BIJU PATNAIK UNIVERSITY OF TECHNOLOGY, ODISHA

ROURKELA

Curriculum and Syllabus

B. Tech (*Mechanical Engineering*) from the Admission Batch

2018-19

Semester (6th)

Sixth Semester							
Theory							
Sl. No.	**Category**	**Course Code**	**Course Title**	**L-T-P**	**Credit**	**University Marks**	**Internal Evaluation**
1	PC	RME6C001	Design of Machine Elements	3-0-0	3	100	50
2	PC	RME6C002	Machining Science and Technology	3-0-0	3	100	50
3	BS		Optimization in Engineering	3-0-0	3	100	50
4	PE	RME6D001	Smart and Composite Materials	3-0-0	3	100	50
		RME6D002	Compressible Flow and Gas Dynamics	3-0-0			
		RME6D003	Computer Integrated Manufacturing and FMS	3-0-0			
5	OE		Artificial Intelligence and Machine Learning	3-0-0	3	100	50
			Electrical Energy Conservation and Auditing	3-0-0			
			Control System	3-0-0			
6	MC*	RIK6F001	Essence of Indian Knowledge Tradition - I	3-0-0	0	-	100 (Pass mark is 37)
Total Credit (Theory)					**15**		
Total Marks						**500**	**250**
Practical							
1	PC	RME6C201	Design of Machine Elements Lab	0-0-3	2		100
2	PC	RME6C202	Machining Science and Technology Lab	0-0-3	2		100
3	PSI		Future Ready Contributor Program	0-0-3	2		100
4	PSI		Seminar - I	0-0-3	1		100
Total Credit (Practical)					**7**		
Total Semester Credit					**22**		
Total Marks							**400**
SUMMER INTERNSHIP TRAINING FOR 45 DAYS							

***Mandatory Non-Credit Courses (MC) result will be reflected with Pass (P) / Fail (F) grade. Thus the grade obtained will not be affecting the grade point average. However it shall appear on the grade sheet as per AICTE rule.**

6th Semester	RME6C001	Design of Machine Elements	L-T-P 3-0-0	3 Credits

Module - I **(10 Lectures)**

1. Mechanical engineering design: Introduction to design procedure, Stages in design, Code andStandardization, Interchangeability, Preferred numbers, Fits and Tolerances, Engineeringmaterials: Ferrous, Non-ferrous, Non-metals, design requirements – properties of materials,Material selection, Use of Data books.

2. Fundamentals of Machine Design: Types of load, Modes of failure, factor of safety concepts,Theories of Failure, concept and mitigation of stress concentration, Fatigue failure and curve,endurance limit and factors affecting it, Notch sensitivity, Goodman, Gerber and Soderberg criteria.

Module – II **(08 Lectures)**

3. Machine Element Design: Design of Joints: Rivets, welds and threaded fasteners based on different types of loading, Boiler joints, cotter joints and knuckle joints.

Module – III **(10 Lectures)**

4. Design of Keys, Shaft and Couplings: Classification of keys and pins, Design of keys and pins, Theories of failure, Design of shafts: based on strength, torsional rigidity and fluctuating load, ASME code for shaft design, Design of couplings: Rigid coupling, Flexible coupling.

5. Design of Mechanical Springs: Types of helical springs, Design of Helical springs, bulking of spring, spring surge, end condition of springs, Design of leaf springs: nipping.

Module – IV **(08 Lectures)**

6. Bearings: Types and selection of ball and roller bearings, Dynamic and static load ratings, Bearing life, Design of sliding contact bearings, Journal bearing, foot step bearing.

Books:

1. Design of Machine Elements, V.B. Bhandari, Tata McGraw Hill
2. Mechanical Engineering Design, J.E.Shigley, C.R.Mischke, R.G.Budynas and K.J.Nisbett, TMH
3. Machine Design, Pandya and Shah, Charotar Book Stall
4. Fundamentals of Machine Component Design by R.C.Juvinall and K.M.Marshek, John Wiley & Sons.
5. Machine Drawing by N.Sidheswar, McGraw-Hill
6. Machine Design, P.C.Sharma and D.K.Agrawal, S.K.Kataria& Sons
7. Machine Design, P. Kanaiah, Scietech Publications
8. Machine Design, Robert L. Norton, Pearson Education Asia.
9. Design of Machine Elements by C. S. Sharma and K. Purohit, PHI

DESIGN DATA HAND BOOKS:

1. Design Hand Book by S.M.Jalaluddin, Anuradha Agencies Publications
2. P.S.G. Design Data Hand Book, PSG College of Tech Coimbature
2. Design Data Hand Book, K. Lingaiah, McGraw Hill, 2nd Ed. 2003.
3. Design Data Hand Book by K.Mahadevan and B.Reddy,CBS Publishers

6th Semester	RME6C002	Machining Science and Technology	L-T-P 3-0-0	3 Credits

MODULE – I **(13 HOURS)**

Geometry of cutting tools in ASA and ORS, Effect of Geometrical parameters on cutting force andsurface finish, Mechanics of chip formation, Merchant's theory, Force relationship and velocityrelationship, Cutting tool materials. Types of Tool Wear: Flank wear, Crater wear, Wearmeasurement, Cutting fluid and its effect; Machinability Criteria, Tool life and Taylor's equation,Effect of variables on tool life and surface finish, Measurement of cutting force, Lathe tooldynamometer, Drill tool dynamometer. Economics of machining.

MODULE II **(13 HOURS)**

Conventional machining process and machine tools – Turning, Drilling, Shaping, Planning, Milling,Grinding. Machine tools used for these processes, their specifications and various techniques used.Principles of machine tools : Kinematics of machine tools, speed transmission from motor to spindle, speed reversal mechanism, mechanism for feed motion, Tool holding and job holding methods indifferent Machine tools, Types of surface generated, Indexing mechanism and thread cuttingmechanism, Quick return mechanism

Production Machine tools – Capstan and turret lathes, single spindle and multi spindlesemiautomatics, Gear shaper and Gear hobbing machines, Copying lathe and transfer machine

MODULE III **(10 HOURS)**

Non-traditional Machining processes :

Ultrasonic Machining, Laser Beam Machining, Plasma Arc Machining, Electro Chemical Machining,Electro Discharge Machining, Wire EDM , Abrasive Jet Machining

Books :

3. Fundamentals of Machining and Machine Tools, G.Boothroyd and W.A.Knight, CRC Press
2. Metal Cutting Principles, M.C.Shaw, Oxford University Press
1. Metal Cutting Theory and Practice, A.Bhattacharya, Central Book Publishers
4. Manufacturing Technology – by P.N.Rao, Tata McGraw Hill publication.
5. Modern Manufacturing Processes, P.C.Pandey, H.S.Shan, Tata McGraw Hill
6. Manufacturing Science, Ghosh and Mallik, East West Press.
7. Metal Cutting Theory and Practice, D.A.Stephenson and J.S.Agapiou, CRC Press
8. Machining Technology; Machine Tools and Operation, H.A.Youssef and H. El-Hofy, CRC Press
9. Machine Tools and Manufacturing Technology, Krar, Rapisarda and Check, Cengage Learning
10. Technology of Machine Tools, Krar, Gill and Smidt, Tata McGraw Hill
11. Principles of Metal Cutting, G.Kuppuswamy, Universities Press
12. Metal Cutting and Machne Tools, G.T.Reddy, Scitech
13. Fundamentals of tool Engineering Design, S.K.Basu, S.K.Mukherjee, R. Mishra , Oxford & IBH Pub Co.
14. Machine Tools, R.N.Datta, New Central Book Agency

Course Name: Machining Science

Course Lik: https://onlinecourses.nptel.ac.in/noc21_me39/preview

Course Instructor: Prof. Sounak Kumar Choudhury, IIT Kanpur

Course Name: Mechanics of Machining

Course Lik: https://onlinecourses.nptel.ac.in/noc21_me29/preview

Course Instructor: Prof. Uday S. Dixit, IIT Guwahati.

6th Semester		Optimization in Engineering	L-T-P 3-0-0	3 Credits

Module I: **(10 Hours)**

Idea of Engineering optimization problems, Classification of optimizationalgorithms, modeling of problems and principle of modeling. Linear Programming:Formulation of LPP, Graphical solution, Simplex method, Big-M method, Revised simplex method, Duality theory and its application, Dual simplex method , Sensitivity analysis in linear programming.

Module II: **(10 Hours)**

Transportation problems:Finding an initial basic feasible solution by NorthwestCorner rule, Least Cost rule, Vogel's approximation method, Degeneracy, Optimalitytest, MODI method, Stepping stone method. **Assignment problems:** Hungarian method for solution of Assignment problems. Integer Programming: Branch and Bound algorithm for solution of integer programming problems.

Module III: **(12 Hours)**

Non-linear programming: Introduction to non-linear programming. Unconstraintoptimization: Fibonacci and Golden Section Search method. Constrained optimization with equality constraint: Lagrange multiplier, Projected gradient method. Constrained optimization with inequality constraint: Kuhn-Tucker condition, Quadratic programming.

Module IV: **(6 Hours)**

Queuing models: General characteristics, Markovian queuing model, M/M/1model, Limited queue capacity, multiple server, Finite sources, Queue discipline.

Books:

[1] Operations Research- Principle and Practice, A. Ravindran, D. T. Philips, J. Solberg, Second edition, Wiley India Pvt Ltd.
[2] Operation Research, Prabhakar Pai ,Oxford University Press
[3] Optimization for Engineering Design, Kalyanmoy Deb, PHI Learning Pvt Ltd.
[2] Operations Research, H.A.Taha, A.M.Natarajan, P.Balasubramanie, A.Tamilarasi, Pearson Education, Eighth Edition.
[5] Engineering Optimization, S S Rao, New Age International Pvt Ltd, 2003.
[6] Linear and Non-linear Optimization, **S**tephen G. Nash, A. Sofer, McGraw Hill, 2nd Edition.
[7] Engineering Optimization, A.Ravindran, K.M.Ragsdell, G.V.Reklaitis, Wiley India Pvt. Ltd, Second edition.
[3] Operations Research, F.S.Hiller, G.J.Lieberman, Tata McGraw Hill, Eighth Edition, 2005.
[9] Operations Research, P.K.Gupta, D.S.Hira, S.Chand and Company Ltd, 2014.

Digital Learning Resources:

Course Name:	Foundations of Optimization
Course Link:	https://nptel.ac.in/courses/111/104/111104071/
Course Instructor:	Dr. Joydeep Dutta, IIT Kanpur

6th Semester	RME6D001	Smart and Composite Materials	L-T-P 3-0-0	3 Credits

MODULE I (7 HOURS)

Introduction: definitions and classifications; natural composites; role of matrix and reinforcement; factors which determine properties; the benefits of composites.

Reinforcements and the reinforcement matrix interface: natural fibers; synthetic organic fibers – aramid, polyethylene; and synthetic inorganic fibers – glass, alumina, boron, carbon, silicon based fibers; particulate and whisker reinforcements, reinforcement-matrix interface – wettability, interfacial bonding, methods for measuring bond strength.

MODULE II (8 HOURS)

Metal matrix composites: Introduction, important metallic matrices; metal matrix composite processing: solid state processing – diffusion bonding, powder metallurgy; liquid state processing – melt stirring, compocasting (rheocasting), squeeze casting, liquid infiltration under gas pressure; deposition – spray co-deposition and other deposition techniques like CVD and PVD; in situ processes. Interface reactions. Properties of MMCs – physical properties; mechanical properties like elastic properties, room temperature strength and ductility, properties at elevated temperatures, fatigue resistance. Processing, structure of multifilamentary superconductors, properties of aluminium reinforced with silicon carbide particles

MODULE III (7 HOURS)

Ceramic matrix composites: Introduction; processing and structure of monolithic materials – technical ceramics, glass-ceramics. Processing of ceramics: conventional mixing and pressing – cold pressing and sintering, hot pressing, reaction bonding processes, techniques involving slurries, liquid state processing – matrix transfer moulding, liquid infiltration, sol-gel processing, vapour deposition techniques like CVD, CVI, liquid phase sintering, lanxide process and in situ processes. Processing, properties and applications of alumina matrix composites - SiC whisker reinforced, zirconia toughened alumina; Glass-ceramic matrix composites; Carbon-carbon composites - porous carbon-carbon composites, dense carbon-carbon composites.

MODULE IV (6 HOURS)

Polymer matrix composites: Introduction; polymer matrices – thermosetting, thermoplastic, rubbers. Processing of PMCs: Hand methods – hand lay-up, spray-up methods; Moulding methods – matched die moulding, bag moulding processes (autoclave moulding), resin transfer moulding, pultrusion; Filament winding; Injection moulding. Processing, properties and applications of fibre-reinforced epoxies, PEEK matrix composites, rubber matrix composites. Damping characteristics. Environmental effects in polymer matrix composites. Recycling of PMCs.

MODULE V (8 HOURS)

Sandwich structures, foam core type arrangements; Honey comb structures. Micromechanics of unidirectional composites: micromechanics models for stiffness – longitudinal stiffness, transverse stiffness, shear modulus, poisson's ratio. Micromechanics models for strength – longitudinal tensile strength, longitudinal compressive strength, transverse tensile strength, transverse compressive strength, inplane shear failure, thermal and moisture effects. Short fibre composites: reasons for using short fibre composites, fibre length, fibre orientation, stress and strain distribution at fibres, critical fibre length and average fibre stress, stiffness and strength: stiffness of aligned systems, non-aligned systems and variable fibre orientation, strength of aligned systems, 2-D composites, variable fibre orientation.

Books:

[1] Composite Materials: Engineering and Science, by Matthews and Rawlings, CRC Press.

[2] An Introduction to composite material, by D.Hull and T.W. Clyne, Cambridge University press.

[3] Metal Matrix Composites, Thermomechanical Behaviour by M.Taya, and R.J.Arsenault, Pergamon Press, Oxford.

[4] Fundamentals of Metal Matrix Composites by S.Suresh, A.Martensen, and A.Needleman, Butterworth, Heinemann

[5] Mechanics of composite materials, R. M. Jones, Mc Graw Hill Book Co.

[6] Mechanics of composite materials and structures, M Mukhopadhay, Universities Press.

[7] Fiber-Reinforced composite materials, Manufacturing & Design, P. K. Mallick, Marcel Dekken, Inc. New York & Basel.
[8] F.L. Matthews and R.D. Rawlings, Composite Materials: Engineering and Science, Chapman Hall, London, 1994.
[9] Weinheim, Structure and Properties of Composites, Materials ScienceTechnology, Vol. 13, VCH, Germany, 1993.

Digital learning Resources:

CourseName:	Introduction to Composites
CourseLink:	https://nptel.ac.in/courses/112/104/112104229/
CourseInstructor:	Dr Nachiketa Tiwari, IITKanpur

Course Name:	Processing of nonmetals
Course Link:	https://nptel.ac.in/courses/112/107/112107086/
Course Instructor:	Dr Indradeep Singh, IIT Roorkee

6th Semester	RME6D002	Compressible Flow and Gas Dynamics	L-T-P 3-0-0	3 Credits

Module I: (9 hours)
Fundamentals of Fluid dynamics and Thermodynamics: continuity equation, Momentum equation, Energy equation of incompressible flow Introduction to compressible flow: Introduction, Isentropic flow in a stream tube, speed of sound, Mach waves; One dimensional Isentropic Flow: Governing equations, stagnation conditions, critical conditions, maximum discharge velocity, isentropic relations

Module II: (9 hours)
Normal Shock Waves: Shock waves, stationary normal shock waves, normal shock wave relations in terms of Mach number; Oblique Shock Waves: Oblique shock wave relations, reflection of oblique shock waves, interaction of oblique shock waves, conical shock waves; Expansion Waves: Prandtl-Meyer flow, reflection and interaction of expansion waves, flow over bodies involving shock and expansion waves

Module III: (9 hours)
Variable Area Flow: Equations for variable area flow, operating characteristics of nozzles, convergent-divergent supersonic diffusers Adiabatic Flow in a Duct with Friction: Flow in a constant area duct, friction factor variations, the Fanno line; Flow with Heat addition or removal: One-dimensional flow in a constant area duct neglecting viscosity, variable area flow with heat addition, one-dimensional constant area flow with both heat exchanger and friction

Module IV: (9 hours)
Generalized Quasi-One-Dimensional Flow: Governing equations and influence coefficients, solution procedure for generalized flow with and without sonic point; Two-Dimensional Compressible Flow: Governing equations, vorticity considerations, the velocity potential, linearized solutions, linearized subsonic flow, linearized supersonic flow, method of characteristics.

Books

1. P. H. Oosthuizen and W. E. Carscallen. Compressible Fluid Flow. NY, McGraw-Hill, 1997.
2. H. W. Liepmann, and A. Roshko, Elements of Gas Dynamics, Dover Pub, 2001.
3. A. H. Shapiro, Compressible Fluid Flow 1 and 2. Hoboken NJ: John Wiley.
4. M. A. Saad, Compressible Fluid Flow. 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1993.
5. F. M. White, Viscous Fluid Flow. 2nd ed. New York: McGraw-Hill, 1991.

Course Name:	Gasdynamics: Fundamentals and Applications
Course Link:	https://onlinecourses.nptel.ac.in/noc21_ae03/preview
Course Instructor:	Prof. Srisha Rao M V, IISc Banglore

6^{th} Semester	RME6D003	Computer Integrated Manufacturing and FMS	L-T-P 3-0-0	3 Credits

MODULE – I (12 HOURS)

Fundamentals of Manufacturing and Automation: Production systems, automation principles and its strategies; Manufacturing industries; Types of production function in manufacturing;Automation principles and strategies, elements of automated system, automation functions and
level of automation; product/production relationship, Production concept and mathematicalmodels for production rate, capacity, utilization and availability; Cost-benefit analysis.Computer Integrated Manufacturing: Basics of product design, CAD/CAM, Concurrent engineering, CAPP and CIM.

MODULE – II (12 HOURS)

Industrial Robotics: Robot anatomy, control systems, end effectors, sensors and actuators; fundamentals of NC technology, CNC, DNC, NC part programming; Robotic programming, Robotic languages, work cell control, Robot cleft design, types of robot application, Processing operations, Programmable Logic controllers: Parts of PLC, Operation and application of PLC, Fundamentals of Net workings; Material Handling and automated storage and retrieval systems, automatic data capture, identification methods, bar code and other technologies.

MODULE – III (12 HOURS)

Introduction to manufacturing systems: Group Technology and cellular manufacturing, Partfamilies, Part classification and coding, Production flow analysis, Machine cell design, Applications and Benefits of Group Technology. Flexible Manufacturing system: Basics of FMS, components of FMS, FMS planning and implementation, flexibility, quantitative analysis of flexibility, application and benefits of FMS. Computer Aided Quality Control: objectives of CAQC, QC and CIM, CMM and Flexible Inspection systems.

Books :

1. Automation, Production Systems and Computer Integrated Manufacturing: M.P. Groover, Pearson Publication.
2. Automation, Production systems & Computer Integrated Manufacturing, M.P Groover, PHI.
3. CAD/CAM/CIM, P.Radhakrishnan, S.Subramanyam and V.Raju, New Age International
4. Flexible Manufacturing Systems in Practice, J Talavage and R.G. Hannam, Marcell Decker
5. CAD/CAM Theory and Practice, Zeid and Subramanian, TMH Publication
6. CAD/CAM Theory and Concepts, K. Sareen and C. Grewal, S Chand publication
7. Computer Aided Design and Manufacturing, L. Narayan, M. Rao and S. Sarkar, PHI.
8. Principles of Computer Integrated Manufacturing, S.K.Vajpayee, PHI
9. Computer Integrated Manufacturing, J.A.Rehg and H.W.Kraebber, Prentice Hall

Course Name:	Computer Integrated Manufacturing
Course Link:	https://onlinecourses.nptel.ac.in/noc21_me65/preview
Course Instructor:	Prof. J Ramkumar, Prof Amandeep Singh, IIT Kanpur

6^{th} Semester		Artificial Intelligence and Machine Learning	L-T-P 3-0-0	3 Credits

Module-I: **(12 hours)**

INTRODUCTION –The Foundations of Artificial Intelligence; - INTELLIGENT AGENTS – Agents and Environments, Good Behaviour: The Concept of Rationality, the Nature of Environments, the Structure of Agents, SOLVING PROBLEMS BY SEARCH – Problem-Solving Agents, Formulating problems, Searching for Solutions, Uninformed Search Strategies, Breadth-first search, Depth-first search, Searching with Partial Information, Informed (Heuristic) Search Strategies, Greedy best-first search, A* Search, CSP, Means-End-Analysis.

Module-II: (12 hours)

ADVERSARIAL SEARCH – Games, The Mini-Max algorithm, optimal decisions in multiplayer games, Alpha-Beta Pruning, Evaluation functions, Cutting off search, LOGICAL AGENTS – Knowledge-Based agents, Logic, Propositional Logic, Reasoning Patterns in Propositional Logic, Resolution, Forward and Backward chaining - FIRST ORDER LOGIC – Syntax and Semantics of First-Order Logic, Using First-Order Logic , Knowledge Engineering in First-Order Logic - INFERENCE IN FIRST ORDER LOGIC – Propositional vs. First-Order Inference, Unification and Lifting, Forward Chaining, Backward Chaining, Resolution

Module-III: **(6 hours)**

UNCERTAINTY – Acting under Uncertainty, Basic Probability Notation, The Axioms of Probability, Inference Using Full Joint Distributions, Independence, Bayes' Rule and its Use, PROBABILISTIC REASONING – Representing Knowledge in an Uncertain Domain, The Semantics of Bayesian Networks, Efficient Representation of Conditional Distribution, Exact Inference in Bayesian Networks, Approximate Inference in Bayesian Networks

Module-IV: **(10 hours)**

LEARNING METHODS – Statistical Learning, Learning with Complete Data, Learning with Hidden Variables, Rote Learning, Learning by Taking Advice, Learning in Problem-solving, learningfrom Examples: Induction, Explanation-based Learning, Discovery, Analogy, FormalLearning Theory, Neural Net Learning and Genetic Learning. Expert Systems: Representingand Using Domain Knowledge, Expert System Shells, Explanation, Knowledge Acquisition.

Books:

[1] Elaine Rich, Kevin Knight, & Shivashankar B Nair, Artificial Intelligence, McGraw Hill,3rd ed.,2009

[2] Stuart Russell, Peter Norvig, *Artificial Intelligence -A Modern Approach*, 2/e, Pearson, 2003.

[3] Nils J Nilsson, *Artificial Intelligence: A New Synthesis*, Morgan Kaufmann Publications,2000

[4] Introduction to Artificial Intelligence & Expert Systems, Dan W Patterson, PHI.,2010

[5] S Kaushik, Artificial Intelligence, Cengage Learning, 1st ed.2011

Digital Learning Resources:

Course Name:	Artificial Intelligence Search Methods For Problem Solving
Course Link:	https://swayam.gov.in/nd1_noc20_cs81/preview
Course Instructor:	Prof. D. Khemani, IIT Madras

Course Name:	Fundamentals of Artificial Intelligence
Course Link:	https://swayam.gov.in/nd1_noc20_me88/preview
Course Instructor:	Prof. S. M. Hazarika, IIT Guwahati
Course Name:	Introduction to Machine Learning
Course Link:	https://nptel.ac.in/courses/106/105/106105152
Course Instructor:	Prof. S. Sarkar, IIT Kharagpur
Course Name:	Machine Learning
Course Link:	https://nptel.ac.in/courses/106/106/106106202
Course Instructor:	Prof. Carl Gustaf Jansson, IIT Madras

6th Semester		Electrical Energy Conservation and Auditing	L-T-P 3-0-0	3 Credits

MODULE – I **(12HOURS)**

Electrical energy conservation: Energy economics- discount rate, payback period, internal rate of return, net present value, and life cycle cost. Energy generation, energy distribution, energy usage by processes, technical and economic evaluation, understanding energy costs, classification of energy conservation measures, plant energy performance, benchmarking and energy performance, matching energy usage to requirement, maximizing energy system efficiency, optimizing the input energy requirements, fuel and energy substitution, and energy balancing.

EB billing- HT and LT supply, transformers, electric motors- motor efficiency computation, energy efficient motors, pumps, fans, blowers, compressed air systems, refrigeration and air conditioning systems, cooling towers, electric heaters (space and liquid), DG-sets, illuminating devices, power factor improvement, and harmonics.

MODULE – II **(08 HOURS)**

Electrical energy audit: Energy consumption pattern and scenario of any region; Energy auditing: Need, types, methodology and approaches; Preliminary energy audit methodology (initial site visit and preparation required for detailed auditing, detailed energy audit activities, information and data collection, process flow diagram and process steps); Procedure and techniques: Data gathering, evaluation of saving opportunities, and energy audit reporting; and Energy audit instruments.

MODULE – III **(15 HOURS)**

Illumination: Illumination, luminous flux, lumen, luminous intensity, candela power, brightness, glare, types of lighting (incandescent, CFL, and LED), requirements of lux for various purposes, determine the method of lighting, select the lighting equipments, and calculate the lighting parameters.

Books :

1. Callaghn, P. W." Design and Management for Energy Conservation", Pergamon Press, Oxford, 1981.
2. Dryden. I. G. C.," The Efficient Use of Energy", Butterworths, London, 1982.
3. Energy Economics -A. V. Desai (Wiley Eastern).
4. Handbook of Energy Efficiency - CRC Press
5. Energy Technology, OP Gupta, Khanna Book Publishing
6. Handbook of Energy Audits Albert Thumann, William J. Younger, Terry Niehus, 2009.
7. Handbook on Energy Audit and Environment Management, Y P Abbi and Shashank Jain, TERI, 2006.

6^{th} Semester		Control System	L-T-P 3-0-0	3 Credits

Module I: **(5 hours)**

Industrial Control examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time-invariant systems. Feedback Control: Open-Loop and Closed-loop systems. Benefits of NegativeFeedback. Block diagram algebra. Signal Flow Graph and Mason'sGain formula.

Module II: **(10 hours)**

Standard test signals. Time response of first and second order systems for standard test inputs. Application of initial and final value theorem. Design specifications for second-ordersystems based on the time-response. Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.

Module III: **(7 hours)**

Relationship between time and frequency response, Polar plots, Bode plots. Nyquist stabilitycriterion. Relative stability using Nyquist stability criterion – gain and phase margins. Closed-loop frequency response: Constant M Circle, Constant N Circle, Nichols Chart.

Module IV: **(10 hours)**

Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness of control systems. Root-loci method of feedback controller design. Design specifications in frequency-domain. Frequency-domain methods of design. Application of Proportional, Integral and Derivative Controllers, Tuning of PID controllers, Lead and Lag and Lag-Lead compensator design.

Module V: **(10 hours)**

Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigenvalues and Stability Analysis. Concept of controllability and observability. Pole-placement by state feedback. Discrete-time systems. Difference Equations. State-space models of linear discrete-time systems. Stability of linear discrete-time systems.

Books:

[1] I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International, 2009.
[2] K. Ogata, "Modern Control Engineering", Prentice Hall, 1991
[3] M. Gopal, "Control Systems: Principles and Design", McGraw Hill Education, 1997.
[4] B. C. Kuo, "Automatic Control System", Prentice Hall, 1995.

Digital Learning Resources:

Course Name: Control System Engineering
Course Link: https://nptel.ac.in/courses/108/102/108102043/
Course Instructor: Prof. M Gopal, IIT Delhi

6^{th} Semester	RIK6F001	Essence of Indian Knowledge Tradition - I	L-T-P 3-0-0	0 Credits

Course Objective:

The course aims at imparting basic principles of thought process, reasoning and inferencing. Sustainability is at the core of Indian Traditional Knowledge Systems connecting society and nature.Holistic life style of Yogic-science and wisdom capsules in Sanskrit literature are also important in modern society with rapid technological advancements and societal disruptions. The course focuses on introduction to Indian Knowledge System, Indian perspective of modern scientific world-view and basic principles of Yoga and holistic health care system.

Course Outcomes:

- Ability to understand, connect up and explain basics of Indian Traditional knowledge modern scientific perspective.

Course Content:

- Basic Structure of Indian Knowledge System (i) वेद, (ii) उपवेद (आयुर्वेद, धनुर्वेद, गन्धर्वेद, स्थापत्य आदि) (iii) वेदांग (शिक्षा, कल्प, निरुत, व्याकरण, ज्योतिष छंद), (iv) उपाङ्ग (धर्म शास्त्र, मीमांसा, पुराण, तर्कशास्त्र)
- Modern Science and Indian Knowledge System
- Yoga and Holistic Health care
- Case Studies.

Books:

1. V. Sivaramakrishna (Ed.), Cultural Heritage of India-Course Material, Bharatiya Vidya Bhavan, Mumbai, 5th Edition, 2014

2. Swami Jitatmanand, Modern Physics and Vedant, Bharatiya Vidya Bhavan

3. Fritzof Capra, Tao of Physics

4. Fritzof Capra, The wave of Life

5. V N Jha (Eng. Trans,), Tarkasangraha of Annam Bhatta, Inernational Chinmay Foundation, Velliarnad, Amaku,am

6. Yoga Sutra of Patanjali, Ramakrishna Mission, Kolkatta

7. GN Jha (Eng. Trans.) Ed. R N Jha, Yoga-darshanam with Vyasa Bhashya, VidyanidhiPrakasham, Delhi, 2016

8. RN Jha, Science of Consciousness Psychotherapy and Yoga Practices, VidyanidhiPrakasham, Delhi, 2016 9. P R Sharma (English translation), ShodashangHridayam

5^{th} Semester	RME5C201	Design of Machine Elements Lab	L-T-P 0-0-3	2 Credits

LIST OF EXPERIMENTS:

1. Design of any one working model related to Design of machine elements i.e., Module I and II.
2. Design of any one working model related to Design of machine elements i.e., Module III and IV.
3. Design & drawing of Riveted joint
4. Design and drawing of Cotter joint
5. Design and drawing of Knuckle joint
6. Design of shafts subjected to combined loading
7. Design and drawing of Flange coupling
8. Design of spring
9. Design of bearing

Total no. of Drawing: 6
3 in drawing sheets
3 in AutoCad/Pro-E/CATIA/ANSYS

5th Semester	RME5C202	Machining Science and Technology Lab	L-T-P 0-0-3	2 Credits

LIST OF EXPERIMENTS:

(Minimum 08 Experiments/Studies)

1. Job on lathe with tapper turning, thread cutting, knurling and groove cutting (3 experiments).
2. Gear cutting (with index head) on milling machine
3. Working with shaper, Planner and slotting machine.
4. Working with surface and cylindrical grinding.
5. Determination of cutting force using Lathe tool dynamometer.
6. Determination of cutting force in drilling using drill tool dynamometer.
7. Study of Non-traditional machining processes.(USM, AJM, EDM, ECM)
8. Study of CNC Lathe and demonstration of making job in CNC lathe.
9. Study of CNC Milling machine and demonstration of making job in CNC Milling machine

6th Semester		**Future-ready Contributor Program Laboratory**	**L-T-P 0-0-3**	**2 Credits**

Outcomes: The Future-ready Contributor Program aims to accomplish the following outcomes in the lives of students–

- Improve the employability of students by giving them the right work ethic and thinking that employers are looking for.
- Build their confidence with which they can go into any job and contribute meaningfully.
- Improve their ability to engage better in the workplace and to be able to handle the challenges that come up there.
- Build their career-worthiness and help them develop into future-ready contributors with ability to navigate a career in a volatile, changing world.
- Widen their choices of career and success, so that they are able to open up more opportunities for themselves and take up unconventional career pathways.
- Enable them recognize how they as technical professionals, can participate and make a positive contribution to their communities and to their state.

The Program content is also designed to expose students to real-world workplace scenarios and sensitize them to some of the challenges faced in society around them, especially in the local communities around them and in their own state of Odisha.

The Contributor Program syllabus has been evolved and fine-tuned over several years, to –

a) address the changing need and contemporary challenges being faced by industry and what employers of today are looking for in the people they hire;
b) working extensively with universities and students and an appreciation of their challenges and concerns;
c) guided by the higher ideas and principles of practical Vedanta in work.

Sr. No.		Content	Total Hrs
1	**Part 1 : Developing self-efficacy and basic inner strength**	**Who is a Future-ready Contributor?** *In this topic, students understand the new work environment, expectations from future workforce, and importance of being a future-ready contributor. This enables students to transform their expectation of themselves in work*	3 hrs lab sessions (discovery-based facilitator led)
2		**Self-esteem & Growth Identity** *In this topic, students learn how to develop a deeper and more resilient self esteem and how to adopt a growth identity/ mindset, that is more appropriate to the demands of the future workplace.*	Same as above
3		**Become a Creator of one's destiny** *In a "victim stance", we see the career environment as full of difficulties and hurdles. We feel powerless or blame our circumstances for not having many opportunities. This makes us fearful of uncertainty and makes us settle for jobs where we remain mediocre. In this topic, students discover the "creator of destiny stance" to challenges and situations. This stance helps them take ownership & responsibility to shape destiny, build a new future & find answers to challenges; and stop being complainers.*	Same as above
4	**Part 2 : Building ability to make more effective career choices**	**Achieving Sustainable Success** *In this topic, students discover how to achieve sustainable or lasting success, by making themselves success-worthy. Where their focus shifts to building one's "engine of success" rather than being on chasing the "fruits of success". This is important, because over a lifetime of work, all people go through ups and downs – where the fruits are not in their control. People who are focused on the fruits of success, fall prey to disappointment, loss in motivation, quitting too early, trying to find shortcuts – when fruits don't come. Whereas people focused on building their engine of success continue to contribute steadily, irrespective of whether fruits come or not.*	Same as above

		This helps them make better choices in life, that leads to steady success & long-term career fulfillment in an uncertain world.	
5		**Career Development Pathways for a changing world** *In this topic, students explore a range of diverse "career development models" and the possibilities for contribution each opens up to them. This helps them open up hidden opportunities that such an environment offers. And free themselves from a herd mentality when making career choices.*	Same as above
6		**Make an impact in every part of one's life** *In this topic, students learn how to expand the contribution possible in any role they have. This helps them take charge of own career growth & discover their power to contribute in any role or job.*	Same as above
7	**Part 3 : Building ability to become solution and value creating individuals in the world**	**Think Solutions** *The market environment in which organizations are operating, is becoming increasingly dynamic and uncertain. So, employers are increasingly seeking out people who can innovate and figure out solutions in the face of any challenge (unlike in the past when it was the people who were most efficient and productive, who were valued by organizations). At the heart of innovation lies this way of thinking of "finding solutions" rather than "seeing problems or roadblocks". Students learn how to build this way of thinking, in this topic.*	Same as above
8		**Value Thinking** *Companies are also looking for employees who do not just work hard, or work efficiently or productively - but those who will make a valuable difference to the fortunes of the company. This difference may come from innovation, but it may also come from focusing on the right things and identifying what really matters – both to the company and to the customers. In this topic, students learn how to build this capability.*	Same as above

9		**Engaging Deeply** *The environment we live in is becoming increasingly complex because more and more things are getting interconnected, new fields are emerging, technologies are rapidly changing, capabilities and knowledge one is trained in will become fast obsolete. In such a scenario, the student's ability to quickly understand and master what is going on, dive deep, get involved in any area, rapidly learn new capabilities that a job demands, is important. In this topic, students learn how to engage deeply. Learning how to dive deep, to quickly understand what is going on, get involved in any area, and rapidly learn.*	Same as above
10	**Part 4 : Building ability to work collaboratively and as good citizens of organizations and the country**	**Enlightened self-interest & collaboration at work** *The changing nature of work in organizations and in the global environment, is increasingly demanding that people work more collaboratively towards shared goals and more sustainable goals. A key to working successfully when multiple stakeholders are involved, is "thinking in enlightened self-interest". In this topic, students learn how to widen their thinking from "narrow self-interest" to "enlightened self-interest" to work more effectively in teams & collaboratives.*	Same as above
11		**Human-centered thinking & Empathy** *In this topic, students learn to recognize & respond to human needs and challenges – the way of thinking at the heart of user-centric designs & customer-centricity.*	Same as above
12		**Trust Conduct** *The biggest currency in a sustainable career is "trust" i.e. being trusted by team members, bosses, customers. When we are trusted, people listen to us, they are willing to give us the chance to grow, give us the space to make mistakes, and work seamlessly with each other without always having to "prove ourselves". In this topic, students learn how to build trust with people they engage with.*	Same as above
Contribution Project Lab Sessions		*3 Contribution projects that help them apply contributor thinking. After students complete their project work (beyond the classroom), each project ends with this 3 hr lab session where they build their project output and*	9 hrs (3 hr lab sessions for each of 3 projects)

	present.	
Project work	*The above Contribution Projects require research, and may need field work beyond the classroom that students are expected to do.*	Beyond classroom

Lab Sessions:

- Students will have to attend twelve discovery-based lab sessions to build new models of thinking & capacities (3 hrs per module)
- They will work closely with their peers to discuss and understand these new models of thinking.
- Their learning will be facilitated by trained college faculty.

Contribution Projects

- Three contribution projects that help them apply contributor thinking
- These will require research and also may need field work

Each ends with a 3 hr lab session where they build their project output