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**

List of Professional Electives in Semester VIII for (Elective-V) PE-ME801 and (Elective-VI) PE-ME802

Subject Code	Subject name
Thermo-Fluid Group	
A	Analysis and Performance of Fluid Machines
B	Power Plant Engineering
C	Cryogenics
D	Introduction to Wind Engineering
Design Group	
E	Tribology
F	3D Printing and Design
Manufacturing Group	
G	Micro and Nano Manufacturing
H	Process Planning and Cost Estimation
I	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)

List of Open Electives (OE-ME801 and OE-ME802) in Semester VIII

Subject Code	Subject Name
A	Total Quality Management
B	Entrepreneurship Development
C	Safety and Occupational Health
D	Industrial Pollution and Control
E	Energy Conservation and Management
F	Waste to Energy- An Overview
G	Automation & Control
H	Internet of Things (IoT)
I	Block Chain
J	Cyber Security
K	Quantum Computing
L	Data Sciences
M	Virtual Reality (VR)

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)

Subject Code : A	**Category:** Professional Elective Courses
Subject Name : Analysis and Performance of Fluid Machines	**Semester**: 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.
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: B	**Category:** Professional Elective Courses
Subject Name: Power Plant Engineering	**Semester**: 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: C	**Category:** Professional Elective Courses
Subject Name: Cryogenics	**Semester**: 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 : D	**Category:** Professional Elective Courses
Subject Name : Introduction to Wind Engineering	**Semester**: 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: E	**Category:** Professional Elective Courses
Subject Name: Tribology	**Semester**: 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:	6

	Elastohydrodynamic Lubrication: Principle and application, pressure-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: F	**Category:** Professional Elective Courses
Subject Name: 3D Printing and Design	**Semester:** 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: G	**Category:** Professional Elective Courses
Subject Name: Micro and Nano Manufacturing	**Semester:** 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: H	**Category:** Professional Elective Courses
Subject Name: Process Planning and Cost Estimation	**Semester:** 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: I	**Category:** Professional Elective Courses
Subject Name: Maintenance Engineering	**Semester:** 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)

Subject Code: A	**Category:** Open Elective Courses
Subject Name: Total Quality Management	**Semester:** 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:

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

3. 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 : B	**Category:** Open Elective Courses
Subject Name : Entrepreneurship Development	**Semester** : 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: C	**Category:** Open Elective Courses
Subject Name: Safety and Occupational Health	**Semester:** 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 : D	**Category:** Open Elective Courses
Subject Name : Industrial Pollution and Control	**Semester :** 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 : E	**Category:** Open Elective Courses
Subject Name : Energy Conservation and Management	**Semester**: 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 : F	**Category:** Open Elective Courses
Subject Name : Waste to Energy- An Overview	**Semester :** 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 : G	**Category:** Open Elective Courses
Subject Name : Automation and Control	**Semester :** 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: H	**Category:** Open Elective Courses
Subject Name: Internet of Things	**Semester:** 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:I	**Category:** Open Elective Courses
Subject Name: Block Chain	**Semester:** 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: J	**Category:** Open Elective Courses
Subject Name: Cyber Security	**Semester:** 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

(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: Quantum Computing	**Semester:** 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: L	**Category:** Open Elective Courses
Subject Name: Data Sciences	**Semester:** 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

(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: Virtual Reality	**Semester:** 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