project	PW-ME781	Project-III	0	0	6	3
	Total Practical			**0**	**0**	**9**	**4.5**
	Total of Seventh Semester			**14**	**0**	**9**	**18.5**

Two papers for (Professional Elective Courses- Elective III and IV, that is, PE-ME701 and PE-ME702) are to be chosen among the List of Professional Elective Papers that were not completed in the earlier semester.

Similarly, one paper for (Open Elective Course- Open Elective I, that is, OE-ME701) are to choose among the List of Open Elective Courses.

Subject Code: PC-ME701	**Category:** Professional Core Courses

Maulana Abul Kalam Azad University of Technology, West Bengal

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Name: Advanced Manufacturing Technology	**Semester**: Seventh
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Manufacturing Processes, Manufacturing Technology	

Course Objectives:

To introduce principles of material removal mechanism of advanced machining processes such as mechanical, electro-chemical and thermal.

To give basic understanding of the machining capabilities, limitations, and productivity of advanced manufacturing technologies.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Mechanical Advanced Machining Processes:** Need and classification of nontraditional machining processes – Material removal in traditional and nontraditional machining processes - considerations in process selection. Ultrasonic machining – Working principle, mechanism of metal removal – Theory of Shaw, elements of the processes, tool feed mechanism, effect of parameters, applications and numerical. Abrasive jet machining, Water jet machining and abrasive water jet machine - Basic principles, equipments, process variables, mechanics of metal removal, MRR, application and limitations.	6
2	**Electro–Chemical Processes:** Principle of ECM process, chemistry of the ECM processes, Parameters of the process, determination of the metal removal rate, dynamics of ECM process, polarization, tool design, advantages and disadvantages, application, electrochemical grinding, electrochemical honing, electrochemical deburring, Application of ECM for deep hole drilling - electrostream drilling and shaped tube electrolytic machining. Chemical machining - Fundamental principle, types of chemical machining, maskants, etchants, advantages, disadvantages, applications	6
3	**Electric Discharge Machining:** Working principle of EDM, Power circuits for EDM - RC pulse generator and controlled pulse generator– Analysis of R-C Circuits – Mechanics of metal removal in EDM, Process parameters, selection of tool electrode and dielectric fluids, surface finish and machining accuracy, characteristics of spark eroded surface and recent development in EDM. Wire EDM – Working principle, process variables, process characteristics and applications. Electric discharge grinding and electric discharge diamond grinding - working principle, process capabilities and applications.	6

4	**Laser, Electron Beam, Ion Beam and Plasma Arc Machining:** General working principle of laser beam machining – Generation of Laser, types of Lasers, process characteristics and applications. Electron Beam Machining - Equipment for production of Electron Beam, theory of EBM, thermal and non-thermal type, process characteristics and applications. Ion Beam Machining - Mechanism of metal removal and associated equipments, process characteristics and applications. Plasma Arc Machining - Metal removal mechanism, process parameters, process characteristics, types of torches, applications.	6
5	**Advanced Finishing Processes:** Abrasive flow Machining (AFM)- working principle, AFM system, process variables, process performance and applications. Magnetic abrasive finishing (MAF)- working principle, MAF system, material removal and surface finish, process variables and applications. Chemomechanical polishing, working principle, material removal and surface finish and applications.	6
6	**Micro-Machining:** Need- evolution- fundamentals and trends in micro technologies- Consequences of the technology and society- challenges to manufacturing technology- evolution of precision in manufacturing, tooling and current scenario, requirements and applications Theory of micromachining- Chip formation- Size effect in micromachining- microturning- microdrilling.	6

Course Outcomes:

Student will be able

1. To understand non- traditional machining processes and the effect of process parameters
2. To differentiate the various non-traditional machining processes
3. To demonstrate micromachining technology

Learning Resources:

1. A. Ghosh and A.K. Mallik, Manufacturing Science, Affiliated East west Press Ltd, 2001.
2. V.K. Jain, Advanced Machining Processes, Allied Publishers Pvt. Ltd. 2002
3. H. El-Hofy, Advanced Machining Processes, McGraw-Hill, New York, 2005.
4. G.F. Benedict, Nontraditional Machining Processes, Marcel Dekker Inc., New York, 1987.
5. J.A. McGeough, Advanced Machining Methods, Chapman and Hakk, London, 1988.
6. M. Adithan, Modern Machining Methods, Khanna Publishers, New Delhi, 2008.
7. P.K. Mishra, Nonconventional Machining, The Institution of Engineers (India) Text Book Series, Narosa Publishing House, New Delhi, 1997.
8. P.C. Pandy and H.S. Shan, Modern Machining Processes, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1980.
9. V. K. Jain, Introduction to Micromachining, Alpha Science International Limited, 2010.
10. J. A. McGeough, Micromachining of Engineering Materials, Taylor & Francis, 2001.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

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Subject Code: HM-HU701	**Category:** Humanities and Social Sciences including Management Courses
Subject Name: Economics for Engineers	**Semester**: Seventh
L-T-P: **2-0-0**	**Credit: 1**
Pre-Requisites: Nil	

Course Objectives:

To make general awareness among budding engineers regarding basic principles of economics and that needed to use in an industry.
To give basic understanding of engineering costs, estimation, depreciation analysis and nasic accounting principles.

Course Contents :

Module No.	Description of Topic	Contact Hrs.
1	Economic Decisions Making- Overview, Problems, Role, Decision making process.	2
2	Engineering Costs & Estimation- Fixed, Variable, Marginal & Average Costs, Sunk Costs, Opportunity Costs, Recurring and Nonrecurring Costs, Incremental Costs, Cash Costs vs Book Costs, Life-Cycle Costs; Types of Estimate, Estimating Models - Per- Unit Model, Segmenting Model, Cost Indexes, Power- Sizing Model, Improvement & Learning Curve, Benefits.	4
3	Present Worth Analysis: End-of-Year Convention, Viewpoint of Economic Analysis Studies, Borrowed Money Viewpoint, Effect of Inflation & Deflation, Taxes, Economic Criteria, Applying Present Worth Techniques, Multiple Alternatives.	4
4	Cash Flow & Rate of Return Analysis- Calculations, Treatment of Salvage Value, Annual Cash Flow Analysis, Analysis Periods; Internal Rate of Return, Calculating Rate of Return, Incremental Analysis; Best Alternative Choosing an Analysis Method, Future Worth Analysis, Benefit-Cost Ratio Analysis, Sensitivity and Break Even Analysis. Economic Analysis in the Public Sector- Quantifying and Valuing Benefits & drawbacks.	4
5	Depreciation- Basic Aspects, Deterioration & Obsolescence, Depreciation and Expenses, Types of Property, Depreciation Calculation Fundamentals, Depreciation and Capital Allowance Methods, Straight-Line Depreciation Declining Balance Depreciation, Common Elements of Tax Regulations For Depreciation and Capital Allowances.	4
6	Inflation and Price Change- Definition, Effects, Causes, Price Change With Indexes, Types of Index, Composite vs Commodity Indexes, Use	3

	of Price Indexes in Engineering Economic Analysis, Cash Flows that inflate at different Rates.	
7	Accounting- Function, Balance Sheet, Income Statement, Financial Ratios Capital Transactions, Cost Accounting, Direct and Indirect Costs, Indirect Cost Allocation.	3

Course Outcomes:

Student will be able

1. To understand Economic Decisions Making criteria
2. To know basic principles of engineering costs, estimation and depreciation analysis.
3. To understand basic accounting principles.

Learning Resources:

1. J.L. Riggs, D.D. Bedworth and S.U. Randhawa, Engineering Economics, 4th Edition, McGraw Hill International Edition, 1996.
2. D. Newnan, T. Eschembach and J. Lavelle, Engineering Economics Analysis, Oxford University Press, 2019.
3. J.A. White, K.E. Case and D.B. Pratt, Principle of Engineering Economic Analysis, John Wiley, 2016.
4. W.G. Sullivan, E.M. Wicks and C.P. Koelling, Engineering Economy, 17th Edition, Pearson, 2018.
5. R. Panneerselvan, Engineering Economics, Prentice Hall of India, 1999.
6. M.R. Lindeburg, Engineering Economics Analysis: An Introduction, Professional Publication, 1993.

Maulana Abul Kalam Azad University of Technology, West Bengal

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: PC-ME791	**Category:** Professional Core Courses
Subject Name: Mechanical Engineering Laboratory III (Manufacturing)	**Semester**: Seventh
L-T-P: **0-0-3**	**Credit: 1.5**
Pre-Requisites: Manufacturing Processes, Manufacturing Technology	

Course Objectives:

Students will gain a practical knowledge of various manufacturing processes in a hands-on environment through experiments and simulations.

Course Contents (12 Experiments/ Problems/ Studies are to do):

1. Measurement of Cutting Force in Turning
2. Study of the effect of parametric variation in arc welding
3. Testing of moulding sand
4. Testing for Weld Quality
5. Study of and Solving problems on geometry of robot manipulator, actuators and grippers
6. Programming on CNC Lathe using G and M Codes
7. Programming on CNC Lathe using APT
8. Programming on CNC Milling Machine using G and M Codes
9. Programming on CNC Milling Machine using APT
10. Programming on CNC machine Simulator and to observe virtual machining
11. Robot Programming
12. Experiments on AJM/ USM/ WEDM/ EDM/ ECM/ LBM
13. Design and manufacture of products using Additive Manufacturing

Course Outcomes:

At the end of the course, a student will be able to:

1. Study cutting forces in machining processes
2. Test the quality of weld and moulding sands
3. Develop a practical understanding of advanced manufacturing processes.
4. Understand the working of a robot and its programming
5. Identify and rectify defects in parts and manufacturing processes related problems.

Learning Resources:

1. M.P. Groover, Principles of Modern Manufacturing, 5th edition, Wiley, 2014.
2. E.P. DeGarmo, J.T. Black and R.A. Kohser, DeGarmo's Materials and Processes in Manufacturing, 11th Edition, John Wiley & Sons, 2011.
3. S. Kalpakjian and Schmid, Manufacturing processes for engineering materials, 5th edition, Pearson Education, 2010.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: PW-ME781	**Category:** Project
Subject Name: Project-III	**Semester**: Seventh
L-T-P: **0-0-6**	**Credit: 3**
Pre-Requisites: All courses	

Course Objectives:

To develop the ability to identify, formulate and analyze engineering problems through literature survey, recent trends in industries and by applying the knowledge of science and engineering fundamentals.

To train students in preparing project reports, to face reviews and viva voce examination.

Course Contents:

It is intended to start the project work early in the seventh semester and carry out both design and fabrication of a mechanical device whose working can be demonstrated. The design and formulation of the problem is expected to be completed in the seventh semester and the fabrication and demonstration will be carried out in the eighth semester. The students in a group of 4 to 6 works on a topic are to be approved by the head of the department under the guidance of a faculty member. The students prepare a comprehensive project report after completing the work to the satisfaction of the supervisor to be submitted at the end of the semester. The progress of the project is evaluated by a committee may be constituted by the Head of the Department. The project work is evaluated based on oral presentation and the project report may jointly by external and internal examiners constituted by the Head of the Department.

Course Outcomes:

Student will be able to carry out some project works based on some design or fabrication or experimental problems in a group building up team spirit and would get sufficient exposure for the way to proceed to solve a practical or design problem.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Semester-VIII

Fourth Year Eighth Semester							
Sl No.	**Category**	**Subject Code**	**Subject Name**	**Total Number of contact hours**			**Credits**
				L	**T**	**P**	
Theory							
1	Professional Elective courses	PE-ME801	Elective V	3	0	0	3
2	Professional Elective courses	PE-ME802	Elective VI	3	0	0	3
3	Open Elective courses	OE-ME801	Open Elective- II	3	0	0	3
4	Open Elective courses	OE-ME802	Open Elective- III	3	0	0	3
	Total Theory			**12**	**0**	**0**	**12**
Practical/ Sessional							
1	Project	PW-ME881	Project- IV	0	0	10	5
2	Professional Core courses	PW-ME882	Comprehensive Viva-Voce	0	0	0	1.5
	Total Practical			**0**	**0**	**10**	**6.5**
	Total of Eighth Semester			**12**	**0**	**10**	**18.5**

Two papers for (Professional Elective Courses- Elective V and VI, that is, PE-ME801 and PE-ME802) are to be chosen among the List of Professional Elective Papers that were not completed in the earlier semesters.

Similarly, two papers for (Open Elective Courses- Open Elective II and III, that is, OE-ME801 and OE-ME802) are to choose among the List of Open Elective Courses that were not completed in the earlier semester.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: PW-ME881	**Category:** Project
Subject Name: Project- IV	**Semester**: Seventh
L-T-P: **0-0-10**	**Credit: 5**
Pre-Requisites: All courses	

Course Objectives:

To develop the ability to conduct investigations of complex engineering problems using research knowledge, methods and other modern engineering tools.
To train the students in preparing project reports, to face review and viva voce examination.

Course Contents:

It is intended to start the project work early in the seventh semester and carry out both design and fabrication of a mechanical device whose working can be demonstrated. The design and formulation of the problem is expected to be completed in the seventh semester and the fabrication and demonstration will be carried out in the eighth semester. The students in a group of 4 to 6 works on a topic are to be approved by the head of the department under the guidance of a faculty member. The students prepare a comprehensive project report after completing the work to the satisfaction of the supervisor to be submitted at the end of the semester. The progress of the project is evaluated by a committee may be constituted by the Head of the Department. The project work is evaluated based on oral presentation and the project report may jointly by external and internal examiners constituted by the Head of the Department.

Course Outcomes:

Student will be able to carry out some project works based on some design or fabrication or experimental problems in a group building up team spirit and would get sufficient exposure for the way to proceed to solve a practical or design problem.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: PW-ME882	**Category:** Professional Core Courses
Subject Name: Comprehensive Viva-Voce	**Semester**: Eighth
L-T-P: **0-0-0**	**Credit: 1.5**
Pre-Requisites: All courses	

Course Objectives:

The objective of comprehensive viva-voce is to assess the overall knowledge, a student acquired in the relevant field of engineering over 4 years of study in the programme. In doing so, the main objective is to prepare the students to face interview both in the academic and the industrial sector.

Course Contents:

The Comprehensive Viva-Voce will be conducted by a Committee consisting of Head of the Department and all Faculty members of the department. The Comprehensive Viva-Voce is intended to assess the student's understanding of the courses he/ she studied during the 4 years B. Tech. programme.

Course Outcomes:

Student will be able to prepare for the interview in a better way by brushing up different course papers so that overall knowledge on Mechanical Engineering areas would be sharpened.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Professional Electives

B.Tech (Mechanical Engineering) Course

There are six Professional Elective Course Papers in Semester VI, VII and VIII as follows:
(Elective-I) PE-ME601, (Elective-II) PE-ME602, (Elective-III) PE-ME701,
(Elective-IV) PE-ME702, (Elective-V) PE-ME801 and (Elective VI) PE-ME802.

Students are to choose one paper for each of the Professional Elective Courses specified in the curriculum structure of a Semester from the following list of Professional Elective Papers. Selection of a paper should be non-repetitive. If a student chooses the paper, **Internal Combustion Engines and Gas Turbines (Code: A1)** as a **Professional Elective I in Semester VI**, its paper code will be **PE-ME601A1**. Similarly, in case **Mechanical Vibration (Code: B3)** is chosen by one in **Semester VII as Professional Elective-IV**, its paper Code will be **PE-ME702B3**.

Subject Code	Subject name
Thermo-Fluid Group	
A1	Internal Combustion Engines and Gas Turbines
A2	Automobile Engineering
A3	Gas Dynamics and Jet Propulsion
A4	Refrigeration and Air Conditioning
A5	Turbo Machinery
A6	Fluid Power Control
A7	Advanced Fluid Mechanics
A8	Analysis and Performance of Fluid Machines
A9	Computational Fluid Dynamics
A10	Power Plant Engineering
A11	Cryogenics
A12	Introduction to Wind Engineering
A13	Elements of Atmospheric Fluid Dynamics
Design Group	
B1	Composite Materials
B2	Selection and Testing of Materials
B3	Mechanical Vibration
B4	Tribology
B5	Finite Element Analysis
B6	Mechatronics
Manufacturing Group	
C1	Advanced Welding Technology
C2	Quantity Production Methods
C3	3D Printing and Design
C4	Micro and Nano Manufacturing

C5	CAD/CAM
C6	Robotics
C7	Material Handling
C8	Principles and Practices of Management
C9	Process Planning and Cost Estimation
C10	Maintenance Engineering

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: A1	**Category:** Professional Elective Courses
Subject Name: Internal Combustion Engines and Gas Turbines	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Thermodynamics, Heat Transfer	

Course Objectives:

To acquire knowledge about the IC engine cycles, classification, working Principles and to measure performance parameters along with heat balance sheet.
To explain different alternate fuels, gas turbines and about jet propulsion

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Basic Engine components and Nomenclature, Classification of Engines, The working principle of Engines, Comparison of 2-Stroke and 4-Stroke Engines; CI, and SI Engines, Ideal and Actual Working Cycles and their analysis, Valve timing Diagram. **Fuels:** Fossil fuels, Chemical structure of Petroleum, Properties of SI and CI Engine Fuels, Fuel Ratings; Octane Number, Cetane Number.	6
2	**Carburetors & Fuel Injection:** Air Fuel Mixture Requirements, Construction and Working of Simple Carburetor, Calculation of Air-Fuel Ratio, Parts of Carburetor. Requirement of Injection Systems, Classification of Injection Systems, Fuel Feed pump, Injection Pumps, Working principles of Governors, Nozzles and Fuel Injector, Injection in SI and CI Engines. **Combustion and Ignition Systems in SI and CI Engines:** Normal and Abnormal Combustion in SI and CI Engines, Stages of Combustion, Detonation and Knocking.	7
3	**Performance parameters for IC Engines:** Engine Power, Engine Efficiencies, Performance Characteristics, Variables Effecting Performance Characteristics, Methods of Improving Engine Performance, Heat Balance. **Modern Automotive Engines:** Changes in Fuel injection Methods in S.I and C.I engines, Common Rail Direct Injection System, Gasoline Direct Injection, Variable Valve Technology, A brief review of Design changes to achieve high efficiency.	7
5	**Alternate Fuels For IC Engines:** Need for use of alternate fuels. Use of alcohol fuels. Biodiesel.	3

	Biogas and Hydrogen in engines.	
6	**Gas Turbine:** Introduction to Gas Turbines, Development, Classification and Application of Gas Turbines, Ideal and Actual Cycles; Effect of Inter cooling, Reheating, Regeneration, Combined cycle and Cogeneration.	6
7	**Gas Turbine Cycles for Aircraft Propulsion:** Criteria of performance, Intake, and propelling nozzle efficiencies, Simple Turbojet Cycle, The turboprop engine, Thrust augmentation, Gas turbine combustion systems, Combustion chamber designs, Gas Turbine Emissions.	7

Course Outcomes:

1. Explained basic concepts of actual cycles with analysis and to describe the fundamental concepts of IC engines along with its working principles.
2. Described the combustion phenomenon in SI and CI engines.
3. Evaluated the performance of IC engines and the importance of alternate fuels.
4. Classified the essential components of gas turbine along with its performance improving methods.
5. Illustrated the working principle of different types of Jet propulsive engines and Rockets.

Learning Resources:

1. V. Ganesan, I.C. Engines, McGraw Hill, 2017.
2. V. Ganesan, Gas Turbines, McGraw Hill, 2004.
3. C.R. Ferguson and A.T. Kirkpatrick, Internal Combustion Engines, Wiley, 2015.
4. H.N. Gupta, Fundamentals of Internal Combustion Engines, PHI, 2012.
5. H. Cohen, H.I.H. Saravanamuttoo, G.F.C. Rogers, P. Straznicky and A.C. Nix, Gas Turbine Theory, Pearson, 2019.
6. J.B. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill Co., 1988.
7. W.W. Pulkrabek, Engineering Fundamentals of IC Engine, PHI Pvt. Ltd., 2002.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : A2	**Category:** Professional Elective Courses
Subject Name : Automobile Engineering	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Thermodynamics, Kinematics & Theory of Machines	

Course Objective:

To impart knowledge on various types of power-driven vehicles and to familiarize the students with the fundamentals of Automotive Engine System, Chassis and suspension system, braking and transmission system, and cooling system.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** History & Development of Automobile. Various sub systems of Automobile.	1
2	**Prime Mover:** Engine for Two-Wheeler & Three-Wheeler vehicles, Engine for passenger cars, commercial and other vehicle, Fuel system for carburetted engine, MPFI engine and Diesel engine, Lubrication and cooling system.	5
3	**Auto Electrical:** Electric Motor as prime mover, Battery, generator, Ignition system, Starting system, lighting & signaling	6
4	**Steering System:** Devis steering & Ackerman steering system. Rack & pinion, cam & lever, worm & sector system.	3
5	**Transmission System:** Flywheel & clutch. Gearbox sliding and constant mesh type, Automatic Transmission, Universal joint, Propeller shaft.	6
6	**Differential & Axle:** Construction & function of differential, Different types of front & rear axles.	3
7	**Suspension System:** Conventional and independent suspension system, application.	3
8	**Brake System:** Disc & drum brake, Hydraulic brake, Parking brake. Stopping distance.	3
9	**Power Requirement:** Various resistances such as air resistance, gradient resistance, rolling resistance. Tractive effort. Torque- Speed curve. Horse	3

	power calculation.	
10	**Automotive air conditioning:** Ventilation, heating, air condition, refrigerant, compressor and evaporator. **Wheels and tyres:** Wheel quality, assembly, types of wheels, wheel rims. Construction of tyres and tyre specifications. **Automotive Restraint Systems:** Seat belt, automatic seat belt tightener system, collapsible steering column and air bags.	3

Course Outcomes:

At the end of the course, the student will be able to:

1. Understand the basic lay-out of an automobile.
2. Explain the operation of engine cooling, lubrication, ignition, electrical and air conditioning systems.
3. Illustrate the principles of transmission, suspension, steering and braking systems.
4. Demonstrate automotive electronics.
5. Study latest developments in automobiles.

Learning Resources:

1. K. Newton, W. Steed and T.K. Garrette, Motor Vehicle, 2nd Edition, Butterworth, 1989.
2. N.K. Giri, Automobile Mechanics, 7th Edition, Khanna Publishers, 1998.
3. A. De, Automobile Engineering, Revised Edition, Galgotia Publication Pvt. Ltd., 2010.
4. W.H. Crouse and D.L. Anglin, Automotive Mechanics, McGraw Hill, New Delhi, 2005.
5. J. Heitner, Automotive Mechanics, Affiliated South West Press, New Delhi, 2000.
6. G.B. Narang, Automobile Engineering, Khanna Publishers, New Delhi, 2001.
7. K. Ramakrishna, Automobile Engineering, PHI Learning Pvt. Ltd., New Delhi, 2012.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: A3	**Category:** Professional Elective Courses
Subject Name: Gas Dynamics and Jet Propulsion	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Thermodynamics, Heat Transfer	

Course Objectives:

To provide the student with the knowledge of basic principles of gas dynamics and its importance in jet propulsion applications.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to Gas Dynamics:** Control volume and system approaches acoustic waves and sonic velocity– Mach number– classification of fluid flow based on mach number– Mach cone-compressibility factor– general features of one dimensional flow of a compressible fluid– continuity and momentum equations for a control volume.	3
2	**Isentropic Flow of an Ideal Gas:** Basic equation- stagnation enthalpy, temperature, pressure and density- stagnation, acoustic speed- critical speed of sound- dimensionless velocity- governing equations for isentropic flow of a perfect gas- critical flow area.	6
3	**Steady One Dimensional Isentropic Flow**: Nozzles- area change effect on flow parameters- chocking- convergent nozzle- performance of a nozzle under decreasing back pressure- Delavel nozzle- optimum area ratio- effect of back pressure- nozzle discharge coefficients- nozzle efficiencies. **Simple Frictional Flow:** Governing equations for Adiabatic flow with friction in a constant area duct- fannoline limiting conditions- effect of wall friction flow properties in an Isothermal flow with friction in a constant area duct governing equations- limiting conditions, numerical problems.	7
4	**Steady One Dimensional Flow with Heat Transfer:** Governing equations- Rayleigh line entropy change caused by heat transfer- conditions of maximum enthalpy and entropy. **Effect of Heat Transfer on Flow Parameters:** Intersection of Fanno and Rayleigh lines. Shock waves in perfect gas- properties of flow across a normal shock- governing equations- Rankine Hugoniat equations- Prandtl's velocity relationship-	8

	converging diverging nozzle flow with shock thickness- shock strength.	
5	**Jet Propulsion Aircraft propulsion:** Types of jet engines- thrust equation, Effect of pressure, velocity and temperature changes of air entering compressors, thrust augmentation methods, Performance of turbo propeller engines, ramjet and pulsejet, scramjet engines.	6
6	**Rocket Propulsion:** Rocket engines, Basic theory of equations- thrust equation- effective jet velocity- specific impulse-rocket engine performance- solid and liquid propelant rockets- comparison of various propulsion systems.	6

Course Outcomes:

Upon completion of this course, student will be able to:

1. Understand basic concepts of gas dynamics and describe the basic fundamental equations of one dimensional flow of compressible fluid and isentropic flow of an ideal gas.
2. Analyze the steady one-dimensional is entropic flow, frictional flow and isothermal flow and express the concepts of steady one dimensional flow with heat transfer.
3. Explain the effect of heat transfer on flow parameters.
4. Illustrate the jet propulsion engines
5. Describe the basic concepts of rocket propulsion

Learning Resources:

1. J.D. Anderson, Modern Compressible flow, McGraw Hill, 2003.
2. H.W. Liepman and A. Roshko, Elements of gas dynamics, Wiley, New York, 1957.
3. H. Cohen, G.E.C. Rogers and Saravanamutto, Gas Turbine Theory, Longman Group Ltd.- 1980.
4. S.M. Yahya, Fundamentals of Compressible Flow, New Age International (P) Limited-1996.
5. N.J. Zucrow, Principles of Jet Propulsion and Gas Turbines, John Wiley, New York,-1970.
6. S.M. Yahya, Fundamentals of compressible flow with aircraft and rocket propulsion, New Age International (P) Ltd., 2007.
7. M.J. Zucrow, Aircraft & Missile Propulsion, Wiley, New York, 2013.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: A4	**Category:** Professional Elective Courses
Subject Name: Refrigeration & Air Conditioning	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Thermodynamics, Heat Transfer	

Course Objective:

1. To know about the basics of refrigeration and air-conditioning system.
2. To learn about different types of Refrigeration, Air-Conditioning and ventilation systems.
3. To know about designing a Refrigeration and Air-Conditioning system.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Introduction: Concepts of Refrigeration and Air-Conditioning. Unit of refrigeration, Refrigerants– Desirable Properties, Nomenclature	02
2	Simple Vapour Compression Refrigeration System (Simple VCRS): Vapour compression cycle on p-h and T-s diagrams. Cycles with subcooling and superheating, their effects; Effect of changes in evaporator pressure and condenser pressure on the performance of a simple VCRS; dry compression and wet compression of refrigerant; actual Vapour Compression Cycle.	05
3	Air Refrigeration System (ARS): Bell-Coleman refrigerator. COP determination, actual air-refrigeration cycle.	03
4	Vapour Absorption Refrigeration System (VARS): Advantages of VARS over VCRS. Working principle of simple VARS, practical VARS. Limitations of VARS, maximum COP of a VARS, Lithium bromide-water System; Aqua-ammonia systems.	04
5	Equipment and Control: Major Refrigeration Equipment-Compressors: Types; reciprocating, rotary & centrifugal, volumetric efficiency, Condensers: types used in refrigeration systems; Evaporators: expansion devices: capillary tubes and thermostatic expansion valves.	06
6	Ventilation– Definition & Requirement, Natural & Mechanical Ventilation, Ventilation Load Calculation.	03
7	Basic definitions and principles related to Psychometry; Psychometric Charts & Their Uses; Heating, Cooling, Heating & Humidification & Cooling & Dehumidification processes. Adiabatic Saturation, Cooling Coils, By-pass Factor.	05
8	Sensible Heat Factors. Heat Load estimation: Simple cases of Cooling and Dehumidification. Duct Sizing & Design. Air-conditioning equipment: Air handling units, Cooling Towers.	8

Course Outcomes:

After completing this course, the students will

1. know about the systems of Refrigeration, Air-Conditioning and Ventilation.
2. learn about different components of these systems.
3. know about designing a Refrigeration and Air-Conditioning system.

Learning Resources:

1. W.F. Stocker and J.W. Jones, Refrigeration and Air Conditioning, McGraw Hill, 2014.
2. C.P. Arora, Refrigeration and Air Conditioning, McGraw Hill India, 2017.
3. P.L. Ballaney, Refrigeration and Air Conditioning, Khanna Publication, New Delhi, 1972.
4. R.C. Arora, Refrigeration and Air Conditioning, PHI, 2010.
5. S.C. Arora and S. Domkundwar, Refrigeration and Air Conditioning, Dhanpat Rai Publication, 2018.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: A5	**Category:** Professional Elective Courses
Subject Name: Turbo Machinery	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Fluid Mechanics and Fluid Machinery	

Course Objective:

To know about the basic characteristics of compressible and incompressible flow machines.
To learn about deriving dimensionless numbers through dimensional analysis.
To know about system of testing and performance analysis of turbo machines.

Course Content:

Module No.	Description of Topic	Contact Hours
1	**Introduction:** Classification: Incompressible and compressible flow machines; Radial, axial and mixed flow machines; Turbines vs pumps, fans and compressors. Applications: Water supply, ventilation, power generation, propulsion.	2
2	**Incompressible- Flow Machines:** i) Hydraulic Turbines: Headrace, penstock, nozzle, runner, draft tube and tail race; Gross head and net head; Velocity diagrams for impulse and reaction turbines; Discharge, head, power and efficiencies.	8
3	ii) Pumps: Reservoir, foot valve, suction line, pump, delivery line and overhead tank; Static head and losses; Velocity diagrams; Discharge, head, power and efficiencies.	8
4	**Compressible-Flow Machines:** Static and stagnation states; Isentropic and adiabatic expansion and compression processes; Nozzle, diffuser and rows of stationary and moving blades; Efficiencies.	8
5	**Dimensional Analysis:** Similarity laws, volume-flow, mass-flow head and power coefficients, pressure ratio, enthalpy ratio, Reynolds number, Mach number; Specific speed and machine selection.	4
6	**Testing and Performance Analysis:** Measurement devices; affinity laws and unit quantities. Set up and operating characteristics of pumps, turbines; fans and turbo-compressors. Cavitation– cause of cavitation and definition of Thoma's cavitation parameter, surge and choking.	6

Course Outcomes:

After completing this course, the students will

1. know basic characteristics of compressible and incompressible flow machines.
2. learn how to derive dimensionless numbers using dimensional analysis.
3. know about the method of testing and performance analysis of turbo machines.

Learning Resources:

1. S.M. Yahya, Turbine, Compressors and Fans, 4th Edition, McGraw Hill Education, 2017.
2. J. Lal, Hydraulic Machines, Metropolitan Book Co., New Delhi, 6th Edition, 2016.
3. S.K. Som, G. Biswas and S. Chakraborty, Introduction to Fluid Mechanics & Fluid Machines, McGraw Hill, 2017.
4. M.M. Das, Fluid Mechanics & Turbo Machines, PHI, 2010.
5. R.K. Bansal, Fluid Mechanics & Machinery, Laxmi Publications, 2018.
6. C. Ratnam, A.V. Kothapalli, Fluid Mechanics & Machinery, I.K. International Publishing House Ltd, 2010.
7. C.S.P. Ojha, R. Berndtsson and P.N. Chandramouli, Fluid Mechanics & Machinery, Oxford University Press, 2008.
8. S.C. Gupta, Fluid Mechanics and Hydraulic Machines, Pearson Publication, 2006.
9. A.T. Sayers, Hydraulic and Compressible Flow Turbomachines, McGraw-Hill, 1990.
10. R.K. Bansal, Fluid Mechanics and Hydraulic Machines, Laxmi Publications, 2018.
11. I.J. Karassic, J.P. Messina, P. Cooper and C.C. Heald, Pump Handbook, McGraw-Hill,New York, 2001.
12. V.M. Cherkassky, Pumps, Fans and Compressors, MIR Publication, Moscow, 1985.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: A6	**Category:** Professional Elective Courses
Subject Name : Fluid Power Control	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Fluid Mechanics and Fluid Machinery	

Course Objective:

1. To know the basics of different types of fluid power control systems and their applications.
2. understand working principles of different components of a pneumatic or hydraulic system.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Fluid power; Applications and advantages; Components of a hydraulic and pneumatic system. Desired properties of a hydraulic fluid; advantage of mineral oil over water; definition of terms like pressure, head, force, density, specific gravity, kinematic and absolute viscosity, compressibility and incompressibility. Pascal's law; analysis of simple hydraulic jack, Mechanical advantage; continuity equation; hydraulic power of a cylinder.	5
2	Hydraulic Pumps: positive displacement pumps; constructional features, working principle and volumetric capacity of external gear pump, vane pump, axial piston pump and radial piston pump.	6
3	Hydraulic Actuators : Constructional features of single acting and double acting hydraulic cylinders; mounting of cylinders, cushioning of cylinder; different application of cylinder through mechanical linkages; force, velocity and power from a cylinder. Hydraulic motors; torque, power and flow rate in a hydraulic motor.	4
4	Hydraulic Valves: Direction control valves – operation and graphical symbol of 3 way and 4 way valves; different modes of activation of valves. Operation and graphical symbols of check valves, pressure relief valve pressure reducing valve, unloading valve and flow control valve.	4
5	Representation of hydraulic components through ANSI symbols. Analysis of hydraulic circuits for single and double acting cylinder control, regenerative circuit, pump unloading circuit, double pump hydraulic system, cylinder synchronization circuit, speed control of a hydraulic motor, circuit to lift and hold heavy load, automatic sequencing of two cylinders.	7

6	Advantages & disadvantages of pneumatic system compared to hydraulic system; constructional details and operation of a reciprocating compressor; working principle and use of filter, pressure regulator, lubricator and silencer; symbols of different pneumatic components; compressed air distribution system in a plant; drawing pneumatic circuits for different operations.	6
7	Use of electrical devices for controlling fluid circuits; function of electrical devices like push-button switches, limit switches, pressure switches, solenoids, relays and timers and their symbols; concept of ladder diagram; study of circuits using electrical control devices such as control of a solenoid actuated cylinder using one limit switch, reciprocation of a cylinder using pressure or limit switches, and two cylinder sequencing circuit using two limit switches.	4

Course Outcomes:

After completing this course, the students will

1. know about different types of fluid power control systems and their applications.
2. learn working principles of different components of a pneumatic and hydraulic system.
3. learn about drawing fluid power control circuits to suit an application.

Learning Resources:

1. S. Ilango and V. Soundararajan, Introduction to Hydraulics and Pneumatics, PHI, 2011.
2. A. Esposito, Fluid Power with Applications, Pearson, 2003.
3. S.R. Majumdar, Pneumatic Systems: Principles and Maintenance, McGraw Hill, 1999.
4. E.C. Fitch Jr., Fluid Power and Control Systems, McGraw Hill, New York,1966.
5. D.S. Banks and D.D. Banks, Industrial Hydraulics, Prentice Hall, 1988.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : A7	**Category:** Professional Elective Courses
Subject Name: Advanced Fluid Mechanics	**Semester :** Sixth/ Seventh/ Eighth
L-T-P : 3-0-0	**Credit:** 3
Pre-Requisites: Fluid Mechanics	

Course Objective:

1. To know about compressible fluid flow.
2. To learn about ideal fluid flow.
3. To know about free surface flow.
4. To know about unsteady flow.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Compressible Flow: review of thermodynamic principles for perfect gases, adiabatic and isentropic relations; steady flow energy equation; speed of propagation of a small disturbance through a compressible fluid, sonic velocity, Mach number, mach cone and Mach wave; isentropic flow, stagnation properties of a compressible flow, isentropic pressure, temperature and density ratios; compressibility correction factor in the measurement of air speed; area– velocity relationship for compressible flow through a variable area duct, mass flow rate through a duct, critical condition and choking; flow through convergent-divergent nozzle, over expansion and under expansion, performance of propulsive nozzles; normal shock, normal shock relations, wave drag.	12
2	Ideal Fluid Flow: rotation of a fluid particle, vorticity, rotational and irrotational motion; velocity potential function, circulation, stream function, flownet; governing equation for two dimensional irrotational motion, simple two dimensional irrotational flows like uniform flow, plane source, plane sink etc; superimposition of simple irrotational flows, combination of a source and a sink, combination of uniform flow and a source (Rankine half body), combination of a uniform flow and a source-sink pair (Rankine oval), doublet and its strength, superimposition of an uniform flow and a doublet (flow past a stationary cylinder); vortex motion– free and forced vortex, strength of a vortex; combination of a uniform flow, a doublet and a free vortex (flow over a rotating cylinder), Magnus effect, Kutta-Joukowski's theorem.	12
3	Free Surface Flow: flow in open channel, Chezy's equation, Manning's equation, economical cross section, specific energy,	8

	hydraulic jump.	
4	Unsteady flow– water hammer.	4

Course Outcomes:

After completing this course, the students will

1. know about compressible fluid flow.
2. learn about ideal fluid flow.
3. know about free surface flow.
4. know about unsteady flow.

Learning Resources:

1. R.K. Bansal, A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publication, New Delhi, 2010.
2. S.K. Som, G. Biswas and S. Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, McGraw-Hill, 2012.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : A8	**Category:** Professional Elective Courses
Subject Name : Analysis and Performance of Fluid Machines	**Semester**: Sixth/ Seventh/ Eighth
L-T-P : 3-0-0	**Credit:** 3
Pre-Requisites: Fluid Mechanics and Fluid Machinery	

Course Objective:

1. To know about the dimensional analysis for fluid machinery.
2. To learn about different heads, losses and efficiencies for pumps, fans and turbines.
3. To know about the Interaction of pumps and Turbines and systems.
4. To know about the Performance characteristics of pumps and turbines.
5. To learn about Cavitation: NPSH, Thoma's cavitation parameter and suction specific speed.
6. To know about the Analysis of flow through propellers and windmills and jet propulsion.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Dimensional analysis for fluid machinery: Dimensionless quantities and their use in design, selection and testing.	3
2	Different heads, losses and efficiencies for pumps, fans and turbines.	3
3	Interaction of pumps and Turbines and systems: Series and Parallel operation of Pumps, Performance and selection of Pumps for different systems characteristics, Surging in Pipelines.	12
4	Performance characteristics: Pumps and Fans-Radial, Mixed flow and Axial flow. Turbines-Francis, Kaplan and Pelton wheel-operating characteristics and Muschel curves, Governing of Turbines.	8
5	Cavitation: NPSH, Thoma's cavitation parameter and suction specific speed.	4
6	Special Devices: Analysis of flow through propellers and windmills, Slipstream and actuator disc theory; Jet propulsion devices.	6

Course Outcomes:

After completing this course, the students will

1. know about the dimensional analysis for fluid machinery.
2. learn about different heads, losses and efficiencies for pumps, fans and turbines.
3. know about the Interaction of pumps and Turbines and systems.
4. know about the Performance characteristics of pumps and turbines.
5. learn about Cavitation: NPSH, Thoma's cavitation parameter and suction specific speed.
6. know about the Analysis of flow through propellers and windmills and jet propulsion.

Learning Resources:

1. R.I. Lewis, Turbomachinery Performance Analysis, Arnold Butterworth-Heinemann, 1996.
2. J. Lal, Hydraulic Machines Including Fluidics, Metropolitan Book Co., 1994.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: A9	**Category:** Professional Elective Courses
Subject Name: Computational Fluid Dynamics	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Fluid Mechanics and Fluid Machines, Engineering Mathematics	

Course Objectives:

The objective of the course is to impart knowledge on numerical modeling and its role for the solution of complex engineering problems in the field of heat transfer and fluid dynamics.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods	2
2	**Governing equations of fluid dynamics:** Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.	4
3	**Mathematical behavior of partial differential equations:** Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations.	2
4	**Basic aspects of discretization:** Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform and unequally spaced grid points.	3
5	**Grids with appropriate transformation:** General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.	4
6	**Parabolic partial differential equations:** Finite difference formulations, Explicit methods - FTCS, Richardson and DuFort-Frankel methods, Implicit methods - Lasonen, Crank-Nicolson	4

	and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis, Linearization.	
7	**Stability analysis:** Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion.	3
8	**Scalar representation of Navier-Stokes equations:** Equations of fluid motion, numerical algorithms: FTCS explicit, FTBCS explicit, Dufort-Frankel explicit, McCormack explicit and implicit, BTCS and BTBCS implicit algorithms, applications.	4
9	**Grid generation:** Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation	3
10	**Finite volume method for unstructured grids:** Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetrahedral Elements, 2-D Heat conduction with Triangular Elements.	3
11	**CFD Solution Procedure:** Problem setup – creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization. **Case Studies:** Benchmarking, validation, Simulation of CFD problems by use of general CFD software, Simulation of coupled heat, mass and momentum transfer problem.	4

Course Outcomes:

At the end of the course, student will be able to:

1. Understand the differential equations for flow phenomena and numerical methods for their solution.
2. Analyze different mathematical models and computational methods for fluid flow and heat transfer simulations.
3. Formulate computational problems related to fluid flows and heat transfer.
4. Estimate the accuracy of a numerical solution by comparison to known solutions of simple test problems and by mesh refinement studies.
5. Evaluate forces in both internal and external flows.

Learning Resources:

1. P.S. Ghosdastidar, Computer Simulation of Flow and Heat Transfer, McGraw-Hill, 1998.
2. K. Muralidhar and T. Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 1995.
3. J.D. Anderson Jr., Computational Fluid Dynamics, McGraw-Hill Book Company, 1995.
4. P. Niyogi, S.K. Chakrabarty and M.K. Laha, Introduction to Computational Fluid Dynamics, Pearson Education, 2006.

5. K.A. Hoffman, and S.T.C. Hiang, Computational Fluid Dynamics, Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.
6. T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2003.
7. D.A. Anderson, J.C. Tannehill, and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer, McGraw Hill Book Company, 2002.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: A10	**Category:** Professional Elective Courses
Subject Name: Power Plant Engineering	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Thermodynamics, Heat Transfer	

Course Objectives:

To familiarize students with different aspects of power plant engineering, working of power plants based on different fuels and to expose the students to the principles of safety and environmental issues.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Analysis of Steam Cycles:** Introduction to the course, Power plant layout and essential feature of Rankine cycle, Reheating and regeneration, Problems on Rankine Cycle, Combined cycle power generation, Binary vapour cycles.	3
2	**Boilers:** Definition, classification, fire tube and water tube boilers, mountings and accessories. Draft in boilers, performance of boiler - boilers efficiency, equivalent evaporation, Losses in boilers. Coal and combustion: Properties of coal, ultimate analysis and proximate analysis, combination calculation. Super heater, economizer and air-pre heater. Handling of coal and ash.	8
3	Fuel bed firing, PF firing and Fluidized bed boilers. Introduction to boiling and circulation in boilers. Power station boilers - Benson, Lamont. Supercritical boiler.	4
4	**Steam turbine:** i) parts and classification, ii) nozzles types, flow through nozzles and nozzle efficiency. Impulse turbine - velocity diagram, work done and blade efficiency.	6
5	**Turbines:** Pressure compounding and velocity compounding of steam turbine. Impulse reaction turbine - Velocity diagram, degree of reaction and Parsons turbine. Governing in Steam turbine.	6
6	**Condensers:** Direct Contact Condenser Surface Condensers, Effect of various parameters on condenser performance, Design of condensers, cooling towers and cooling ponds.	6
7	**Power plant economics and other issues:**	3

	Load duration curves, Power plant economics, estimation of tariff. Diesel and gas plants, Pollution and control, Greenhouse effect and control, Peak load plants.	

Course Outcomes:

At the end of the course, student will be able to

1. Understand functions of the various components of power plant.
2. Illustrate the working of nuclear, thermal and gas based power plants.
3. Evaluate the design layout and working of hydroelectric power plants.
4. Estimate the feasibility and its implications on power generating units.

Learning Resources:

1. P.K. Nag, Power Plant Engineering, McGraw Hill, 2017.
2. Domkundwar, Arora and Domkundwar, Power Plant Engineering, Dhanpat Rai & Sons, New Delhi, 2016.
3. M.M. Ei-Wakil, Power Plant Technology, McGraw Hill Com., 1985.
4. P.C. Sharma, Power Plant Engineering, S.K. Kataria & Sons, New Delhi, 2010.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: A11	**Category:** Professional Elective Courses
Subject Name: Cryogenics	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Thermodynamics, Heat Transfer	

Course Objectives:

To provide the knowledge of evolution of low temperature science, properties of materials at low temperature and to familiarize with various gas liquefaction and refrigeration systems.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Definition and engineering applications of cryogenics, Properties of solids for cryogenic systems.	5
2	**Low Temperature Properties:** Properties of engineering materials (Mechanical properties, Thermal properties, Electric and Magnetic properties), Properties of Cryogenic fluids.	3
3	**Refrigeration and Liquefaction:** Simple Linde cycle, Pre-cooled Joule-Thomson cycle, dual-pressure cycle, Simon helium liquefier, classical cascade cycle, mixed-refrigerant cascade cycle.	6
4	**Ultra-low-temperature refrigerators:** Definition and fundamentals regarding ultra-low temperature refrigerators, Equipment associated with low-temperature systems, Various advantages and disadvantages.	7
5	**Storage and Handling of Cryogenic Refrigerants:** Storage and transfer systems, Insulation, Various types of insulation typically employed, Poly Urethane Foams (PUFs) and Polystyrene Foams (PSFs), Vacuum Insulation, and so on.	7
6	**Cryogenic Instrumentation:** Pressure, flow-rate, liquid-level and temperature measurements. Types of heat exchangers used in cryogenic systems (only description with figure). Cryo pumping applications.	6

7	**Applications:** Broad applications of cryogenic refrigerants in various engineering systems.	2

Course Outcomes:

Students will

1. Understand principles of cryogenic systems.
2. Understand air and helium liquefaction processes.
3. Be able to classify cascade refrigeration systems.
4. Understand principles of ultra-low temperature systems and their applications.
5. Be able to evaluate storage systems used in cryogenic applications.

Learning Resources:

1. M. Mukhopadhyay, Fundamentals of Cryogenic Engineering, Prentice Hall of India, 2010.
2. T. Flynn, Cryogenic Engineering, Revised and Expanded, CRC, 2004.
3. Arora and Domukundwar, Refrigeration and Air-conditioning, Dhanpat Rai & Co., 2018.
4. A.R. Jha, Cryogenic Technology and Applications, Butterworth-Heinemann, 2005.
5. K.D. Timmerhaus and R. Reed, Cryogenic Engineering, Fifty Years of Progress, Springer, 2007.
6. R.F. Barron, Cryogenic Systems, McGraw Hill, 1986.
7. R.B. Scott, Cryogenic Engineering, Van Nostrand Co., 1959.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : A12	**Category:** Professional Elective Courses
Subject Name : Introduction to Wind Engineering	**Semester**: Sixth/ Seventh/ Eighth
L-T-P : 3-0-0	**Credit:**3
Pre-Requisites: Fluid Mechanics	

Course Objective:

1. To know about the basic concepts of wind engineering.
2. To learn about bluff body aerodynamics as applied to wind engineering.
3. To know about the structural dynamics related to wind engineering.
4. To know about the aero-elastic phenomena caused due to wind flows.
5. To learn about wind tunnel simulation of aerodynamic and aero–elastic behaviour of bluff bodies.
6. To know about the application of wind engineering to design tall structures and stacks.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Introduction; state of the art in wind engineering.	4
2	Bluff body aerodynamics: boundary layer separation; wake and vortex formations; pressure, lift, drag and moment effect.	7
3	Structural dynamics: single degree of freedom linear system; multi–degree of freedom linear system; example of along–wind response.	7
4	Aero-elastic phenomena; vortex shedding and lock–in phenomena; models of vortex–induced response; across wind galloping; wake galloping; flutter; torsional divergence.	6
5	Wind tunnel simulation of aerodynamic and aero–elastic behaviour of bluff bodies.	6
6	Application to design of tall buildings, slender towers and stacks.	6

Course Outcomes:

After completing this course, the students will

1. know about the basic concepts of wind engineering.
2. learn about bluff body aerodynamics as applied to wind engineering.
3. know about the structural dynamics related to wind engineering.
4. know about the aero-elastic phenomena caused due to wind flows.
5. learn about wind tunnel simulation of aerodynamic and aero–elastic behaviour of bluff bodies.
6. know about the application of wind engineering to design tall structures and stacks.

Learning Resources:

1. E. Simiu and R.H. Scanlan, Wind Effects on Structures– Fundamentals and Applications to Design, John Wiley & Son, New York, 1996.
2. J.D. Holmes, Wind Loading of Structures, CRC Press, 2015. .
3. J.B. Barlow, W.H. Rae and A. Pope, Low Speed Wind Tunnel Testing, Wiley International, New York, 1999.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : A13	**Category:** Professional Elective Courses
Subject Name : Elements of Atmospheric Fluid Dynamics	**Semester**: Sixth/ Seventh/ Eighth
L-T-P : 3-0-0	**Credit: 3**
Pre-Requisites: Fluid Mechanics, Thermodynamics	

Course Objective:

1. To know about the general structure of the atmosphere and its behaviour.
2. To learn about various types of atmospheric circulations.
3. To know about the effects of earth's rotation and friction on wind movements.
4. To know about the structure of atmospheric boundary layer and turbulence.
5. To learn about smoke dispersion patterns and chimney height determination.
6. To know about the similarity analysis and scaling and wind tunnel simulation & testing.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	General structure of the atmosphere; elements of meteorology- lapse rate of temperature, temperature inversions, isotherms & isobars.	6
2	Atmospheric circulation, vertical convection, centrifugal effects, stability of the atmosphere.	6
3	Effect of earth's rotation, effect of friction. Atmospheric motions; wind scales.	6
4	Atmospheric boundary layer, governing equations; Ekman spiral; logarithmic and power laws; atmospheric turbulence.	6
5	Effect of wind on smoke dispersion; determination of chimney height.	5
6	Basic similarity requirements; dimensional analysis; basic scaling considerations; wind tunnel simulations of atmospheric flows; wind tunnel testing.	7

Course Outcomes:

After completing this course, the students will

1. know about the general structure of the atmosphere and its behaviour.
2. learn about various types of atmospheric circulations.
3. know about the effects of earth's rotation and friction on wind movements.
4. know about the structure of atmospheric boundary layer and turbulence.
5. learn about smoke dispersion patterns and chimney height determination.
6. know about the similarity analysis and scaling and wind tunnel simulation & testing.

Learning Resources:

1. E. Simiu and R.H. Scanlan, Wind Effects on Structures– Fundamentals and Applications to Design, John Wiley & Son, 1996.
2. S. Eskinazi, Fluid Mechanics and Thermodynamics of Our Environment, Academic Press, 1975.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: B1	**Category:** Professional Elective Courses
Subject Name: Composite Materials	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Materials Engineering	

Course Objectives:

To understand the mechanical behaviour of composite materials.

To get an overview of the methods of manufacturing composite materials.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Definition and applications of composite materials, Fibres- glass, carbon, ceramic and aramid fibres; Matrices- polymer, graphite, ceramic and metal matrices; characteristics of fibres and matrices. Lamina- assumptions, macroscopic viewpoint, generalized Hooke's law, reduction of homogeneous orthotropic lamina, isotropic limit case, orthotropic stiffness matrix, commercial material properties, rule of mixtures, transformation matrix, transformed stiffness.	12
2	Manufacturing of composite materials, bag moulding, compression moulding, pultrusion, filament welding, other manufacturing processes	8
3	Basic assumptions of laminated anisotropic plates, symmetric laminates, angle ply laminates, cross ply laminates, laminate structural moduli, evaluation of lamina properties, determination of lamina stresses, maximum stress and strain criteria, von Mises Yield criterion for isotropic materials, generalized Hill's criterion for anisotropic materials, Tsai-Hill's criterion for composites, prediction of laminate failure, thermal analysis of composite laminates.	8
4	Analysis of laminated plates- equilibrium equations of motion, energy formulation, static bending analysis, buckling analysis, free vibrations, natural frequencies.	8

Course Outcomes:

Upon completion of this course, the students will have an overview of the mechanical behaviour and application of composite materials

Learning Resources:

1. R.F. Gibson, Principles of Composite Material Mechanics, 2nd Edition, McGraw Hill, 1994.
2. M.W. Hyer, Stress Analysis of Fiber-Reinforced Composite Materials, McGraw Hill, 1998.
3. K.K. Chawla, Composite Materials- Science and Engineering, Springer International Publishing, 2019.
4. M. Mukhopadhyay, Mechanics of Composite Materials and Structures, University Press, 2013.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: B2	**Category:** Professional Elective Courses
Subject Name: Selection and Testing of Materials	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Materials Engineering, Design of Machine Elements	

Course Objectives:

The subject exposes students to the basics parameter for selection of materials and different classes of materials, and various destructive and non destructive testing methods of materials and its industrial applications.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Engineering Materials** Introduction – classification of engineering materials – selection of materials for engineering purposes –selection of materials and shape –classification metal and alloys, polymers, ceramics and glasses, composites, natural materials,-non metallic materials- smart materials - physical, metrical properties of metals.	5
2	**Material Properties** Mechanical properties - fatigue strength - fracture Toughness - Thermal Properties - Magnetic Properties - Fabrication Properties - electrical, optical properties - Environmental Properties, Corrosion properties - shape and size - Material Cost and Availability– failure analysis.	3
3	**Materials Selection Charts and Testing** Ashby material selection charts-Testing of Metallic Materials - Selection of Materials for Biomedical Applications - Medical Products - Materials in Electronic Packaging - Advanced Materials in Sports Equipment - Materials Selection for Wear Resistance - Advanced Materials in Telecommunications - Using Composites - Manufacture and Assembly with Plastics, fiber and Diamond Films	6
4	**Mechanical Testing** Introduction to mechanical testing, Hardness test (Vickers, Brinell, Rockwell), Tensile test, Impact test (Izod, Charpy) - Principles, Techniques, Methods, Advantages and Limitations, Applications. Bend test, Shear test, Creep and Fatigue test - Principles, Techniques, Methods, Advantages and Limitations, Applications.	6
5	**Non Destructive Testing** Visual inspection, Liquid penetrant test, Magnetic particle test,	6

	Thermography test – Principles, Techniques, Advantages and Limitations, Applications. Radiographic test, Eddy current test, Ultrasonic test, Acoustic emission- Principles, Techniques, Methods, Advantages and Limitations, Applications.	
6	**Material Characterization Testing** Macroscopic and Microscopic observations, Optical and Electron microscopy (SEM and TEM) - Principles, Types, Advantages and Limitations, Applications. Diffraction techniques, Spectroscopic Techniques, Electrical and Magnetic Techniques- Principles, Types, Advantages and Limitations, Applications.	6
7	**Other Testing** Thermal Testing: Differential scanning calorimetry, Differential thermal analysis. Thermomechanical and Dynamic mechanical analysis: Principles, Advantages, Applications. Chemical Testing: X-Ray Fluorescence, Elemental Analysis by Inductively Coupled Plasma-Optical Emission Spectroscopy and Plasma-Mass Spectrometry.	4

Course Outcomes:

1. To understand importance of engineering materials.
2. To choose materials for engineering applications.
3. To identify the material properties.
4. To identify suitable testing technique to inspect industrial component.
5. To use different techniques and know its applications and limitations.

Reference Books:

1. L. Gladius, Selection of Engineering Materials, Prentice Hall Inc. New Jersey, USA, 1995.
2. J.A. Charles and F.A.A. Crane, Selection and Use of Engineering Materials, 3rd Edition, Butterworths, London, UK, 1996.
3. M.F. Ashby, Materials Selection in Mechanical Design, 3rd Edition, Elsevier, 2005.
4. B. Raj, T. Jayakumar and M. Thavasimuthu, Practical Non-Destructive Testing, Narosa Publishing House, 2009.
5. ASM Metals Handbook, Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio, USA.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : B3	**Category:** Professional Elective Courses
Subject Name : Mechanical Vibration	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Kinematics & Theory of Machines	

Course Objectives:

To understand the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions through acquiring knowledge on vibratory models of dynamic systems with changing complexities, differential equation of motion of vibratory systems, free and forced (harmonic, periodic, non-periodic) vibration, single and multi degree of freedom linear systems.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Causes and effects of vibration, Classification of vibrating system, Discrete and continuous systems, degrees of freedom, Identification of variables and Parameters, Linear and nonlinear systems, linearization of nonlinear systems, Physical models, Schematic models and Mathematical models.	6
2	**SDF systems**: Formulation of equation of motion: Newton -Euler method, De Alembert's method, Energy method, Undamped Free vibration response and Damped Free vibration response, Case studies on formulation and response calculation.	6
3	**Forced vibration response:** Response to harmonic excitations, solution of differential equation of motion, Vector approach, Complex frequency response, Magnification factor Resonance, Rotating/reciprocating unbalances, Force Transmissibility, Motion Transmissibility, Vehicular suspension, Vibration measuring instruments, Case studies on forced vibration,	6
4	**Two degree of freedom systems:** Introduction, Formulation of equation of motion: Equilibrium method, Lagrangian method, Case studies on formulation of equations of motion. Free vibration response, Eigen values and Eigen vectors, Normal modes and mode superposition, Coordinate coupling, decoupling of equations of motion, Natural coordinates, Response to initial conditions, free vibration response case studies, Forced vibration response, undamped vibration absorbers, Case studies on undamped vibration absorbers.	7
5	**Multi degree of freedom systems:**	7

	Introduction , Formulation of equations of motion, Free vibration response, Natural modes and mode shapes, Orthogonally of model vectors, normalization of model vectors, Decoupling of modes, model analysis, mode superposition technique, Free vibration response through model analysis, Forced vibration analysis through model analysis, Model damping, Rayleigh's damping, Introduction to experimental model analysis.	
6	**Continuous systems**: Introduction to continuous systems, Exact and approximate solutions, free vibrations of strings, bars and beams.	4

Course Outcomes: Upon completion of this course, the students will be able to

1. Understand the causes and effects of vibration in mechanical systems.
2. Demonstrate schematic models for physical systems and formulate governing equations of motion.
3. Explain the role of damping, stiffness and inertia in mechanical systems
4. Analyze rotating and reciprocating systems and compute critical speeds.
5. Evaluate and design machine supporting structures, vibration isolators and absorbers.

Reference Books:

1. L. Meirovich, Elements of Vibration analysis, 2nd Edition, Mc-Graw Hill, 2007.
2. S.S. Rao, Mechanical Vibrations. 4th Edition, Pearson Education, 2011.
3. W.T. Thompson, Theory of Vibration, CBS Publishers, 2002.
4. C.W. de Silva, Vibration: Fundamentals and Practice, CRC Press, 2000.
5. G.K. Grover, Mechanical Vibrations, 8th Edition, Nemchand & Bros, Roorkee, 2009.
6. F.S. Tse, I.E. Morse and R.T. Hinke, Mechanical Vibrations, 2nd Edition, Chapman and Hall, 1991.
7. V.P. Singh, Mechanical Vibrations, 3rd Edition, Dhanpat Rai & Co., 2006.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: B4	**Category:** Professional Elective Courses
Subject Name: Tribology	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Fluid Mechanics, Design of Machine Elements	

Course Objectives:

1. To provide students with the fundamental knowledge in the field of Industrial tribology.
2. To provide basic concepts in the design of automotive lubrication system.
3. To provide knowledge of friction and wear mechanism in automotive system.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to Tribology: Introduction to Tribology, Tribology in design, Tribology in industry, economic aspects of Tribology, lubrication, basic modes of lubrication, lubricants, properties of lubricants-physical and chemical, types of additives, extreme pressure lubricants, recycling of used oils and oil conservation, disposal of scrap oil, oil emulsion. Types of sliding contact bearings, comparison of sliding and rolling contact bearings.	6
2	Friction and Wear: Friction: Introduction, laws of friction, kinds of friction, causes of friction, friction measurement, theories of friction, effect of surface preparation. Wear: Types of wear, various factors affecting wear, measurement of wear, wear between solids and liquids, theories of wear.	6
3	Hydrodynamic lubrication: Theory of hydrodynamic lubrication, mechanism of pressure development in oil film, two-dimensional Reynold's equation, infinitely long journal bearing, infinitely short journal bearing, finite bearing. Hydrodynamic thrust bearing: Introduction, flat plate thrust bearing, pressure equation, load, centre of pressure, friction in tilting pad thrust bearing.	6
4	Hydrostatic Lubrication: Hydrostatic lubrication: Basic concept, advantages and limitations, viscous flow through rectangular slot, load carrying capacity and flow requirement of hydrostatic step bearing, energy losses, optimum design of step bearing. Compensators and their actions. Squeeze film lubrication: Introduction, circular and rectangular plates approaching a plane.	6
5	Elastohydrodynamic Lubrication and Gas Lubrication: Elastohydrodynamic Lubrication: Principle and application, pressure-	6

	viscosity term in Reynolds equation, Hertz theory. Ertel- Grubin Equation. Gas lubrication: Introduction, merits and demerits, applications. Lubrication in metal working: Rolling, forging, drawing and extrusion. Bearing materials, bearing constructions, oil seals, shields and gaskets.	
6	Surface Engineering: Introduction to surface engineering, concept and scope of surface engineering, manufacturing of surface layers, solid surface geometrical, mechanical and physic chemical concepts, superficial -layer, development of concept, structure of superficial layer, general characteristics of superficial layer, obtained by machining, strengthening and weakening of superficial layer.	6

Course Outcomes:
Lerner will be able to
1. Apply knowledge of tribology for industrial component design.
2. Apply design concepts practically for automotive lubrication systems.

Text Books:
1. A. Cameron, Basic Lubrication Theory, Wiley Eastern Ltd., 1976.
2. S. Wen and P. Huang, Principles of Tribology, 2nd Edition, Wiley, 2012.
3. B.C. Majumdar, Introduction to Tribology and Bearings, S. Chand and Company Ltd., New Delhi, 2008.
4. D.D. Fuller, Theory and Practice of Lubrication for Engineers, John Wiley and Sons, 1984.
5. J. Halling, Principles of Tribology, McMillan Press Ltd., 1978.
6. B. Bhushan and B.K. Gupta, Handbook of Tribology: Materials, Coatings and Surface Treatments, McGraw-Hill, 1991.
7. J. Davis, Surface Engineering for Corrosion and Wear Resistance, Woodhead Publishing, 2001.
8. T. Burakowski and T. Wierzchon, Surface Engineering of Metals: Principles, Equipment, Technologies, Taylor and Francis, 1999.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: B5	**Category:** Professional Elective Courses
Subject Name: Finite Element Analysis	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Engineering Mechanics, Strength of Materials, Mathematics	

Course Objectives:

To apprise the students about the basics of the Finite Element analysis technique, a numerical tool for the solution of different classes of problems in solid mechanics, thermal engineering, and fluid mechanics.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Historical background, Relevance of FEA/FEM to design problems, Application to the continuum– Discretization, Matrix approach, Matrix algebra– Gaussian elimination, Governing equations for continuum, Classical Techniques in FEM, Weighted residual method, Ritz method, Galerkin method	6
2	**One dimensional problems:** Finite element modeling– Coordinates and shape functions, Potential energy approach– Element matrices and vectors, Assembly for global equations, Boundary conditions, Higher order elements- Shapes functions, Applications to axial loadings of rods– Extension to plane trusses, Bending of beams– Finite element formulation of stiffness matrix and load vectors, Assembly to Global equations, boundary conditions, Solutions and Post processing, Example Problems.	6
3	**Two dimensional problems– scalar variable problems:** Finite element modeling– CST element, Element equations, Load vectors and boundary conditions, Assembly, Application to heat transfer, Examples	3
4	**Two dimensional problems– vector variable problems**: Vector Variable problems, Elasticity equations–Plane Stress, Plane Strain and Axisymmetric problems, Formulation, element matrices, Assembly, boundary conditions and solutions Examples	7
5	**Isoparametric elements for two dimensional problems:** Natural coordinates, Isoparametric elements, Four node quadrilateral element, Shape functions, Element stiffness matrix and force vector, Numerical integration, Stiffness integration, Displacement and Stress calculations, Examples.	6
6	**Numerical Integration and 2-D problems of Elasticity:** Introduction to numerical integration, two dimensional integrals,	8

	plane stress, plane strain, axisymmetric, plate bending problems. **Thermal Applications:** Two- dimensional heat conduction analysis, formulation of functional, element matrices and case studies. **Fluid Mechanics Applications:** Stream function formulation, velocity potential formulation and torsional analysis of a prismatic bar. **Computer implementation:** Pre-processor, Processor, Post-processor. Discussion about finite element packages.	

Course Outcomes:

Student will be able to

1. Apply finite element method to solve problems in solid mechanics and heat transfer.
2. Formulate and solve problems in one dimensional structures including trusses, beams and frames.
3. Formulate FE characteristic equations for two dimensional elements and analyse plain stress, plain strain, and axi-symmetric and plate bending problems.
4. To learn and apply finite element solutions to structural, thermal, fluid mechanics problem
5. To develop the knowledge and skills needed to effectively evaluate finite element analyses

Text Books:

1. P. Seshu, Textbook of Finite Element Analysis, Prentice Hall of India, 2009.
2. J. N. Reddy, Finite Element Method in Engineering, McGraw Hill, 2009.
3. O.C. Zienkiewicz, R.L. Taylor and J.Z. Zhu, The Finite Element Method for Solid and Structural Mechanics, 4th Edition, Elsevier 2007.
4. R.D. Cook, D.S. Malkus and M.E. Plesha, Concepts and Applications of Finite Element Analysis, Wiley, 2001.
5. T.R. Chandrupatla and A.D. Belegundu, Introduction to Finite Elements in Engineering, Pearson, 2012.
6. C.S. Krishnamoorthy, Finite Element Analysis, McGraw Hill, 1994.
7. K.J. Bathe, Finite Element Procedures, Prentice Hall of India, 1982.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: B6	**Category:** Professional Elective Courses
Subject Name: Mechatronics	**Semester**: Sixth/ Seventh/ Eighth
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Fluid Mechanics and Fluid Machinery, Kinematics and Theory of Machines, Basic Electrical Engineering, Basic Electronics Engineering	

Course Objectives:

To provide knowledge on electrical circuits, signal conditioning.
To make familiar about control system and power electronics in designing mechatronic system

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to Mechatronics: Definition, Mechatronics in design and manufacturing, Comparison between Traditional and Mechatronic approach; Concurrent engineering	3
2	Review of fundamentals of electronics: Logic gates and their operations, Signal processing devices, Data conversion devices, Input and output devices. Sensors and Transducers, Actuators, Limit switches, Relays	6
3	Control Systems: Open loop and closed loop control, block diagrams, transfer functions, Laplace transforms.	3
5	Electrical Drives: Stepper motors, servo drives.	2
6	Mechanical Drives: Different mechanisms, Ball screws, Linear motion bearings, Transfer systems.	3
7	Pneumatic and Hydraulic Drives: Elements of pneumatic and hydraulic drives, comparison between them. Design of pneumatic and hydraulic circuits, symbolic representations of such circuits indicating different valves, actuators, etc.	4
8	Basics of 8085 microprocessor, programmable register architecture, buses, memory mapping, clock pulse and data transfer operations, and simple assembly and mnemonic programming on 8085 microprocessor.	5
9	Use of On-Off, PI and PID controllers to control different drives, Programming in PLC controller using Ladder diagram.	4
10	Mathematical modeling of physical systems, such as spring-mass vibration system, linear and rotory motion and its Laplace Transform.	2
11	Basics of time domain analysis, Introduction to discrete-time systems and Z-transform.	2
12	Introduction to Mechatronic systems, such as automatic brake, door closing and opening, robot, CNC machine, AGV, etc.	2

Course Outcomes:

At the end of the course, the student will be able to

1. Model and analyze mechatronic systems for an engineering application
2. Identify sensors, transducers and actuators to monitor and control the behavior of process or product.
3. Develop PLC programs for an engineering application.
4. Evaluate the performance of mechatronic systems.

Books:

1. W. Bolton, Mechatronics, 5th Edition, Addison Wesley Longman Ltd., 2010.
2. D. Shetty and R. Kolk, Mechatronics System Design, 3rd Edition, PWS Publishing, 2009.
3. D.G. Alciatore & M.B. Histand, Introduction to Mechatronics and Measurement systems, 4th Edition, McGraw Hill, 2006.
4. A. Smaili and F. Arnold, Applied Mechatronics, Oxford University Press, Indian Edition, 2007.
5. M.D. Singh and J.G. Joshi, Mechatronics, Prentice Hall of India, 2006.
6. K.K. Appu Kuttan, Introduction to Mechatronics, Oxford University Press, New Delhi, 2007.
7. HMT Ltd., Mechatronics, McGraw Hill Publication, 2017.
8. F.H. Raven, Automatic Control Engineering, McGraw Hill India, 2013.
9. K. Ogata, Modern Control Engineering, Prentice Hall, 2010.
10. B.C. Kuo, Automatic Control Systems, Prentice Hall, 1975.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: C1	**Category:** Professional Elective Courses
Subject Name: Advanced Welding Technology	**Semester:** Sixth/ Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Manufacturing Processes	

Course Objective:

To impart knowledge about different welding processes and their applicability.
To make the students understand the mechanism behind weld joints.
To impart ideas of different testing techniques of the welded joint.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Review of welding processes, joint design.	3
2	Descriptions and Parametric influences on Welding processes: Arc Welding- SMAW, Stud Arc welding, SAW, GMAW, GMAW-P, FCAW, GTAW, GTAW-P. Resistance Welding processes- Spot, Butt, Seam, Projection. Solid State Welding processes- Forge welding, Friction welding, Friction Stir welding, Diffusion welding, Roll welding.	6
3	Arc Welding- Different types of equipment, Power sources, Choice of Polarity, Arc characteristics, Modes of Metal Transfer, Welding Positions, Electrode selection.	5
4	Critical and Precision Welding processes- USW, PAW, LBW, EBW. Underwater Welding- Wet Welding and Dry Welding: Hyperberic and Cavity. Welding of Plastics- Hot Gas Welding, Hot Tool Welding, Hot Press Welding, Friction Welding, Ultrasonic Welding. Joining of Ceramics and Composites.	8
5	Welding Metallurgy, HAZ, Effect of different process parameters on the characteristics of weldment. Weldability of Plain Carbon Steel, Stainless Steel, Cast Iron, Aluminium and its Alloys.	8
6	Welding Defects- Types, Causes, Inspection and Remedial Measures. Testing of Welded Joints- Visual Inspection, Dye-Penetration (DP) Test, Ultrasonic Test and Radiography Test.	3
7	Welding Fixtures, Welding Automation and Robotic Welding. Safe Practices in Welding.	3

Course Outcome:

1. To familiarize different types of welding processes.
2. To familiarize the basic mechanism behind weld joint and influencing factors.
3. To impart the knowledge different tests to judge soundness of the weld joint.

Learning Resources:

1. O.P. Khanna, A Text Book of Welding Technology, Dhanpat Rai & Sons, 2015.
2. R.S. Parmar, Welding Engineering and Technology, Khanna Publishers, 2013.
3. M. Bhattacharyya, Weldment Design, The Association of Engineers, India Publication, Kolkata, 1991.
4. J.C. Lippold and D.J. Kotecki, Welding Metallurgy and Weldability of Stainless Steels, Wiley India (P) Ltd., New Delhi, 2011.
5. H. Udin, E.R. Funk and J. Wulf, Welding for Engineers, John Wiley and Sons, 1954.
6. J.L. Morris, Welding Process and Procedures, 2nd Edition, Prentice Hall, 1955.
7. J. F. Lancaster, The Metallurgy of Welding, 6th Edition, William Andrew Publishing, 1999.
8. B. Raj, V. Shankar, A.K. Bhaduri (Editors), Welding Technology for Engineers, Narosa Publishing House, 2006.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: C2	**Category:** Professional Elective Courses
Subject Name: Quantity Production Method	**Semester:** Sixth/ Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Manufacturing Technology	

Course Objectives:

To provide knowledge on different types of quantity production methods practised in industry.
To make students familiar with planning and scheduling for having high productivity and quality enhancement in industry.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Engineering Production; aim and objectives history of progress, definition and requirements. Levels of production; piece, batch, lot, mass and quantity production. Mechanisation and Role of automation in industrial production; need, degree and types of automation.	4
2	**Quantity Production Methods- Concept:** Broad classification of engineering production methods: Major sequential steps in industrial production; Preforming, semi finishing, heat treatment, finishing, assembly and inspection. Quantity production (methods) of common items: (i) shafts and spindles, (ii) automobile parts, engine block, piston, connecting rods and crank shaft, (iii) metallic wires, rods, tubes, bars, plates and sheets, (iv) various types of gears and bearings. Methods of quantity production of cutting tools, tool inserts and tool holders. Small size products: Pins, clips, needles, metallic caps, washers, utensils, chains springs, paste tubes and coins. Large scale production of bolts and nuts. Quantity production by spinning, bulging, magneto forming, hydro forming and explosive forming. Production by powder metallurgical process.	16
3	**Planning and Scheduling:** 3.1 Process planning and scheduling for quantity production using (i) semi-automatic and automatic lathes, (ii) transfer machines (iii) CNC machining systems (including machining centres, DNC	6

	and FMS) 3.2 Design and use of jigs and fixtures for batch production in machine shops	
4	**Productivity and Quality Enhancement in Quantity production:** Group technology; concept and application in large scale production. Inspection and quality control in quantity production. Computerisation and robotization in quantity production.	4
5	**Non-Conventional Manufacturing of Products in Quantity:** Quantity production by non-traditional processes; EDM, Wire-Cut EDM, ECM, AJM, AWJM, WJM, USM, CHM, EBM and PAM. Regenerative Manufacturing; Rapid Prototyping, Rapid Tooling and Rapid Manufacturing. Quantity Production of Ceramic and Polymer Products.	6

Course Outcomes:

At the end of the course, the student will be able to:

1. Gather knowledge about different quantity production methods practised in industry.
2. Understand planning and scheduling methods usually used in industry to have high productivity and to enhance quality.

Learning Resources:

1. M.P. Groover, Fundamentals of Modern Manufacturing, Wiley Pub, 2009.
2. S. Kalpakjian, Manufacturing Engineering and Technology, Pearson, 2002.
3. S.D.El Wakil, Processes and Design for Manufacturing, CRC Press, 2019.
4. R.A. Lindberg, Process and Materials of Manufacture, Pearson 2015.
5. E.P. DeGarmo, J.T. Black and R.A. Kosher, Materials and Processes in Manufacturing, Prentice Hall, 1997.
6. C. Donaldson, Tool Design, 4th Edition, McGraw Hill Publication, 2012.
7. G.C. Sen and A. Bhattacharyya, Principles of Machine Tools, New Central Agency Publication, Kolkata, 2015.
8. P.K. Mishra, Non-Conventional Machining, Narosa Publication, 1997.
9. A. Ghosh, Rapid prototyping, East-West Press Publication, New Delhi, 2016.
10. M. Palay, Metal Cutting Tool Production, MIR Publication, Moscow, 1968.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: C3	**Category:** Professional Elective Courses
Subject Name: 3D Printing and Design	**Semester:** Sixth/ Seventh/ Eighth
L-T-P: 3-0-0	**Credit:**3
Pre-Requisites: Computer Aided Design, Engineering Materials	

Objectives:

The course is designed to impart knowledge and skills related to 3D printing technologies, selection of material and equipment and develop a product using this technique in Industry 4.0environment.

Module No.	Description of Topic	Contact Hrs.
1	**3D Printing (Additive Manufacturing):** Introduction, Process, Classification, Advantages, Additive V/s Conventional Manufacturing processes, Applications.	2
2	**CAD for Additive Manufacturing**: CAD Data formats, Data translation, Data loss, STL format.	3
3	**Additive Manufacturing Techniques:** 3.1 Stereo-Lithography, LOM, FDM, SLS, SLM, Binder Jet technology. 3.2 Process, Process parameter, Process Selection for various applications. 3.3 Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defence, Automotive, Construction, Food Processing, Machine Tools	10
4	**Materials:** 4.1 Polymers, Metals, Non-Metals, Ceramics 4.2 Various forms of raw material- Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, Polymers and their properties. 4.3 Support Materials	7
5	**Additive Manufacturing Equipment:** 5.1 Process Equipment- Design and process parameters 5.2 Governing Bonding Mechanism 5.3 Common faults and troubleshooting 5.4 Process Design	8
6	**Post Processing:** Requirement and Techniques	3
7	**Product Quality:** 7.1 Inspection and testing 7.2 Defects and their causes	3

Course Outcomes:

At the end of the course, the student will be able to:

1. Develop CAD models for 3D printing, import and export CAD data to generate .stl file.
2. Select a specific material for the given application.
3. Select a 3D printing process for an application.
4. Produce a product using 3D Printing or Additive Manufacturing.

Learning Resources:

1. L. Gibson, D.W. Rosen and B. Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.
2. A. Gebhardt, Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing, Hanser Publisher, 2011.
3. C.K. Chua and K.F. Leong, 3D Printing and Rapid Prototyping- Principles and Applications, World Scientific, 2017.
4. J.D. Majumdar and I. Manna, Laser-Assisted Fabrication of Materials, Springer Series in Material Science, 2013.
5. L. Lu, J. Fuh and Y.S. Wong, Laser-Induced Materials and Processes for Rapid Prototyping, Kulwer Academic Press, 2001.
6. Z. Fan and F. Liou, Numerical Modelling of the Additive Manufacturing (AM)Processes of Titanium Alloy, InTech, 2012.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: C4	**Category:** Professional Elective Courses
Subject Name: Micro and Nano Manufacturing	**Semester:** Sixth/ Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Manufacturing Technology	

Course Objective:

To give an outline of different micromachining and micro manufacturing technologies and their applications.
To give an idea about nanotechnology by molecular or atomic manipulation and to make nano-features. Also to give knowledge various application areas of some nano materials.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to micromachining, milimachining and nanotechnology, their differences, history of their development, application of miniaturized components in electronics, mechanical, MEMS, medical applications such as laparoscopic surgery, laser angioplasty, etc.	3
2	Different fabrication processes: Silicon process, LIGA process, Precision Machining Processes- Laser-Assisted Etching, Photoforming, Stereolithography, Electrochemical Micromachining, etc**.**	6
3	Components of Micromachines: Microsensors, Microfittings, Microactuators- electromagnetic, electrostatic, piezoelectric, and thermally and photothermally actuated micromechanisms, Microfluidic devices.	4
4	Microdrip fabrication, Micromanufacturing using electron microscopes, Handling of micro components with laser tweezers, etc., Microfinishing Processes like honing, lapping, superfinishing, burnishing.	3
5	Mesoscopic domain of micromachines- Introduction, biological systems, cells as machines, role of proteins, physics of micromechanism, future prospects.	3
6	Fabrication of devices with high-precision nano-features on metals and semiconductors utilizing Electrochemical Microsystem Technology (EMST) and Electrochemical Nanotechnology (ENT), Self-Assembled Monolayers by molecular self-assembly, Manipulation with DNA in biological system based	6

	nanofabrication.	
7	Nanomaterials, such as carbon nanotube (CNT) or graphene, etc. - Their uses in various manufacturing applications.	6

Course Outcome:
After completing this course, the students will

1. Know different micromachining and micro-manufacturing technologies and their applications.
2. Gain some knowledge about nanotechnology by molecular or atomic manipulation and to make nano-features.
3. Get an idea about various application areas of some nanomaterials.

Learning Resources:
1. I. Fujimasa, Micromachines: A New Era in Mechanical Engineering, Oxford Science Publications, 1996.
2. V.K. Jain, Introduction to Micromachining, Alpha Science International Ltd., 2014.
3. J.P. Davim and M.J. Jackson, Nano and Micromachining, Wiley, 2010.
4. J.A. McGeough, Micromachining of Engineering Materials, Taylor & Francis Inc, 2001.
5. B. Bhattacharyya, Electrochemical Micromachining for Nanofabrication, MEMS and Nanotechnology, Elsevier Publication, 2015.
6. S. Kalpakjian, Manufacturing Engineering and Technology, Pearson, 2002.
7. P.C. Pandey and H.S. Shan, Modern Machining Processes, Tata-McGraw Hill Publication, 1980.
8. H.E. Hofy, Advanced Machining Processes- Nontraditional and Hybrid Machining Processes, McGraw Hill Publication, New York, 2005.
9. R.L. Murty, Precision Engineering in Manufacturing, New Age International Publishers, 1996.
10. M. Ratner and D. Ratner, Nanotechnology, Prentice Hall/ Pearson Education, USA, 2003.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: C5	**Category:** Professional Elective Courses
Subject Name: CAD/CAM	**Semester:** Sixth/ Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Manufacturing Technology, Elements of Mechanical Design, Mathematics	

Course Objective:

To impart knowledge about computer aided design- geometric modeling, stress analysis.
To give an idea about computer aided manufacturing system, its components including application of robot.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Fundamentals of CAD- Design process, benefits of computer aided design, graphics standards.	3
2	Geometric modeling- wire-frame, surface and solid modeling Transformation- translation and rotation exercise problems and programming. Stress analysis- basics of FEM, formation of stiffness matrix for two elements.	6
3	Introduction to computer aided manufacturing (CAM) systems, basic building blocks of computer integrated manufacturing (CIM).	4
4	Toolings of CNC machines, tool and work handling systems involving robot, AGV, RTV, AS/RS, ATC, APC.	3
5	Robotics; types, anatomy, drives and applications.	3
6	Computer aided production planning and control, Manufacturing from product design- CADCAM interface, concept of group technology (GT), CAPP.	6
7	Control systems, Process monitoring, Adaptive control systems, etc.	2
8	Automatic inspection systems, use of CMM, Reverse Engineering.	1

Course Outcome:

1. To familiarize the basics of computer aided design- geometric modeling, stress analysis.
2. To familiarize the basics of computer aided manufacturing.
3. To familiarize the components of computer aided manufacturing system including application of robot and control systems.

Learning Resources:

1. P.N. Rao, N.K. Tewari and T.K. Kundra, Computer Aided Manufacturing, McGraw-Hill Publication, 2017.
2. M.P. Groover and E.W. Zimmers Jr., CAD/CAM, Prentice Hall of India, 1983.
3. P. Radhakrishnan, S. Subramanyan and V. Raju, CAD/CAM/CIM, New Age International Publishers, 2007.
4. P.N. Rao, CAD/CAM, McGraw Hill Publication, 2010.
5. M.P. Groover, Automation, Production Systems, and Computer- Integrated Manufacturing, Prentice Hall of India, 2016.
6. I. Zeid, CAD/CAM- Theory and Practice, McGraw-Hill Publishing Co. Ltd., New Delhi, 1991.
7. S.R. Deb and S. Deb, Robotics Technology and Flexible Automation, McGraw-Hill Publication, 2010.
8. S.K. Saha, Introduction to Robotics, McGraw-Hill Publication, 2008.
9. P.B. Mahapatra, Computer-Aided Production Management, Prentice Hall of India, 2010.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: C6	**Category:** Professional Elective Courses
Subject Name: Robotics	**Semester:** Sixth/ Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Manufacturing Technology	

Course Objective:

To impart knowledge about the engineering aspects of Robots and their application

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction: Basic concepts- Robot anatomy- Manipulators- kinematics: Forward and inverse kinematics- Precision movement, robot specifications and Work volume, Types of Robot drives- Basic robot motions- Point to point control, continuous path contour.	8
2	End Effectors: End effectors- classification- mechanical, magnetic, vacuum and adhesive gripper- gripper force analysis and design. Robot control- Unit control system concept- servo and non-servo control of robot joints, adaptive and optimal control.	7
3	Sensors: Sensor devices, Types of sensors- contact, position and displacement sensors, Force and torque sensors- Proximity and range sensors- acoustic sensors- Robot vision systems- Sensing and digitizing- Image processing and analysis.	6
4	Robot Programming: Robot language classification- programming methods- off and on line programming- Lead through method- Teach pendent method- VAL systems and language, simple program.	8
5	Industrial Application: Application of robots- Material handling- Machine loading and unloading, Assembly, Inspection, Welding, Spray painting, Mobile robot, Microbots- Recent developments in robotics- safety consideration.	7

Course Outcome:

1. To familiarize the Basics of robots Control system.
2. To familiarize the end effectors, Sensor technology and Industrial application of robot.

Learning Resources:

1. S.R. Deb, Robotics technology and flexible automation, McGraw Hill publishing company limited, New Delhi, 1994.

2. M.P. Groover. Industrial Robotics Technology Programming and Applications, McGraw Hill Book Co, Singapore, 1987.
3. S.K. Saha, Introduction to Robotics, McGraw-Hill Publication, 2014.
4. Y. Koren, Robotics for Engineers, McGraw Hill, New York, 1985.
5. P.G. Ranky and C.Y. Ho, Robots Modelling Control and Applications with Software, Springer Verlag, 1985.
6. J.J. Craig, Introduction to Robotics, Addison-Wesley, 2009.
7. R.J. Schilling, Fundamentals of Robotics Analysis and Control, Prentice Hall of India, 1996.
8. T. Yoshikawa, Foundations of Robotics Analysis and Control, Prentice Hall of India, 2010.
9. K.S. Fu, R.C. Gonzales and C.S.G. Lee, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1997.
10. W. Stadler, Analytical Robotics and Mechatronics, McGraw Hill Book Co., 1995.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: C7	**Category:** Professional Elective Courses
Subject Name: Material Handling	**Semester**: Sixth/ Seventh/ Eighth
L-T-P : **3-0-0**	**Credit: 3**
Pre-Requisites: Kinematics and Theory of Machines	

Course Objective:

1. To know about the material handling systems used in industry.
2. To learn about basic designing principles of some material handling systems.
3. To know about modern handling system using a robot.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Definition, importance and scope of material handling (MH); classification of materials; codification of bulk materials ; utility of following principles of MH– (i) materials flow, (ii) simplification, (iii) gravity, (iv) space utilization, (v) unit size, (vi) safety, (vii) standardization, (viii) dead-weight, (ix) idle time, (x) motion.	4
2	**Unit load**: Definition; advantages & disadvantages of unitization; unitization by use of platform, container, rack, sheet, bag and self contained unit load; descriptive specification and use of pallets, skids, containers, boxes, crates and cartons; shrink and stretch wrapping. **Classification of MH Equipment**: Types of equipment– (i) industrial trucks & vehicles, (ii) conveyors, (iii) hoisting equipment, (iv) robotic handling system and (v) auxiliary equipment; Independent equipment wise sub classification of each of above type of equipment.	6
3	**Industrial trucks & vehicles**: Constructional features and use of the following equipment – (i) wheeled hand truck, (ii) hand pallet truck, (iii) fork lift truck; Major specifications, capacity rating and attachments of fork lift truck.	5
4	**Conveyors:** Use and characteristics of belt conveyor, constructional features of flat and troughed belt conveyor; Use and constructional features of chain conveyors– (i) apron, car and trolley type; Construction of link-plate chains; Dynamic phenomena in chain drive; Use and constructional features of roller conveyors; Gravity and powered roller conveyor; Pneumatic conveyor-use and advantages; Positive, negative and combination system of pneumatic conveyors; constructional feature, application and conveying capacity of screw conveyor.	8

5	**Hoisting Equipment**: Advantage of using steel wire rope over chain; constructional features of wire ropes; Rope drum design; Pulley system-simple vs. multiple pulley; Load handling attachments : hooks, grabs, tongs, grab bucket; Arrangement of hook suspension with cross piece and pulleys (sheaves); Use and constructional features of (i) hand operated trolley hoist , (ii) winch; (iii) bucket elevator, (iv) Jib crane, (v) overhead traveling crane and (vi) wharf crane; Level luffing system of a wharf crane; Utility of truck mounted and crawler crane.	8
6	**Robotic handling**: Materials handling at workplace; Major components of a robot; Applications of robotic handling.	2
7	**Auxiliary Equipment:** Descriptive specification and use of (i) Slide and trough gates, (ii) belt, screw and vibratory feeders, (iii) Chutes, (iv) positioners like elevating platform, ramps, universal vice; (v) ball table.	3

Course Outcomes:

After completing this course, the students will

1. know about constructional features, working principle and specific applications of each of the material handling system.
2. learn about unit load calculation and selecting specification of some material handling system.

Learning Resources:

1. S. Ray, Introduction to Materials Handling, New Age International Pub., 2017.
2. T.K. Ray, Mechanical Handling of Materials, Asian Books Pvt. Ltd., 2005.
3. T.H. Allegri, Materials Handling: Principles and Practices, CBS Publishers and Distributors, 2018.
4. J.M. Apple, Material Handling System Design, John Wiley & Sons, 1972.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: C8	**Category:** Professional Elective Courses
Subject Name: Principles & Practices of Management	**Semester:** Sixth/ Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Basic Engineering Concept	

Course Objectives:

To provide knowledge on different aspects of management applied in an industry.
To make familiar about some management decision making systems and motivational aspects usually practiced in an industry.

Module No.	Description of Topic	Contact Hrs.
1	**Management:** Definition, nature, importance, evolution of management thoughts– pre & post scientific era, contributions made by Taylor, Fayol, Gilbreth, Elton Mayo, McGregor, Maslow– Covering Time & Motion Study, Hawthrone Experiments; Is management a science or art? Functions of manager, ethics in managing and social responsibility of managers.	5
2	**Planning & Control:** Why Management process starts with planning, steps in planning, planning premises, types of planning, barriers to effective planning, operational plan, strategic planning, Mckinsey's 7's Approach, SWOT analysis, Controlling- concept, Planning- control relationship, process of control, human response to control, dimensions of control, MBO.	5
3	**Decision Making & Organizing:** Nature, process of decision making, decision making under Certainty and Uncertainty, decision-tree, group-aided decision, brain-storming; Organizing – concept, nature and process of organizing, authority and responsibility, delegation and empowerment, centralization and decentralization, concept of departmentation.	6
4	**Staffing & Motivation:** Concept, Manpower planning, Job design, recruitment & selection, training anddevelopment, performance appraisal, motivation, motivators and satisfaction, motivating towards organizing objectives, morale building.	5
5	**Leadership & Communication:** Defining leadership and its role, should managers lead, leadership style, leadership development, Leadership behavior. Communication- Process, Bridging gap-using tools of communication, electronic media in Communication.	5
6	**Financial Management:** Financial functions of management, Financial Planning, Management of Working Capital, Sources of	5

	Finance.	
7	**Marketing Management:** Functions of Marketing, Product Planning & Development, Marketing Organization, Sales Organization, Sales Promotion, Consumer Behaviour, Marketing Research and Information.	5

Course Outcomes: At the end of the course, the student will be able to:

1. Understand the evolutionary development of management thought and general principles of management.
2. Understand the management functions in an organization

Learning Resources:

1. S. Robbins and M. Culter, Management, Pearson, 2016.
2. J.R. Schermerhorn, Introduction to Management, Wiley India Edition, 2011.
3. C.J. O'Donnel and H. Koontz, Principles of Management, McGrew Hill, 1995.
4. R.L. Daft, New Era of Management, Cengage Learning, 2008.
5. J.A.F. Stoner, R. Freeman and D.R. Gilbert. Jr., Management, Prentice Hall of India, 1985.
6. H. Koontz and H. Weihrich, Essentials of Management, McGrew Hill, 2007.
7. D.C. Bose, Principles of Management and Administration, Prentice Hall of India, 2012.
8. K. Nerkar, V. Chopde and Kogent Learning Solutions Inc, Principles and Practices of Management, Dreamtech Press, 2011.
9. P. Diwan, Management Principles and Practices, Excel Books, New Delhi, 2002.
10. R.L. Daft, Principles of Management, Cengage Learning, 2012.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: C9	**Category:** Professional Elective Courses
Subject Name: Process Planning and Cost Estimation	**Semester:** Sixth/ Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Manufacturing Processes	

Course Objectives:

To introduce process planning concepts to make cost estimation for various products.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction of Process Planning- methods of process planning, drawing interpretation, material evaluation, steps in process selection, production equipment and tooling selection.	6
2	Process planning activities- process parameter calculation for various production processes, selection of jigs and fixtures, selection of quality assurance methods, documents for process planning, economics of process planning, case studies.	8
3	Introduction to cost estimation- importance of costing and estimation, methods of costing, elements of cost estimation, types of estimates, estimating procedure, estimation of labour cost, material cost, allocation of overhead charges, calculation of depreciation cost.	7
4	Machining time estimation- importance of machine time calculation, machining time for different lathe operations, drilling and boring time calculations, Machining time calculation for Milling, Shaping, Planing and Grinding.	7
5	Production costs- different production processes for different jobs, estimation of forging cost, estimation of welding cost, estimation of foundry cost, estimation of machining cost.	8

Course Outcomes:

Upon completion of this course, the students will be able to use the concepts of process planning and cost estimation for various products

Learning Resources:

1. P. Scalon, Process Planning, Design/ Manufacture Interface, Elsevier Sc. & Tech, 2002.
2. P.F. Ostwaal and J. Munez, Manufacturing Processes and Systems, 9th Edition, John Wiley, 1998.
3. A.V. Chitale and R.C. Gupta, Product Design and Manufacturing, 2nd Edition, Prentice Hall, 2002.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: C10	**Category:** Professional Elective Courses
Subject Name: Maintenance Engineering	**Semester:** Sixth/ Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Manufacturing Processes	

Course Objectives:

To provide knowledge on different aspects of repair and maintenance practised in industry.
To make students familiar with different repair and maintenance strategies used in industry.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Definitions of repair and maintenance; Importance of maintenance; Different maintenance systems- breakdown, preventive, planned; predictive maintenance through condition monitoring; Maintainability, failure pattern, availability of equipment/ systems, design for maintainability.	5
2	**Total Productive Maintenance (TPM):** definition, objective & methodology; Implementation of TPM; Lean maintenance; Overall equipment effectiveness (OEE).	3
3	**Organizational structures for maintenance:** Objective; Maintenance functions and activities; Organizational requirements; Types of maintenance organizations, Manpower planning; Engineering stores & inventory management.	4
4	**Economic Aspect of Maintenance:** Life cycle costing; Maintenance cost & its impact; Maintenance budget; Cost control; Maintenance audit- Procedure, tools, planning, reports.	4
5	**Function and use of Maintenance Equipment, Instruments & Tools:** Facilities like NDT, painting, coating and cladding, Gas cutting and welding, crack detection, vibration monitor, balancing equipment, compressor, basic machine tools, lubricators and lubricants, chain pulley block, Tools like different types of wrenches, torque wrench, pipe wrench, plier, screw driver, dimension measuring instruments, feeler gauge, scraper, fitting shop tools, spirit level, hand grinder & drill, screw jack, etc.	6
6	**Lubrication:** Purpose & importance; Type of lubricants, Properties of lubricants; Types of lubrication and their typical applications, lubrication devices, centralized lubrication system; Gasket, packing and seals.	4
7	**Repair & Maintenance Procedures:** Repair of cracks, threads,	10

	worn shafts, keyways, bush bearing, damaged gear tooth. Assembly and dismantling of antifriction bearing; Maintenance of bearing, clutches, coupling, brakes, Alignment of shafts, belt and chain drives, gear drives, centrifugal pump, pipe and pipe fittings, electrical wiring, isolators and main switches, small induction motors; Steps for installation of a machine.	

Course Outcomes:

At the end of the course, the student will be able to:

1. Know different types of repair and maintenance procedures practised in industry.
2. Understand different repair and maintenance strategies used in industry.
3. Understand the organizational structure of an industry for maintenance management and the economy involved in this.

Learning Resources:

1. R.C. Mishra and K. Pathak, Maintenance Engineering and Management, PHI, 2012.
2. S.K. Srivastava, Maintenance Engineering and Management, S. Chand & Company Ltd., New Delhi, 1998.
3. K. Venkataraman, Maintenance Engineering and Management, PHI, 2007.
4. K. Mobley, Maintenance Engineering Handbook, McGraw Hill, Eighth Edition, 2014.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Open Electives

B.Tech (Mechanical Engineering) Course

There are three Open Elective Course Papers in Semester VII and VIII as follows:
(Open Elective-I) OE-ME701, (Open Elective-II) OE-ME801, and
(Open Elective-III) OE-ME802.

Students are to choose one paper for each of the Open Elective Courses specified in the curriculum structure of a Semester from the following list of Open Elective Papers. Selection of a paper should be non-repetitive. If a student chooses the paper, **Industrial Engineering (Code: A)** as an **Open Elective-I in Semester VII**, its paper code will be **OE-ME701A**. Similarly, in case **Safety and Occupational Health (Code: F)** is chosen by one in **Semester VIII as Open Elective-III**, its paper Code will be **OE-ME802F**.

Subject Code	Subject Name
A	Industrial Engineering
B	Total Quality Management
C	Project Management
D	Entrepreneurship Development
E	Introduction to Product Design and Development
F	Safety and Occupational Health
G	Industrial Pollution and Control
H	Energy Conservation and Management
I	Non-conventional Energy Sources
J	Waste to Energy- An Overview
K	Biomechanics and Biomaterials
L	Computational Methods in Engineering
M	Automation & Control
N	Internet of Things (IoT)
O	Artificial Intelligence (AI)
P	Block Chain
Q	Cyber Security
R	Quantum Computing
S	Data Sciences
T	Machine Learning
U	Virtual Reality (VR)
V	Water Resource Engineering

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: A	**Category:** Open Elective Courses
Subject Name: Industrial Engineering	**Semester:** Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Basic Engineering Knowledge	

Course Objectives:

To provide introductory knowledge on Industrial Engineering, concept of Productivity and work study.
To make familiar about facility layout and planning, systems of production planning and control and technics of inventory management.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to Industrial Engineering and Productivity:** Definition and Functions of Industrial Engineering, Origin and development of factory system, Contribution of Taylor and Gilbreth Productivity: Definition of productivity, Factors Influencing Productivity, Causes of Low Productivity, Productivity Measurement Models, Productivity Improvement Techniques.	3
2	**Work Study**: Basic Concept, Steps Involved in Work Study, Techniques of Work Study, Human Factors in the Application of Work Study. Method Study: Basic Concept, Steps Involved in Method Study, Recording Techniques, Operation Process Charts, Flow Process Charts, Two-Handed-Process Charts, Multiple Activity Charts, Flow Diagrams. String Diagrams, Principles of Motion Economy, Micro-Motion Study, Therbligs, SIMO Charts. Work Measurement: Basic Concept, Techniques of Work Measurement, Steps Involved in Time Study, Time Study Equipment, Performance Rating, Basic concept and Procedure of Work Sampling Study.	10
3	**Facility Layout and Planning:** Nature, Significance and Scope of Facility layout and design; Steps in facility layout planning, Assembly Line Balancing. Material Handling: Definition, Objective and Principles of Material Handling, Classification of Material Handling Devices.	10
4	**Production Planning and Control:** Introduction to Production Systems, Types of production systems, Need and functions of PPC. Forecasting: Definition and Functions of Forecasting, Forecasting	4

	techniques: linear regression, moving average, exponential smoothing; Analysis of forecast error. Aggregate production planning, Capacity Planning, ERP, Master Production Schedule. Basic sequencing and scheduling techniques.	
5	**Introduction to Inventory Management:** Importance and areas of materials management, Introduction to Inventory: Definitions, Need for inventory, Types of inventory, Inventory costs; Structure of inventory models, Deterministic models; safety stock, inventory control systems; Selective inventory management. MRP and JIT-based production systems, Concept of zero inventory, Fundamental concepts of purchasing, storing, distribution, and value analysis & engineering.	9

Course Outcomes: At the end of the course, the student will be able to:

1. Understand the concepts of Industrial Engineering.
2. Explain production systems and their characteristics.
3. Understand the role of productivity in streamlining a production system.
4. Describe different aspects of work system design and facilities design pertinent to manufacturing industries
5. Apply forecasting and scheduling techniques to production systems.
6. Apply the inventory management tools in managing inventory

Learning Resources:

1. O.P. Khanna, Industrial Engineering and Management, Dhanpat Rai Publication, 1980.
2. M.T. Telsang, Industrial Engineering and Production Management, S. Chand Publishing, 2018.
3. K.B. Zandin and H.B. Maynard, Maynard's Industrial Engineering Hand Book, McGraw Hill Education, 2001.
4. ILO, Introduction to Work Study, Oxford and IBH Publishing, 1992.
5. B. Mahadevan, Operations Management: Theory and Practice, Pearson, 2010.
6. S.N. Chary, Production and Operations Management, McGraw-Hill Education, 2019.
7. K. Bedi, Production and Operations Management, Oxford University Press, 2004.
8. A. Tompkins, J.A. White, Y.A. Bozer, and J.M.A. Tanchoco, Facilities Planning, Wiley, 2005.
9. S. Ray, Introduction to Materials Handling, New Age International, 2016.
10. S.L. Narasimhan, D.W. McLeavy and P.J. Billington, Production Planning and Inventory Control, Prentice Hall, 2009.
11. E.A. Silver, D.F. Pyke and R. Peterson, Inventory Management and Production Planning and Scheduling, John Wiley, 1998.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: B	**Category:** Open Elective Courses
Subject Name: Total Quality Management	**Semester:** Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Basic Engineering Knowledge	

Course Objectives:

To express knowledge about various aspects of quality and total quality management.
To understand different tools of TQM and related standards.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Need for quality, Definition of Quality, Evolution of quality, Product quality and Service quality, Dimensions of Quality, Definition of Total quality management, Quality Planning, Quality costs - Analysis, Techniques for Quality Costs, and Basic concepts of Total Quality Management. Quality Council, Quality Statements, Strategic quality planning, Barriers to TQM Implementation, Benefits of TQM, Contributions of Deming, Juran and Crosby.	6
2	**TQM Principles:** Customer satisfaction- Customer Perception of Quality, Customer Complaints, Service Quality. Customer Retention; Employee involvement, motivation; Empowerment; Team and Teamwork; Quality circles, recognition and reward, performance appraisal; Continuous process improvement; PDCA cycle, 5S, Kaizen; Supplier partnership, Partnering, Supplier rating & selection.	6
3	**TQM Tools and Techniques:** Benchmarking- Reasons to Benchmark, Benchmarking Process; Quality Function Deployment (QFD); Taguchi Quality Loss Function; Seven traditional tools of quality; New management tools; Process capability; Six sigma- concepts, methodology; TPM- concepts, improvement needs, performance measures; FMEA- Stages of FMEA.	18
4	**Quality Systems:** Need for ISO 9000 and Other Quality Systems, ISO 9001:2015 Quality System- Elements, Documentation; Quality Auditing, QS 9000, ISO 14000- Concept, Requirements and Benefits; TQM implementation in manufacturing and service sectors	6

Course Outcomes: At the end of the course, the student will be able to:

3. Understand quality management philosophies, techniques, and frameworks
4. Apply tools and techniques of TQM in manufacturing and service sectors.

5. Understand the implications of quality management standards and systems

Learning Resources:

7. D.H. Besterfield, C. Besterfield, G.H. Besterfield, M. Besterfield, H. Urdhwareshe and R. Urdhwareshe, Total Quality Management, Pearson Education, 2018.
8. A. Mitra, Fundamentals of Quality Control and Improvement, Wiley Student Edition, 2008.
9. S. Ramasamy, Total Quality Management, McGraw Hill Publishing Co., New Delhi, 2011.
10. J.R. Evans and W.M. Lindsay, The Management and Control of Quality, Cengage Learning, 1999.
11. D.C. Montgomery, Introduction to Statistical Quality Control, John Wiley, 2019.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: C	**Category:** Open Elective Courses
Subject Name: Project Management	**Semester:** Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Basic Engineering Knowledge	

Course Objectives:

To have knowledge about resource allocation, market and demand analysis, technical analysis, economic and ecological analysis related to project management.
To understand optimisation techniques applied to project management.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Introduction to Project Management, History of Project Management, Types & Characteristics of Projects, Project Life Cycle. Project Identification and Screening.	4
2	**Project Analysis:** Facets of Project Analysis, Strategy and Resource Allocation, Market and Demand Analysis, Technical Analysis, Economic and Ecological Analysis. Cash flows for project appraisal- Investment evaluation using capital budgeting techniques, net present value, profitability index, internal rate of return, payback period, accounting rate of return.	12
3	**Network Technique for Project Management:** Development of Project Network, Time Estimation, Determination of the Critical Path, PERT Model, CPM Model.	10
4	**Optimisation in Project Management:** Time and Cost trade-off in CPM, Crashing procedure, Scheduling when resources are limited.	5
5	**Organization systems for project implementation:** Work Breakdown, coordination and control, Project Management Softwares.	5

Course Outcomes:

At the end of the course, the student will be able to:

1. Understand the concept of projects and its phases.
2. Analyze project from marketing, operational and financial perspective.
3. Develop network diagrams for planning and execution of a given project.

Learning Resources:

1. P. Chandra, Project: A Planning Analysis, McGraw Hill Book Company, New Delhi, 2017.

2. C.F. Grey, E.W. Larson and G.V. Desai, Project Management the Managerial Process, McGraw Hill Education (India), New Delhi, 1990.
3. K. Harold, Project Management: A Systems Approach to Planning, Scheduling and Controlling, Wiley Student Edition, 2013.
4. J.D. Wiest and F.K. Levy, A Management Guide to PERT/ CPM with PERT/ PDM/ DCPM and Other Networks, PHI Learning Private Limited, 1970.
5. A. Kanda, Project Management: A Life Cycle Approach, PHI, 2010.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : D	**Category:** Open Elective Courses
Subject Name : Entrepreneurship Development	**Semester** : Seventh/ Eighth
L-T-P : **3-0-0**	**Credit: 3**
Pre-Requisites: Basic Engineering Knowledge	

Course Objective:

To develop and strengthen entrepreneurial quality and motivation in students and to impart basic entrepreneurial skills.
To understand how to run a business efficiently and effectively.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Entrepreneurship: Types of Entrepreneurs– Difference between Entrepreneur and Intrapreneur, Entrepreneurship in Economic Growth, Factors Affecting Entrepreneurial Growth.	7
2	Motivation: Major Motives Influencing an Entrepreneur– Achievement Motivation Training, Self Rating, Business Games, Thematic Apperception Test– Stress Management, Entrepreneurship Development Programs– Need, Objectives.	7
3	Business: Small Enterprises– Definition, Classification– Characteristics, Ownership Structures– Project Formulation– Steps involved in setting up a Business– identifying, selecting a Good Business opportunity, Market Survey and Research, Techno Economic Feasibility Assessment– Preparation of Preliminary Project Reports– Project Appraisal– Sources of Information– Classification of Needs and Agencies.	8
4	Financing And Accounting: Need– Sources of Finance, Term Loans, Capital Structure, Financial Institution, Management of working Capital, Costing, Break Even Analysis, Taxation– Income Tax, Excise Duty– Sales Tax.	7
5	Support to Entrepreneurs: Sickness in small Business– Concept, Magnitude, Causes and Consequences, Corrective Measures– Business Incubators– Government Policy for Small Scale Enterprises– Growth Strategies in small industry– Expansion, Diversification, Joint Venture, Merger and Sub Contracting.	7

Course Outcomes:

Upon completion of this course, the students will be able to:

1. Gain knowledge and skills needed to run a business successfully.
2. Interpret key regulations and legal aspects of entrepreneurship in India.
3. Understand the concept of business plan and ownerships.

Learning Resources:

1. S.S. Khanka, Entrepreneurial Development, S. Chand & Co. Ltd., New Delhi, 2013.
2. D.F. Kuratko, Entrepreneurship– Theory, Process and Practice, 9th Edition, Cengage Learning, 2014.
3. R.D. Hisrich and M.P. Peters, Entrepreneurship, 8th Edition, McGraw Hill, 2013.
4. M.J. Manimala, Enterprenuership Theory at Cross Roads: Paradigms and Praxis, 2nd Edition, Dream Tech, 2005.
5. R. Roy, Entrepreneurship, 2nd Edition, Oxford University Press, 2011.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : E	**Category:** Open Elective Courses
Subject Name: Introduction to Product Design and Development	**Semester**: Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Elements of Machine Design, Basics of Management Principles	

Course Objective:

To have an overall idea about the whole process of product design and development.
To be able to explain concept generation, concept selection and concept testing.
To be able to apply the basic concepts on design for environment.
To become industry-ready to work in product design department.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to product design, design and development process, sequential engineering design method, product planning and project selection.	10
2	Identifying customer needs– interpreting raw data; Product specifications– establishing target specifications, setting final specifications.	9
3	Concept generation– activities of concept generation, clarifying problem, exploring the output; Concept selection– concept screening and concept scoring, methods of selection.	9
4	Concept testing– qualitative and quantitative methods including survey, measurement and customer's response; Design for environment– basic concepts.	8

Course Outcomes:

After completing this course, the students will be

1. Identify and analyse the product design and development processes industry.
2. Define the components and their functions of product design and development processes
3. Analyse, evaluate and apply the methodologies for product design, development and management.
4. Undertake a methodical approach to the management of product development to satisfy customer needs.
5. Carry out cost and benefit analysis through various cost models.

Learning Resources:

1. K.T. Ulrich and S.D. Eppinger, Product Design and Development, 7th Edition, McGraw-Hill, 2019.
2. B. Gupta, Concepts in Engineering Design, Dhanpat Rai & Co., New Delhi, 2016.
3. A.C. Chitale and R.C. Gupta, Product Design and Manufacture, Prentice-Hall, 6th Edition, 2014.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: F	**Category:** Open Elective Courses
Subject Name: Safety and Occupational Health	**Semester:** Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Basic Engineering Knowledge	

Course Objectives:

To express knowledge about various aspects of industrial safety and occupational health.
To understand causalities of an accident and steps for their prevention.
To aware about health and safety management and related legislation.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Development of industrial safety. Developments in Occupational Health, Occupational Safety and Health in India.	2
2	Accidents and their prevention, Theory of accident, Anatomy of an accident, Causalities of an accidents. Cost of accidents, Principles of accident prevention, Techniques of accident prevention, Safe work environment, Housekeeping, Job safety analysis, Investigation of accidents, Ergonomics, Personal protective equipment, Promotion of health and safety, Basic safety programming.	6
3	Fire hazard- Types of fire, Fire hazards, Fire explosion, fire prevention, Means of escape in case of fire inspection safety, Supervision safety, Responsibility safety inspection, Fire prevention authorities, Rules safety training safety, Appraisal safety communication, Safety audit.	6
4	Occupational health and safety- Occupational Health, Occupational health services in places of employment, Occupational physician, Occupational health in developing countries, Occupational safety, Occupational safety in developing countries, Promoting occupational health and safety, Work related diseases, Occupational health hazards, Recognition of hazards, Industrial hygiene, Occupational diseases, Basics of OHSAS 18001.	6
5	Health and safety at workplaces- Health and Safety hazards, Occupational health requirements, Occupational safety requirements, Occupational welfare requirements, Abstracts and Notices, Obligations of a worker, Obligations of occupier, Personal protective equipment, Causes of accidents, Prevention of accidents, Safety Legislation, Safety Guidelines, emergency actions, related acts (related to chemical processes, mines, workshop practices, construction work, electrical	6

	installations).	
6	Health and safety management- Basics of Safety management, Role of safety supervisor, Planning for safety, Safety Policies, Safety Promotion, Safety Committee, Safety education & training, Health and Safety Process, Measuring Safety, Risk Management, Loss Control.	4
7	Accident Compensation- Brief introduction to different acts- The Dangerous Machines (Regulations) Act, 1983, The Employers' Liability Act, 1938 The (Indian), Fatal Accidents Act, 1855, The Public Liability Insurance Act, 1991, The Workmen's Compensation Act, 1923, The Employees' State Insurance Act, 1948, Role of National Safety Council, International labour office.	6

Course Outcome:

1. To have knowledge about various aspects of industrial safety and occupational health.
2. To have understanding about the reasoning behind an accident and steps for their prevention.
3. To have awareness about legislation related to health and safety management.

Learning Resources:

1. A. Waring, Safety management Systems, Chapman & Hall, 1996.
2. N.P. Cheremisinoff and M.L. Graffia, Environmental Health & Safety Management– A Guide to Compliance, Noyes Publication, 2003.
3. J. Ridley and J. Channing, Safety at Work, 5th Edition, Butterworth & Heinemann, 2001.
4. J. Stranks, Occupational Health & Hygiene, Pitman Publication, 1995.
5. R. Pybuss, Safety Management: Strategy & Practice, Butterworth & Heinemann, 1997.
6. H.L. Kalia, A. Singh, S. Ravishankar & S.V. Kamat, Essentials of Safety Management, Himalaya Publishing House, 2002.
7. A.M. Sarma, Industrial Health & Safety Management, Himalaya Publishing House, 2002.
8. J.M. Stellman (Ed.), Encyclopaedia of Occupational Health & Safety (4th Ed.), Vol. I-IV, International Labour Office, Geneva, 2012.
9. A. Waring, Safety Management System, Chapman & Hill, London, 1996.
10. J. Jaynes, Practical Health & Safety Management for Small Business- 2000, Butterworth Heinemann, 2000.
11. H.L. Kalia, Industrial Safety and Human Behaviour, AITBS Publishes, India, 2019.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : G	**Category:** Open Elective Courses
Subject Name : Industrial Pollution and Control	**Semester :** Seventh/ Eighth
L-T-P : 3-0-0	**Credit:** 3
Pre-Requisites: Basic Chemistry, Thermodynamics, Fluid Mechanics	

Course Objective:

To know about the various types of pollution caused by the industries and their effects on the environment.
To learn specifically about the causes, processes and control techniques of air pollution.
To know specifically about the causes, processes and control techniques of water pollution.
To know specifically about the causes, processes and control techniques of noise pollution.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Introduction; classification of pollution; effects of pollution on human beings, plants and animals.	8
2	Air pollution: physical effects; atmospheric dispersion and diffusion; method of sampling and analysis; modeling technique; practical control of air pollution and abatement.	10
3	Water pollution: water quality parameters; dispersion and diffusion of pollutants in water; control and abatement of water pollution.	9
4	Noise pollution: physics of sound generation and transmission; physical characters of noise; physiological effects of noise; measuring instruments and technique; assessment of noise; noise control principle, practice and laws.	9

Course Outcomes:

After completing this course, the students will

1. know about the various types of pollution caused by the industries and their effects on the environment.
2. know specifically about the causes, processes and control techniques of air pollution.
3. know specifically about the causes, processes and control techniques of water pollution.
4. know specifically about the causes, processes and control techniques of noise pollution.

Learning Resources:

1. P.N. Chermisinoff, Air Pollution Control and Design for Industry, Taylor & Francis, 1993.
2. N.J. Sell, Industrial Pollution Control: Issues and Techniques, Wiley–Blackwell, 1992.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : H	**Category:** Open Elective Courses
Subject Name : Energy Conservation and Management	**Semester**: Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Thermodynamics, Basic Electrical Engineering	

Objectives:

To understand the energy data from industries and carry out energy audit for energy savings.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to energy & power scenario of world, National Energy consumption data, environmental aspects associated with energy utilization; Energy Auditing- need, types, methodology and barriers, role of energy managers, instruments of energy auditing.	9
2	Components of EB billing, HT and LT supply, transformers, cable sizing; Concept of capacitors, power factor improvement, harmonics; Electric motors- motor efficiency computation, energy efficient motors; Illumination- Lux, Lumens, types of lighting, efficacy, LED lighting and scope of energy conservation in lighting.	9
3	Thermal systems, Boilers, Furnaces and Thermic Fluid heaters- efficiency computation and energy conservation measures; Steam distribution and usage, steam traps, condensate recovery, flash steam utilization; Insulation & Refractories.	9
4	Energy conservation in major utilities; pumps, fans, blowers, compressed air systems, Refrigeration& Air Conditioning systems, Cooling Towers, DG sets. Energy Economics- discount period, payback period, internal rate of return, net present value; Life Cycle costing- ESCO concept.	9

Course Outcomes:

Upon completion of this course, the students will be able to

1. Understand principles of energy management and its influence on environment.
2. Comprehend methods of energy production for improved utilization.
3. Improve the performance of thermal systems using of energy management principles
4. Analyse the methods of energy conservation for air conditioning, heat recovery and thermal energy storage systems.
5. Prepare energy audit report of energy consumption for industries.

Learning Resources:

1. L.C. Witte, P.S. Schmidt and D.R. Brown, Industrial Energy Management and Utilization, Hemisphere Publication, Washington, 1988.
2. P.W. Callaghn, Design and Management for Energy Conservation, Pergamon Press, Oxford, 1981.
3. B.K. De, Energy Management Audit & Conservation, 2nd Edition, Vrinda Publication, 2010.
4. W.R. Murphy and G. McKay, Energy Management, Butterworths Publication, London, 1987.
5. Energy Manager Training Manual, Bureau of Energy Efficiency (BEE) under Ministry of Power, GOI, 2004 (available at www.energymanagertraining.com).

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : I	**Category:** Open Elective Courses
Subject Name: Non-Conventional Energy Resources	**Semester**: Seventh/ Eighth
L-T-P : 3-0-0	**Credit:** 3
Pre-Requisites: Thermodynamics, Fluid Dynamics and Heat Transfer	

Course Objective:

To have an idea about different sources of renewable energy that would be sustainable.
To have the concept of using solar energy for heating as well as Photovoltaic Generation.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Principles of Renewable Energy: The history of energy scene, energy of the future: sustainable energy, development and role of renewable energy, Scientific Principles of renewable energy.	4
2	Review of principles of thermodynamics, fluid dynamics and heat transfer.	1
3	Solar Radiation: i) Sun-Earth geometry, ii) Extraterrestrial Solar Radiation, iv) Measurement and estimation of solar radiation.	4
4	Solar Water Heating: i) Flat Plate Collectors: Heat Transfer analysis, Testing ii) Evacuated Tube Collectors	5
5	Other Solar Thermal Applications: i) Air heaters, ii) Water Desalination, iii) Space Cooling, iv) Solar Concentrators, v) Solar ponds	3
6	Photovoltaic Generation: i) Photon absorption at Silicon p-n junction, ii) Solar Cell, iii) Application and Systems.	4
7	Wind Power: i) Turbine types & terms, ii) Mechanical & Electrical Power from Wind Turbines.	3
8	Biomass & Biofuels: i) Use of Biomass, ii) Classification & Use of Biofuels.	3
9	Wave Power & Tidal Power: Basic Concepts	3
10	Ocean Thermal Energy Conversion, Geothermal Energy. Energy Storage	6

Course Outcomes:

After completing this course, the students will

5. know about the energy scenario at present and the need of using renewable energy for sustainability.
6. know specifically the use of solar energy for heating as well as photovoltaic generation.

Learning Resources:

1. G. Boyle, Renewable Energy, 2nd Edition, Oxford University Press, 2010.
2. J. Twidell and T. Weir, Renewable Energy Resources, 2nd Edition, Taylor & Francis, 2006.
3. B.H. Khan, Non Conventional Energy Resources, McGraw Hill, 2010.
4. G.D. Rai, Non Conventional Energy Sources, Khanna Publishers, New Delhi, 2017.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : J	**Category:** Open Elective Courses
Subject Name : Waste to Energy- An Overview	**Semester :** Seventh/ Eighth
L-T-P : 3-0-0	**Credit:**3
Pre-Requisites: Basic Chemistry, Thermodynamics, Fluid Mechanics	

Course Objective:

To know about the various types of bio-wastes.
To learn about biomass pyrolysis, biomass gasification and gasifiers.
To know about biomass combustion and combustors, biogas plants and production.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to Energy from Waste: Classification of waste as fuel– Agro based, Forest residue, Industrial waste- MSW– conversion devices– Incinerators, gasifiers, digesters	6
2	Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods – Yields and application – Manufacture of pyrolytic oils and gases, yields and applications	5
3	Biomass Gasification: Gasifiers– Fixed bed system– Downdraft and updraft gasifiers– Fluidized bed gasifiers– Design, construction and operation	5
4	Biomass Combustion: Biomass stoves– Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors.	4
5	Biogas: Properties of biogas (Calorific value and composition)- Biogas plant technology and status– Bio energy system- Design and constructional features- Biomass resources and their classification– Biomass conversion processes- Thermo chemical conversion- Direct combustion- biomass gasification- pyrolysis and liquefaction- biochemical conversion- anaerobic digestion– Types of biogas Plants.	10

Course Outcomes:

After completing this course, the students will

1. know about the various types of bio-wastes.
2. learn about biomass pyrolysis, gasification and gasifiers.
3. know about biomass combustion and combustors, biogas plants and production.

Learning Resources:

1. A.V. Desai, Non Conventional Energy, Wiley Eastern Ltd., 1990.
2. K.C. Khandelwal and S.S. Mahdi, Biogas Technology - A Practical Hand Book, Vol. I & II, McGraw Hill Publishing Co. Ltd., 1983.
3. D.S. Challal, Food, Feed and Fuel from Biomass, IBH Publishing Co. Pvt. Ltd., 1991.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : K	**Category:** Open Elective Courses
Subject Name : Biomechanics and Bio materials	**Semester** : Seventh/ Eighth
L-T-P : **3-0-0**	**Credit: 3**
Pre-Requisites: Biology, Engineering Mechanics	

Course Objective:

To know musculoskeletal anatomy, dynamics to human motion and biomaterial interfaces.
To understand fundamentals of biomaterials science, physico-chemical properties of biomaterials and their testing techniques.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Musculoskeletal Anatomy**: Basic Statics and Joint Mechanics (elbow, shoulder, spine, hip, knee, ankle)	6
2	**Basic Dynamics to Human Motion**: Review of linear and angular kinematics; Kinetic equations of motion; Work & energy methods; Momentum methods; Examples in biomechanics; Modern kinematic measurement techniques; Applications of human motion analysis Structure, Function, and Adaptation of Major Tissues and Organs.	6
3	**Fundamental Strength of Materials in Biological Tissues**: Introduction to Viscoelasticity. **Fundamentals of biomaterials science**. Concept of biocompatibility. Classes of biomaterials used in medicine, basic properties, medical requirements and clinical significance. Disinfection and sterilization of biomaterials.	6
4	**Physico-Chemical Properties of Biomaterials**: mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance), tribological (friction, wear, lubricity), morphology and texture, physical (electrical, optical, magnetic, thermal), chemical and biological properties.	6
5	**Elements in Contact with the Surface of a Biomaterial**: Blood composition, plasma proteins, cells, tissues. **Phenomena at the Biointerfaces**. Molecular and cellular processes with living environment, blood-materials interaction, short and long term reactions to the body.	6

6	**Testing of Biomaterials**: in vitro, in vivo preclinical and in vivo clinical tests. Technologies of biomaterials processing, as implants and medical devices; improvement of materials biocompatibility by plasma processing.	6

Course Outcomes:

Upon completion of this course, the students will be able to:

1. Understand dynamics of human motion with the knowledge of musculoskeletal anatomy and biomaterial interfaces.
2. Understand fundamental characteristics and properties of biomaterials and their testing techniques.

Learning Resources:

1. D.V. Knudson, Fundamentals of Biomechanics, Springer, 1999.
2. N. Ozkaya, M. Nordin, D. Goldsheyder and D. Leger, Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation, Springer, 2012.
3. Y.C. Fung, Biomechanics: Mechanical Properties of Living Tissues, Springer, 1981.
4. M. Nordin and V.H. Frankel, Basic Biomechanics of the Musculoskeletal System, Barnes & Noble, 2011.
5. B.D. Ratner and A.S. Hoffman (Eds.), Biomaterials Science, An Intoduction to Materials in medicine, 3rd Edition, Academic Press, New York, 2012.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : L	**Category:** Open Elective Courses
Subject Name : Computational Methods in Engineering	**Semester** : Seventh/ Eighth
L-T-P : **3-0-0**	**Credit: 3**
Pre-Requisites: Mathematics- IB, Mathematics- IIB, Mathematics- III	

Course Objective:

To learn about different numerical techniques.
To learn about the application of numerical techniques in different fields of mechanical engineering.
To learn about different transformation techniques.
To understand concept of linear regression and statistical analysis.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Approximations:** Accuracy and precision, round off and truncation errors, error propagation.	3
2	**Linear algebraic equations:** Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods– convergence, Eigen values and Eigen vectors.	4
3	**Interpolation methods**: Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials.	5
4	**Differentiation and Integration:** High accuracy integration formula, extrapolation, derivatives of unequally spaced data, Gauss quadrature and integration.	5
5	**Numerical solution of Algebraic equation:** Bisection method, Regula-Falsi method, Newton-Raphson method.	4
6	**Transform techniques**: Continuous Fourier series, frequency and time domains, Laplace transform, Fourier integral and transform, Discrete Fourier Transform, fast Fourier Transform.	6
7	**Differential Equations:** Initial and boundary value problems, eigen value problems, solutions to elliptical and parabolic equations, partial differential equations.	5
8	**Regression methods**: Linear and non-linear regression, multiple linear regression, general linear test squares. **Statistical methods**: Statistical representation of data, modelling and analysis of data, ANOVA, test of hypotheses.	4

Course Outcomes:

On completion of this course the students will be able to

1. understand the concept of truncation and round off errors; fixed and floating point arithmetic and propagation of error and interpolation or extrapolation.
2. integrate different functions numerically and understand the error expressions.
3. solve systems of linear, algebraic and ordinary differential equations.
4. apply Laplace and Fourier transformation techniques.
5. use linear and non-linear regression techniques and do analysis of variance (ANOVA).

Learning Resources:

1. S.K. Gupta, Numerical Methods for Engineers, New Age International, 2005.
2. S.C. Chapra and R.P. Canale, Numerical Methods for Engineers, McGraw Hill, 1989.
3. R.J. Schilling and S.L. Harris, Applied Numerical Methods for Engineering using MATLAB and C, Brooks/Cole Pub., 2000.
4. W.W. Hines and Montgomery, Probability and Statistics in Engineering and Management Studies, John Wiley, 1990.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : M	**Category:** Open Elective Courses
Subject Name : Automation and Control	**Semester :** Seventh/ Eighth
L-T-P : 3-0-0	**Credit:** 3
Pre-Requisites: Basic Electronics Engineering, Mathematics	

Course Objective:

To know about various types of control systems used in different industries.
To learn about mathematical representation and analysis of control systems.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to control system:** Concept of feedback and Automatic control, Effects of feedback, Objectives of control system, Definition of linear and nonlinear systems, Elementary concepts of sensitivity and robustness. Types of control systems, Servo mechanisms and regulators, examples of feedback control systems. Transfer function concept. Pole and Zeroes of a transfer function. Properties of Transfer function. **Mathematical modeling of dynamic systems:** Translational systems, Rotational systems, Mechanical coupling, Liquid level systems, Electrical analogy of Spring–Mass-Dashpot system. Block diagram representation of control systems. Block diagram algebra. Signal flow graph. Mason's gain formula. **Control system components:** Potentiometer, Synchros, Resolvers, Position encoders.	8
2	**Time domain analysis:** Time domain analysis of a standard second order closed loop system. Concept of undamped natural frequency, damping, overshoot, rise time and settling time. Dependence of time domain performance parameters on natural frequency and damping ratio. Step and Impulse response of first and second order systems. Effects of Pole and Zeros on transient response. Stability by pole location. Routh-Hurwitz criteria and applications. **Error Analysis:** Steady state errors in control systems due to step, ramp and parabolic inputs. Concepts of system types and error constants.	8
3	**State variable Analysis:** State variable model of Linear Time-invariant system, properties of the State transition matrix, State transition equation, Definition of transfer function & Characteristic equation, definition of controllability and observability.	8
4	**Stability Analysis using root locus:** Importance of Root locus	12

	techniques, construction of Root Loci for simple systems. Effects of gain on the movement of Pole and Zeros. **Frequency domain analysis of linear system:** Bode plots, Polar plots, Nichols chart, Concept of resonance frequency of peak magnification. Nyquist criteria, measure of relative stability, phase and gain margin. Determination of margins in Bode plot. Nichols chart. M circle and M-Contours in Nichols chart.	
5	**Control System performance measure:** Improvement of system performance through compensation. Lead, Lag and Lead- lag compensation, PI, PD and PID control.	4

Course Outcomes:
After completing this course, the students will
1. know about the various types of control systems.
2. learn about modeling control systems.

Learning Resources:
1. K. Ogata, Modern Control Engineering, 4th Edition, Pearson Education, 2010.
2. I.J. Nagrath and M. Gopal, Control System Engineering, New Age International, 2009.
3. D. Roy Choudhury, Control System Engineering, PHI, 2005.
4. B.C. Kuo and F. Golnaraghi, Automatic Control Systems, 8th Edition, PHI, 2014.
5. M.N. Bandyopadhyay, Control Engineering Theory & Practice, PHI, 2002.
6. K.R. Varmah, Control Systems, Mc Graw Hill, 2010.
7. Norman Nise, Control System Engineering, 5th Edition, John Wiley & Sons, 2010.
8. R.C. Dorf and R.H. Bishop, Modern Control System, 11th Edition, Pearson Education, 2011.
9. C.G. Graham, F. Graebe, F. Stefan, S.E. Mario, Control System Design, PHI, 2009.
10. N.F. Macia and G.J. Thaler, Modeling & Control of Dynamic System, Thompson, 2004.
11. C.T. Kilian, Modern Control Technology Components & Systems, 3rd Edition, Cengage Learning, 2005.
12. Y. Singh and S. Janardhanan, Modern Control Engineering, Cengage Learning, 2010.
13. R. Anandanatarajan and R. Ramesh Babu, Control System Engineering, Scitech, 2015.
14. W.A. Wolovich, Automatic Control system, Oxford University Press, 1995.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: N	**Category:** Open Elective Courses
Subject Name: Internet of Things	**Semester:** Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Sensors, System Integration, Cloud and Network Security	

Objectives:

The objective of this course is to impart necessary and practical knowledge of components of Internet of Things and develop skills required to build real-life IoT based projects.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to IoT:** Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service (XaaS), Role of Cloud in IoT, Security aspects in IoT.	7
2	**Elements of IoT**: Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/ Node.js/ Arduino) for Communication Protocols- MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.	8
3	**IoT Application Development:** Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.	15
4	**IoT Case Studies:** IoT case study and mini project based on Industrial automation/ Transportation/ Agriculture/ Healthcare/ Home Automation	6

Course Outcomes:

At the end of the course, the student will be able to:

5. Understand internet of Things and its hardware and software components
6. Interface I/O devices, sensors & communication modules
7. Remotely monitor data and control devices, and develop real life IoT based projects

Learning Resources:

1. V. Madisetti and A. Bahga, Ïnternet of Things, A Hands on Approach, University Press, 2015.

2. S.R.N. Reddy, R. Thukral and M. Mishra, Introduction to Internet of Things: A Practical Approach, ETI Labs, 2017.
3. P. Raj and A.C. Raman, The Internet of Things: Enabling Technologies, Platforms and Use Cases, CRC Press, 2017.
4. J. Jose, Internet of Things, Khanna Publishing House, New Delhi, 2018.
5. A. McEwen, Designing the Internet of Things, Wiley, 2013.
6. R. Kamal, Internet of Things: Architecture and Design, McGraw Hill, 2017.
7. C. Pfister, Getting Started with the Internet of Things, O Reilly Media, 2011.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: O	**Category:** Open Elective Courses
Subject Name: Artificial Intelligence (AI)	**Semester:** Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Basic Programming in Python, Data Structures	

Course Objectives:

This course will give an opportunity to gain expertise in one of the most fascinating and fastest growing areas of Computer Science through classroom program that covers fascinating and compelling topics related to human intelligence and its applications in industry, defence, healthcare, agriculture and many other areas. This course will give the students a rigorous, advanced and professional graduate-level foundation in Artificial Intelligence.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Concept of AI, history, current status, scope, agents, environments, Problem Formulations, Review of tree and graph structures, State space representation, Search graph and Search tree.	2
2	**Search Algorithms**: Random search, Search with closed and open list, Depth first and Breadth first search, Heuristic search, Best first search, A* algorithm, Game Search.	7
3	**Probabilistic Reasoning:** Probability, conditional probability, Bayes Rule, Bayesian Networks- representation, construction and inference, temporal model, hidden Markov model.	10
4	**Markov Decision process:** MDP formulation, utility theory, utility functions, value iteration, policy iteration and partially observable MDPs.	10
5	**Reinforcement Learning:** Passive reinforcement learning, direct utility estimation, adaptive dynamic programming, temporal difference learning, active reinforcement learning- Q learning.	7

Course Outcomes:

At the end of the course, the student will be able to:

1. Build intelligent agents for search and games.
2. Solve AI problems through programming with Python.
3. Learning optimization and inference algorithms for model learning.
4. Design and develop programs for an agent to learn and act in a structured environment.

Learning Resources:

1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 3rd Edition, Prentice Hall, 2009.
2. E. Rich, K. Knight and K. Knight, Artificial Intelligence, McGraw Hill, 1991.
3. M.C. Trivedi, A Classical Approach to Artifical Intelligence, Khanna Publishing House, New Delhi, 2018.
4. S. Kaushik, Artificial Intelligence, Cengage Learning India, 2011.
5. D. Poole and A. Mackworth, Artificial Intelligence: Foundations for Computational Agents, Cambridge University Press, 2010.
6. Websites for reference: https://nptel.ac.in/courses/106105077
7. Websites for reference: https://nptel.ac.in/courses/106106126
8. Websites for reference: https://aima.cs.berkeley.edu

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: P	**Category:** Open Elective Courses
Subject Name: Block Chain	**Semester:** Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Cryptography Techniques, Data Structures and Algorithms, Introduction to Programming	

Course Objectives:

The objective of this course is to provide conceptual understanding of how block chain technology can be used to innovate and improve business processes. The course covers the technological underpinning of block Chain operations in both theoretical and practical implementation of solutions using block Chain technology.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Introduction: Overview of Block chain, Public Ledgers, Bitcoin, Smart Contracts, Block in a Block chain, Transactions, Distributed Consensus, Public vs Private Block chain, Understanding Crypto currency to Block chain, Permissioned Model of Block chain, Overview of Security aspects of Block chain. Basic Crypto Primitives: Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle tree, Digital Signature, Public Key Cryptography, A basic crypto currency.	5
2	**Understanding Block Chain with Crypto Currency**: Bitcoin and Block chain: Creation of coins, Payments and double spending, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay. Working with Consensus in Bitcoin: Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW) – basic introduction, Hashcash PoW, Bitcoin PoW, Attackson PoW and the monopoly problem, Proof of Stake, Proof of Burn and Proof of Elapsed Time, The life of a Bitcoin Miner, Mining Difficulty, Mining Pool.	7
3	**Understanding Block Chain for Enterprises:** Permissioned Block chain: Permissioned model and use cases, Design issues for Permissioned block chains, Execute contracts, State machine replication, Overview of Consensus models for permissioned block chain- Distributed consensus in closed environment, Paxos, RAFT Consensus, Byzantine general problem, Byzantine fault tolerant system, Lamport- Shostak- Pease BFT Algorithm, BFT over Asynchronous systems.	10

	Enterprise application of Block chain: Cross border payments, Know Your Customer (KYC), Food Security, Mortgage over Block chain, Block chain enabled Trade, We Trade– Trade Finance Network, Supply Chain Financing, Identity on Block chain	
4	**Block chain application development:** Hyperledger Fabric-Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, Writing smart contract using Hyperledger Fabric, Writing smart contract using Ethereum, Overview of Ripple and Corda.	14

Course Outcomes:
At the end of the course, the student will be able to:
1. Understand block chain technology.
2. Develop block chain based solutions and write smart contract using Hyperledger Fabricand Ethereum frameworks.
3. Build and deploy block chain application for on premise and cloud based architecture.
4. Integrate ideas from various domains and implement them using block chain technologyin different perspectives.

Learning Resources:
1. M. Swan, Block Chain: Blueprint for a New Economy, O'Reilly, 2015.
2. J. Thompsons, Block Chain: The Block Chain for Beginners- Guide to Block Chain Technology and Leveraging Block Chain Programming, CreateSpace Independent Publishing Platform, 2017.
3. D. Drescher, Block Chain Basics, 1st Edition, Apress, 2017.
4. A. Kaushik, Block Chain and Crypto Currencies, Khanna Publishing House, New Delhi, 2019.
5. I. Bashir, Mastering Block Chain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained, Packt Publishing, 2018.
6. R. Modi, Solidity Programming Essentials: A Beginner's Guide to Build Smart Contracts for Ethereum and Block Chain, Packt Publishing, 2018.
7. S. Baset, L. Desrosiers, N. Gaur, P. Novotny, A. O'Dowd and V. Ramakrishna, Hands-On Block Chain with Hyperledger: Building Decentralized Applications with Hyperledger Fabric and Composer, Import, 2018.

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: Q	**Category:** Open Elective Courses
Subject Name: Cyber Security	**Semester:** Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Basic knowledge of Computers, Basic knowledge of networking and Internet, Hands on Windows operating system	

Course Objectives:

The course has been designed to give students an extensive overview of cyber security issues, tools and techniques that are critical in solving problems in cyber security domains. The course aims at providing students with concepts of computer security, cryptography, digital money, secure protocols, detection and other security techniques. The course will help students to gauge understanding in essential techniques in protecting Information Systems, IT infrastructure, analysing and monitoring potential threats and attacks, devising security architecture and implementing security solutions. The students will also have a wider perspective to information security from national security perspective from both technology and legal perspective.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Cyber Security Concepts:** Essential Terminologies: CIA, Risks, Breaches, Threats, Attacks, Exploits. Information Gathering (Social Engineering, Foot Printing & Scanning). Open Source/ Free/ Trial Tools: nmap, zenmap, Port Scanners, Network scanners.	2
2	**Cryptography and Cryptanalysis**: Introduction to Cryptography, Symmetric key Cryptography, Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of Firewalls- Types of Firewalls, User Management, VPN Security, Security Protocols: security at the Application Layer- PGP and S/MIME, Security at Transport Layer- SSL and TLS, Security at Network Layer- IPSec. Open Source/ Free/ Trial Tools: Implementation of Cryptographic techniques, Open SSL, Hash Values Calculations MD5, SHA1, SHA256, SHA 512,Steganography (Stools)	4
3	**Infrastructure and Network Security:** Introduction to System Security, Server Security, OS Security, Physical Security, Introduction to Networks, Network packet Sniffing, Network Design Simulation. DOS/ DDOS attacks. Asset	5

	Management and Audits, Vulnerabilities and Attacks. Intrusion detection and Prevention Techniques, Host based Intrusion prevention Systems, Security Information Management, Network Session Analysis, System Integrity Validation. Open Source/ Free/ Trial Tools: DOS Attacks, DDOS attacks, Wireshark, Cain & abel, iptables/ Windows Firewall, snort, suricata, fail2ban.	
4	**Cyber Security Vulnerabilities& Safe Guards:** Internet Security, Cloud Computing & Security, Social Network sites security, Cyber Security Vulnerabilities-Overview, vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Authorization, Unprotected Broadband communications, Poor Cyber Security Awareness. Cyber Security Safeguards- Overview, Access control, IT Audit, Authentication. Open Web Application Security Project (OWASP), Web Site Audit and Vulnerabilities assessment. Open Source/ Free/ Trial Tools: Win Audit, Zap proxy (OWASP), burp suite, DVWA kit.	6
5	**Malware:** Explanation of Malware, Types of Malware: Virus, Worms, Trojans, Root kits, Robots, Adware's, Spywares, Ransom wares, Zombies etc., OS Hardening (Process Management, Memory Management, Task Management, Windows Registry/ services another configuration), Malware Analysis. Open Source/ Free/ Trial Tools: Antivirus Protection, Anti Spywares, System tuning tools, Anti Phishing.	6
6	**Security in Evolving Technology:** Biometrics, Mobile Computing and Hardening on android and ios, IOT Security, Web server configuration and Security. Introduction, Basic security for HTTP Applications and Services, Basic Security for Web Services like SOAP, REST etc., Identity Management and Web Services, Authorization Patterns, Security Considerations, Challenges. Open Source/ Free/ Trial Tools: adb for android, xcode for ios, Implementation of REST/ SOAP web services and Security implementations.	6
7	**Cyber Laws and Forensics:** Introduction, Cyber Security Regulations, Roles of International Law, the state and Private Sector in Cyberspace, Cyber Security Standards. The INDIAN Cyberspace, National Cyber Security Policy 2013. Introduction to Cyber Forensics, Need of Cyber Forensics, Cyber Evidence, Documentation and Management of	7

	Crime Sense, Image Capturing and its importance, Partial Volume Image, Web Attack Investigations, Denial of Service Investigations, Internet Crime Investigations, Internet Forensics, Steps for Investigating Internet Crime, Email Crime Investigations. Open Source/ Free/ Trial Tools: Case Studies related to Cyber Law, Common Forensic Tools likedd, md5sum, sha1sum, Ram dump analysis, USB device	

Course Outcomes:

At the end of the course, the student will be able to:

1. Understand, appreciate, employ, design and implement appropriate security technologies and policies to protect computers and digital information.
2. Identify & Evaluate Information Security threats and vulnerabilities in Information Systems and apply security measures to real time scenarios.
3. Identify common trade-offs and compromises that are made in the design and development process of Information Systems.
4. Demonstrate the use of standards and cyber laws to enhance information security in the development process and infrastructure protection.

Learning Resources:

1. W. Stallings, Cryptography and Network Security, Pearson Education/PHI, 2006.
2. V.K. Jain, Cryptography and Network Security, Khanna Publishing House, New Delhi, 2013.
3. G. Gupta and S. Gupta, Information Security and Cyber Laws, Khanna Publishing House, New Delhi, 2019.
4. A. Kahate, Cryptography and Network Security, McGraw Hill, 2003.
5. V.K. Pachghare, Cryptography and Information Security, PHI Learning, 2015.
6. N. Godbole, Information System Security, Wiley, 2008.
7. H. Bothra, Hacking, Khanna Publishing House, New Delhi, 2017.

Maulana Abul Kalam Azad University of Technology, West Bengal

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: R	**Category:** Open Elective Courses
Subject Name: Quantum Computing	**Semester:** Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Data Structure and Algorithm, Programming in Python/C#	

Course Objectives:

The objective of this course is to impart necessary knowledge to the learner so that he/she candevelop and implement algorithm and write programs using these algorithms.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to Quantum Computing:** 1.1 Motivation for studying Quantum Computing 1.2 Major players in the industry (IBM, Microsoft, Rigetti, D-Wave etc.) 1.3 Origin of Quantum Computing 1.4 Overview of major concepts in Quantum Computing • Qubits and multi-qubits states, Bra-ket notation. • Bloch Sphere representation • Quantum Superposition • Quantum Entanglement	4
2	**Math Foundation for Quantum Computing**: Matrix Algebra- Basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation, Eigen values and Eigen vectors.	6
3	**Building Blocks for Quantum Program:** 3.1 Architecture of a Quantum Computing platform 3.2 Details of q-bit system of information representation: • Block Sphere • Multi-qubits States • Quantum superposition of qubits (valid and invalid superposition) • Quantum Entanglement • Useful states from quantum algorithmic perceptive e.g. Bell State • Operation on qubits: Measuring and transforming using gates. • Quantum Logic gates and Circuit: Pauli, Hadamard, phase shift, controlled gates, Ising, Deutsch, swap etc. 3.3 Programming model for a Quantum Computing Program • Steps performed on classical computer	7

	• Steps performed on Quantum Computer • Moving data between bits and qubits.	
4	**Quantum Algorithms:** 4.1 Basic techniques exploited by quantum algorithms. • Amplitude amplification • Quantum Fourier Transform • Phase Kick-back • Quantum Phase estimation • Quantum Walks 4.2 Major Algorithms • Shor's Algorithm • Grover's Algorithm • Deutsch's Algorithm • Deutsch -Jozsa Algorithm 4.3 OSS Toolkits for implementing Quantum program • IBM quantum experience • Microsoft Q • Rigetti PyQuil (QPU/QVM)	19

Course Outcomes:
At the end of the course, the student will be able to:
1. Explain the working of a Quantum Computing program, its architecture and programmodel
2. Develop quantum logic gate circuits
3. Develop quantum algorithm
4. Program quantum algorithm on major toolkits

Learning Resources:
1. M.A. Nielsen, Quantum Computation and Quantum Information, Cambridge University Press, 2010.
2. D. McMahon, Quantum Computing Explained, Wiley, 2016.
3. IBM Experience: https://quantumexperience,ng,bluemix.net
4. Microsoft Quantum Development Kit, https://www.microsoft.com/en-us/quantum/development-kit
5. S.D.K. Forest, PyQuil: https://pyquil.readthedocs.io/en/stable/

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: S	**Category:** Open Elective Courses
Subject Name: Data Sciences	**Semester:** Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Introduction to Programming, Probability	

Course Objectives:

The objective of this course is to impart necessary knowledge of the mathematical foundations needed for data science and develop programming skills required to build data science applications.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to Data Science:** Concept of Data Science, Traits of Big data, Web Scraping, Analysis vs Reporting	3
2	**Introduction to Programming Tools for Data Science**: 2.1 Toolkits using Python: Matplotlib, NumPy, Scikit-learn, NLTK 2.2 Visualizing Data: Bar Charts, Line Charts, Scatter plots 2.3 Working with data: Reading Files, Scraping the Web, Using APIs (Example: Using the Twitter APIs), Cleaning and Munging, Manipulating Data, Rescaling, Dimensionality Reduction	5
3	**Mathematical Foundations:** 3.1 Linear Algebra: Vectors, Matrices, 3.2 Statistics: Describing a Single Set of Data, Correlation, Simpson's Paradox, Correlation and Causation 3.3 Probability: Dependence and Independence, Conditional Probability, Bayes's Theorem, Random Variables, Continuous Distributions, The Normal Distribution, The Central Limit Theorem 3.4 Hypothesis and Inference: Statistical Hypothesis Testing, Confidence Intervals, P- hacking, Bayesian Inference	10
4	**Machine Learning:** Overview of Machine learning concepts– Over fitting and train/test splits, Types of Machine learning– Supervised, Unsupervised, Reinforced learning, Introduction to Bayes Theorem, Linear Regression- model assumptions, regularization (lasso, ridge, elastic net), Classification and Regression algorithms- Naïve Bayes, K-Nearest Neighbors, logistic regression, support vector machines (SVM), decision trees, and random forest, Classification Errors, Analysis of Time Series- Linear Systems Analysis, Nonlinear Dynamics, Rule Induction, Neural Networks- Learning and	14

	Generalization, Overview of Deep Learning.	
5	**Case Studies of Data Science Application:** Weather forecasting, Stock market prediction, Object recognition, Real Time Sentiment Analysis.	4

Course Outcomes:

At the end of the course, the student will be able to:

1. Demonstrate understanding of the mathematical foundations needed for data science.
2. Collect, explore, clean, munge and manipulate data.
3. Implement models such as k-nearest Neighbors, Naive Bayes, linear and logistic regression, decision trees, neural networks and clustering.
4. Build data science applications using Python based toolkits.

Learning Resources:

1. J. Grus, Data Science from Scratch: First Principles with Python, O'Reilly Media, 2019.
2. A. Géron, Hands-On Machine Learning with Scikit- Learn and Tensor Flow: Concepts, Tools, and Techniques to Build Intelligent Systems, 1st Edition, O'Reilly Media, 2017.
3. V.K. Jain, Data Sciences and Analytics, Khanna Publishing House, New Delhi, 2019.
4. V.K. Jain, Big Data and Hadoop, Khanna Publishing House, New Delhi, 2017.
5. J. Jose, Machine Learning, Khanna Publishing House, New Delhi, 2020.
6. R. Chopra, Machine Learning, Khanna Publishing House, New Delhi, 2020.
7. I. Goodfellow, Y. Bengio and A. Courville, Deep Learning, MIT Press, 2016.
8. http://www.deeplearningbook.org
9. J. Han and J. Pei, Data Mining Concepts and Techniques, 3rd Edition, Morgan Kaufmann Publishers, 2012.

Maulana Abul Kalam Azad University of Technology, West Bengal

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : T	**Category:** Open Elective Courses
Subject Name : Machine Learning	**Semester** : Seventh/ Eighth
L-T-P : **3-0-0**	**Credit: 3**
Pre-Requisites: Mathematics- IB, Mathematics- IIB, Mathematics- III	

Course Objective:

To introduce students to the basic concepts and techniques of Machine Learning.
To have a thorough understanding of the Supervised and Unsupervised learning techniques.
To study the various probability based learning techniques.
To understand graphical models of machine learning algorithms.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Introduction: Learning– Types of Machine Learning– Supervised Learning– The Brain and the Neuron– Design a Learning System– Perspectives and Issues in Machine Learning– Concept Learning Task– Concept Learning as Search– Finding a Maximally Specific Hypothesis– Version Spaces and the Candidate Elimination Algorithm– Linear Discriminants– Perceptron– Linear Separability– Linear Regression.	8
2	Linear Models: Multi-layer Perceptron– Going Forwards– Going Backwards: Back Propagation Error– Multilayer Perceptron in Practice– Examples of using the MLP– Overview– Deriving Back Propagation– Radial Basis Functions and Splines– Concepts– RBF Network– Curse of Dimensionality– Interpolations and Basis Functions– Support Vector Machines.	7
3	Tree and Probabilistic Models: Learning with Trees– Decision Trees– Constructing Decision Trees– Classification and Regression Trees– Ensemble Learning– Boosting– Bagging– Different ways to Combine Classifiers– Probability and Learning– Data into Probabilities– Basic Statistics– Gaussian Mixture Models– Nearest Neighbor Methods– Unsupervised Learning– K means Algorithms– Vector Quantization– Self Organizing Feature Map.	7

4	Dimensionality Reduction and Evolutionary Models: Dimensionality Reduction– Linear Discriminant Analysis– Principal Component Analysis– Factor Analysis– Independent Component Analysis– Locally Linear Embedding– Isomap– Least Squares Optimization. Evolutionary Learning– Genetic algorithms– Genetic Offspring- Genetic Operators– Using Genetic Algorithms– Reinforcement Learning– Overview– Getting Lost Example– Markov Decision Process.	7
5	Graphical Models: Markov Chain Monte Carlo Methods– Sampling– Proposal Distribution– Markov Chain Monte Carlo– Graphical Models– Bayesian Networks– Markov Random Fields– Hidden Markov Models– Tracking Methods.	7

Course Outcomes:

Upon completion of this course, the students will be able to:

1. Distinguish between, supervised, unsupervised and semi-supervised learning
2. Apply the appropriate machine learning strategy for any given problem
3. Suggest supervised, unsupervised or semi-supervised learning algorithms for any given problem
4. Design systems that uses the appropriate graph models of machine learning
5. Modify existing machine learning algorithms to improve classification efficiency

Learning Resources:

1. S. Marsland, Machine Learning– An Algorithmic Perspective, 2nd Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.
2. T.M. Mitchell, Machine Learning, First Edition, McGraw Hill Education, 2013.
3. P. Flach, Machine Learning: The Art and Science of Algorithms that Make Sense of Data, First Edition, Cambridge University Press, 2012.
4. J. Bell, Machine learning– Hands on for Developers and Technical Professionals, First Edition, Wiley, 2014.
5. E. Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning Series), 3rd Edition, MIT Press, 2014.

Maulana Abul Kalam Azad University of Technology, West Bengal

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: U	**Category:** Open Elective Courses
Subject Name: Virtual Reality	**Semester:** Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Fundamentals of C++	

Course Objectives:

The objective of this course is to provide a detailed understanding of the concepts of Virtual Reality and its applications.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to Virtual Reality:** Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark 3D Computer Graphics: Introduction, The Virtual world space, positioning the virtual observer, the perspective projection, human vision, stereo perspective projection, 3D clipping, Colour theory, Simple 3D modelling, Illumination models, Reflection models, Shading algorithms, Radiosity, Hidden Surface Removal, Realism-Stereographic image.	5
2	**Geometric Modelling**: Geometric Modelling: Introduction, From 2D to 3D, 3D space curves, 3D boundary representation. Geometrical Transformations: Introduction, Frames of reference, Modelling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection Generic VR system: Introduction, Virtual environment, Computer environment, VR technology, Model of interaction, VR Systems.	10
3	**Virtual Environment:** Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Nonlinear interpolation, the animation of objects, linear and non-linear translation, shape & object in betweening, free from deformation, particle system. Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft.	8

4	**VR Hardware and Software:** Human factors: Introduction, the eye, the ear, the somatic senses. VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems. VR Software: Introduction, Modelling virtual world, Physical simulation, VR toolkits, Introduction to VRML	8
5	**VR Applications:** Introduction, Engineering, Entertainment, Science, Training. The Future: Virtual environment, modes of interaction	5

Course Outcomes:

At the end of the course, the student will be able to:

1. Understand geometric modelling and Virtual environment.
2. Study about Virtual Hardware and Software
3. Develop Virtual Reality applications.

Learning Resources:

1. J. Vince, Virtual Reality Systems, Pearson Education Asia, 2007.
2. R. Anand, Augmented and Virtual Reality, Khanna Publishing House, New Delhi.
3. Adams, Visualizations of Virtual Reality, McGraw Hill, 2000.
4. G.C. Burdea and P. Coiffet, Virtual Reality Technology, Wiley Inter Science, 2nd Edition, 2006.
5. W.R. Sherman and A.B. Craig, Understanding Virtual Reality: Interface, Application and Design, Morgan Kaufmann, 2008.
6. Websites for Reference: www.vresources.org
7. Websites for Reference: www.vrac.iastate.edu
8. Websites for Reference: www.w3.org/MarkUp/VRM

Maulana Abul Kalam Azad University of Technology, West Bengal

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: V	**Category:** Open Elective Courses
Subject Name: Water Resource Engineering	**Semester:** Seventh/ Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Fluid Mechanics	

Course Objectives:

The objective of this course is to provide an understanding of the concepts of closed conduit flow, open channel flow, surface water hydrology and rainfall, and also groundwater hydrology and its charactristics.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Fluid Mechanics:** Review of fluid statics, Review of fluid dynamics; dimensional analysis.	4
2	**Closed Conduit Flow:** Closed conduit flow, Design of water distribution systems, pipe network analysis: Hardy Cross Method, Design of Network Reservoir pipeline.	9
3	**Open Channel Flow:** Continuity, momentum equations, Chezy, Mannings and energy equations, Water surface profiles.	9
4	**Surface Water Hydrology:** Rainfall depth, duration, distribution, determination of average rainfall depth by Arithmatic, Mean Method, Thiessen Polygon Method and Isohyetal Method, Rainfall/ runoff equations, Rainfall/ runoff models, unit hydrograph, hydrologic routing models.	10
5	**Groundwater Hydrology:** Porosity and water content, Equations of ground water flow (unconfined aquifers/ confined, aquifers/ unsaturated flow), Estimation of aquifer parameters using graphical and analytical approach.	4

Course Outcomes:

At the end of the course, the student will be able to:

1. Understand characteristic features of closed conduit flow and open channel flow.
2. Know different features of surface water hydrology and rainfall.
3. Study about groundwater hydrology and its characteristic relationships.

Learning Resources:

1. S.K. Garg, Hydrology and Water Resources Engineering, Khanna Pub., 1973.
2. R.A. Wurbs and W.P. James, Water Resources Engineering, Pearson, 2001.
3. K. Subramanya, Engineering Hydrology, 4th Edition, McGraw-Hill, New Delhi, 2013.

4. C.S.P. Ojha, R. Berndtsson and P. Bhunya, Engineering Hydrology, Oxford University Press, 2008.
5. M.J. Deodhar, Elementary Engineering Hydrology, Pearson Education, 2008.
6. K. Subramanya, Flow in Open Channels, 5th Edition, McGraw-Hill, 2019.
7. R. Srivastava, Flow through Open Channels, Oxford University Press, 2008.
8. V.T. Chow, Open-Channel Hydraulics, The Blackburn Press, 2009.