Savitribai Phule Pune University

Faculty of Science & Technology

Curriculum for

Second Year

Robotics & Automation

(2019 Course)

(With effect from June 2020)

Savitribai Phule Pune University, Pune SE (Robotics & Automation) 2019 Course (With effect from Academic Year 2020-21)														
Semester-III														
Course Code	**Course Name**	**Teaching Scheme (Hours/Week)**			**Examination Scheme and Marks**						**Credit**			
		Theory	**Practical**	**Tutorial**	**IN-Sem**	**End-Sem**	**TW**	**PR**	**OR**	**Total**	**TH**	**PR**	**TUT**	**Total**
207007	Engineering Mathematics-III	3		1	30	70	25			125	3		1	4
211501	Industrial Electronics and Electrical Technology	3			30	70				100	3			3
211082	Strength of Materials	3			30	70				100	3			3
211502	Manufacturing Technology	3			30	70				100	3			3
211503	Materials Science and Engineering Metallurgy	3			30	70				100	3			3
211504	Industrial Electronics and Electrical Technology Lab		2				25			25		1		1
211086	Strength of Materials Lab		2						25	25		1		1
211505	Manufacturing Technology Lab		2					50		50		1		1
211506	Materials Science and Engineering Metallurgy Lab		2						25	25		1		1
211507	C Programming Lab		4				50			50		2		2
211090	Mandatory Audit Course 3	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		**15**	**12**	**1**	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**6**	**1**	**22**

Savitribai Phule Pune University, Pune
SE (Robotics & Automation)
2019 Course
(With effect from Academic Year 2020-21)

Semester-IV

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	IN-Sem	End-Sem	TW	PR	OR	Total	TH	PR	TUT	Total
211508	Industrial Engineering and Management	3			30	70				100	3			3
211509	Control System Engineering	3			30	70				100	3			3
211510	Design of Machine Elements	3			30	70				100	3			3
211511	Metrology and Quality Assurance	3			30	70				100	3			3
211512	Computer Graphics for Robotics	3			30	70				100	3			3
211513	Control System Engineering Lab		2				25	25		50		1		1
211514	Design of Machine Elements Lab		2						25	25		1		1
211515	Metrology and Quality Assurance Lab		2					25		25		1		1
211516	Computer Graphics for Robotics Lab		2				25			25		1		1
211517	Robot Operating System		2						25	25		1		1
211099	Project Based Learning		4				50			50		2		2
211100	Mandatory Audit Course 4	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**14**	**0**	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**7**	**0**	**22**

Abbreviations:
TH : Theory TW : Term Work PR : Practical
OR : Oral TUT : Tutorial

Engineering Mathematics III
207007

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Lectures: 3 Hrs./Week	Theory: 3	In-Sem Exam: 30 Marks
Tutorials: 1 Hr./Week	Tutorials: 1	End-Sem Exam: 70 Marks
		Term work: 25 Marks

Prerequisites: - Differential and Integral calculus, Differential equations of first order and first degree, Fourier series, Collection, classification and representation of data, Permutations & combinations and Vector algebra.

Course Objectives:
To make the students familiarize with concepts and techniques in Ordinary & Partial differential equations, Laplace transform & Fourier transform, Statistical methods, Probability theory and Vector calculus. The aim is to equip them with the techniques to understand advanced level mathematics and its applications that would enhance analytical thinking power, useful in their disciplines.

Course Outcomes: At the end of this course, students will be able to
1) Solve higher order linear differential equations and its applications to model and analyze mass spring systems.
2) Apply Integral transform techniques such as Laplace transform and Fourier transform to solve differential equations involved in vibration theory, heat transfer and related mechanical engineering applications.
3) Apply Statistical methods like correlation, regression in analyzing and interpreting experimental data applicable to Reliability engineering and probability theory in testing and quality control.
4) Perform Vector differentiation and integration, analyze the vector fields and apply to fluid flow problems.
5) Solve Partial differential equations such as wave equation, one and two dimensional heat flow equations.

Unit I:
Linear Differential Equations (LDE) and Applications (07)
LDE of nth order with constant coefficients, Complementary Function, Particular Integral, General method, Short methods, Method of variation of parameters, Cauchy's and Legendre's DE, Simultaneous and Symmetric simultaneous DE. Modelling of mass-spring systems, free and forced damped and undamped systems.

Unit II:
Transforms (07)
Laplace Transform **(LT):** LT of standard functions, properties and theorems, Inverse LT, Application of LT to solve LDE.
Fourier Transform **(FT):** Fourier integral theorem, Fourier transform, Fourier Sine & Cosine transform, Inverse Fourier Transforms.

Unit III:
Statistics (07)
Measures of central tendency, Measures of dispersion, Coefficient of variation, Moments, Skewness and Kurtosis, Curve fitting: fitting of straight line, parabola and related curves, Correlation and Regression, Reliability of Regression Estimates.

Unit IV:
Probability and Probability Distributions (07)
Probability, Theorems on Probability, Bayes Theorem, Random variables, Mathematical Expectation, Probability distributions: Binomial, Poisson, Normal, Test of Hypothesis: Chi-Square test, t-distribution.

Unit V:
Vector Calculus (07)
Vector differentiation, Gradient, Divergence and Curl, Directional derivative, Solenoidal and Irrotational fields,

Vector identities. Line, Surface and Volume integrals, Green's Lemma, Gauss's Divergence theorem and Stoke's theorem.

Unit VI:

Applications of Partial Differential Equations (PDE) (07)

Basic concepts, modelling of Vibrating String, Solution of Wave equation, One and two dimensional Heat flow equations, method of Separation of variables, use of Fourier series. Solution of Heat equation by Fourier transforms.

Text Books:

1. Higher Engineering Mathematics by B.V. Ramana (Tata McGraw-Hill).
2. Higher Engineering Mathematics by B. S. Grewal (Khanna Publication, Delhi).

Reference Books:

1. Advanced Engineering Mathematics, 10e, by Erwin Kreyszig (Wiley India).
2. Advanced Engineering Mathematics, 2e, by M. D. Greenberg (Pearson Education).
3. Advanced Engineering Mathematics, 7e, by Peter V. O'Neil (Cengage Learning).
4. Differential Equations, 3e by S. L. Ross (Wiley India).
5. Introduction to Probability and Statistics for Engineers and Scientists, 5e, by Sheldon M. Ross (Elsevier Academic Press)
6. Partial Differential Equations for Scientists and Engineers by S. J. Farlow (Dover Publications, 1993)

Guidelines for Tutorial and Term Work:

i) Tutorial shall be engaged in four batches (batch size of 20 students maximum) per division.
ii) Term work shall be based on continuous assessment of six assignments (one per each unit) and performance in internal tests.

Industrial Electronics and Electrical Technology
211501

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Prerequisites: Basic Electrical Engineering, Basic Electronics Engineering

Course Outcomes:

1. Develop the capability to identify and select suitable DC motor / induction motor /
2. Identify special purpose motor and its speed control method for given industrial application.
3. Program Arduino IDE using conditional statements
4. Interfacing sensors with Arduino IDE
5. Analyze Microcontrollers and embedded systems terminologies and sensors

Unit I: Introduction to Microcontrollers (07)

Introduction to microcontroller and microprocessors, role of embedded systems, open source embedded platforms, Atmega 328P- features, architecture, portstructure, sensors and actuators, data acquisition systems, introduction to Arduino IDE-features, IDE overview, programming concepts: variables, functions, conditional statements.

Unit II: Peripheral Interface-1 (07)

Concept of GPIO in Atmega 328P based Arduino board, digital input and output, UART concept, timers, interfacing with LED, LCD and keypad, serial communication using Arduino IDE

Unit III: Peripheral Interface-2 (07)

Concept of ADC in Atmega 328P based Arduino board, interfacing with temperature sensor (LM35), LVDT, strain gauge, accelerometer, concept of PWM, DC motor interface using PWM

Unit IV: D. C. Machines (07)

Construction, working principle of D.C. generator, emf equation of D. C. generator (derivation not expected), working principle of D.C. motor, types of D.C. motor, back emf, torque equation for D.C. motor, characteristics of D.C. motor (series and shunt only), three-point starter for D.C shunt motor, methods for speed control of D.C. shunt and series motors, industrial applications.

Unit V: Three Phase Induction Motors (07)

Constructional feature, working principle of three phase induction motors, types; torque equation, torqueslip characteristics; power stages; efficiency, starters (auto transformer starter, star delta starter); methods of speed control and industrial applications.

Unit VI: Special Purpose Motors (07)

Construction, working principle, characteristic and applications of stepper motors, A.C. and D.C servomotors, universal motors, industrial applications, brushless DC motors, linear induction motors, single phase induction motors,(types, construction, working principle of split phase and shaded pole type induction motors), descriptive treatment for AC series motor (difference between AC series and DC series motor, construction and working).

Text Books

1. Edward Hughes "Electrical Technology", ELBS, Pearson Education.
2. Ashfaq Husain, "Electrical Machines", Dhanpat Rai & Sons
3. S. K. Bhattacharya, "Electrical Machine", Tata Mc Graw Hill publishing Co. Ltd,2nd Edition
4. Nagrath & Kothari, "Electrical Machines", Tata Mc Graw
5. Ajay Deshmukh, 'Microcontrollers Theory and Applications', TATA McGraw Hill
6. Arduino microcontroller processing for everyone-Steven F Barret,Morgan and Claypool Publisher.
7. C programming with ardino-Warwick Smith Elektor Publication.

Reference

1. Electrical Machines, Lowe, Nelson Publications.
2. A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, "Electrical Machines", TataMcGraw Hill Publication Ltd. Fifth Edition.
3. Permanent Magnet Synchronous and Brushless DC Motor Drives, R. Krishnan, CRC press
4. Smarajit Ghosh, "Electrical Machines", Pearson Education, New Delhi.[R5]Kenneth J. Ayala, 'The 8051 Microcontroller', Cengage Learning
5. Started with Arduino by Massimo Banzi and Michael Shiloh Published by Maker Media, Inc

Strength of Materials
211082

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Prerequisites: Engineering Mechanics, Physics

Course Outcomes:

On successful completion of the course students should be able to-

- Understand the concepts of stress and strain at a point as well as the stress-strain relationship for homogeneous, isotropic materials.
- Understand the analysis and design the members subjected to tension, compression, torsion, bending and combined stresses using fundamental concepts of stress, strain and elastic behavior of materials.
- Understand the procedure of determining the stresses and strains in members subjected to combined loading and apply the theories of failure for static loading.
- Understand analysis of slender, long columns and determine and illustrate principal stresses, maximum shearing stress and stresses acting on a structural member.

Unit I

Simple stresses and strains: (07)

Basic Concepts- Concept of stress and strain (linear, lateral, shear and volumetric), Hooke's law, Poisson's ratio, modulus of elasticity, modulus of rigidity, stress strain diagrams for ductile and brittle materials, factor; of safety, working stress, generalized Hooke's law, concept of 3-D stress state, bulk modulus, interrelation between elastic constants.

Unit II **(07)**

Axially Loaded Components

Axial force diagram, stresses, strains, strains & deformations in determinate and indeterminate, homogenous and composite bars under concentrated loads, self-weight and temperature changes.

Transversely Loaded Components

Shear Force and Bending Moment in Determinate Beams due to Concentrated Loads, Uniformly Distributed Loads. Relation between SF and BM Diagrams for Cantilevers, Simple and Compound Beams, Bends Defining Critical and Maximum Values and Positions of Points of Contra Flexure- Construction of Loading Diagram and BMD from SFD and Construction of Loading Diagram and SFD from BMD.

Unit III **(07)**

Bending stresses

Theory of simple bending, assumptions, derivation of flexure formula, second moment of area of common cross sections with respect to centroidal and parallel axes. Bending stress

Shear stresses:

Concept, derivation of shear stress distribution formula, shear stress distribution diagram for common symmetrical sections, maximum and average shear stress, shear connection between flange and web.

Unit IV **(07)**

Transformation of Stresses and Strains

Normal and shear stresses on any oblique plane. Concept of principal planes. Derivation of expressions for principal stresses and maximum shear stress, position of principal planes and planes of maximum shear, graphical solution using Mohr's circle of stresses.

Strain energy and impact

Concept of strain energy, derivation and use of expressions for deformations of axially loaded members under gradual impact loads. Strain energy due to self-weight.

Unit V **(07)**

Torsion of circular shafts:

Stresses, strains and deformations in determinate and indeterminate shafts of solid and hollow homogeneous and composite circular cross section subjected to twisting moment. Derivation of torsion equation. Stresses due to combined torsion, bending and axial force on shafts.

Cylinders and spherical shells

Thin and thick cylinders, thin spheres, volumetric strains, pre-stress in cylinders, cylinders under combined loading, compound cylinders analysis, spherical shells analysis.

Unit VI **(07)**

Slope and deflection of Beams:

Relation between BM and slope, slope and deflection of determinate beams, Double Integration Method (Macaulay's Method).Derivation of Formulae for Slope and Deflection for Standard Cases.

Buckling

Concept of buckling of columns. Derivation of Euler's formula for buckling load for column with hinged ends. Concept of equivalent length for various end conditions. Limitations of Euler's formula. Rankin's formula. Johnson's formula, safe load on columns.

Reference Books

1. Ramamrutham S. and Narayanan R., "Strength of Materials", Dhanapat Rai and Sons,1992, ISBN: 818743354X
2. Rao Prakash "Strength Of Materials- A Practical Approach", Vol I, Universities Press India Limited, ISBN: 8173711259
3. Rattan S. S., "Strength of Materials", Tata McGraw-Hill Education,2011, ISBN: 007107256X
4. Junnarkar and Shah H J., "Mechanics of Structures", Charotar Press, 2002, ISBN: 81-85594-06-6.
5. Rajput R. K., "Strength of Materials", S. Chand Publication. ISBN-10 : 8188458104
6. Khurmi R. S., "Strength of Materials", S. Chand Publication., ISBN:8121928222
7. Beer F. P., Johnston E. R and Dewolf J. T., "Mechanics of Materials", McGraw Hill Higher Education, 5th edition, 2004, ISBN: 978-007 3529 387.
8. Gere J. M. and Timoshenko S. P., "Mechanics of Materials", 4th Edition, PWS Pub. Co, 2001, ISBN 978-0534934293.
9. Popov E. P., "Engineering Mechanics of Solids", Prentice Hall of India LTD, New Delhi, 2008.ISBN-10 :0137261594
10. Singer and Pytel, "Strength of Materials", Addison Wesley Publishing Corporation, 1999, ISBN 0 321 04541 6.
11. Timoshenko S P. and Young D. N., "Strength of Materials", Affiliated East-West Press PVT. LTD. New Delhi, 2006, ISBN : 8176710199

Manufacturing Technology
211502

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:03 hours / week	Theory:03	In-Sem: 30 Marks
		End-Sem : 70 Marks

Prerequisites: Systems of Mechanical Engineering, Physics, Engineering Metallurgy, Strength of material

Course Outcomes:

Students should be able to

1. Describe and classify metal casting processes
2. Classify and analyze various forming processes
3. Understand special casting and forming processes
4. Classify and describe different types of welding and joining processes
5. Understand various non conventional machining process.
6. Understand various applications of robots in manufacturing

Unit I: Casting **(07)**

Sand casting process: Introduction of sand casting. Patterns, Pattern materials, pattern allowances and design. Core prints and core seats. Mould strength, Ingredients of moulding materials and their effect on mould strength, testing of moulding sand. Melting: types of melting furnace (Cupola, electric arc furnace, Induction furnace- Construction, operations and zones), Casting Design consideration, Metal pouring, Gating system, Principles of gating, design of gating system, solidification time, riser design, cleaning, finishing of casting. Defects and respective remedies in casting. Special Casting Process.

Unit II : Forging and Rolling of Metals **(07)**

Fundamentals of Material Forming: Introduction of forming processes. Concept of plastic deformation Classification of material forming process, Theory of plasticity, Yield criteria for ductile materials: Von- mises criteria, Tresca criteria.

Forging: Introduction, Classification of forging processes. Forging equipment- Hammers, presses, Upstter etc., construction, working, capacities and selection of equipment. Basic forging
operations such as fullering, edging, drawing, blocking, finishing etc., Types of forging dies, Cleaning and finishing of forgings, Forging defects and the remedies.

Rolling of Metals: Scope and importance of rolling. Types of Rolling Mills - Construction and working. Deformation in rolling and determination forces required. Process variables, Rolling problems: Roll flattening, Roll cambering, Mill spring – its effect on rolling process. Defects in rolling.

Unit III: Wire, Rod and Tube Drawing and Extrusion **(07)**

Wire, Rod and Tube Drawing: Introduction to rod and wire drawing machines - construction and working. Preparation of stock for wire drawing. Wire drawing dies, material and design. Analysis of wire drawing operation, Variables in wire drawing, Maximum reduction in wire in one pass, forces required in drawing. Multiple drawing, strip drawing. Tube Drawing: Methods, force calculation, lubrication in tube drawing.

Extrusion Types: Direct, Indirect, impact, hydrostatic extrusion. Dies for extrusion, stock preparation. Extrusion ratio, Circumscribing circle diameter (CCD), Shape factor. Equipment (with and without friction), Work done in extrusion, Metal flow in extrusion, defects. Role of friction and lubricants.Manufacture of seam-less tubes.

Unit IV: Welding **(07)**

Introduction & classification of welding processes, Types of Electrodes, coding of Electrodes, Electrode efficiency, fluxes, welding symbols. **Arc welding processes**- Basic of electric arc welding: DCSP, DCRP & ACHF. Optimum

arc setting. Carbon arc, submerged arc, Tungsten inert gas (TIG), Metal Inert gas(MIG), Plasma arc, stud welding-Theory, comparison on merits, limitations and applications. **Gas welding**: processes and equipment used, type of flames, adjustment of flames, oxyacetylene welding, gas cutting –merits, limitations and applications. **Electric resistance welding**: processes and equipment used, Spot, Seam, Projection welding, Resistance tube welding, -merits, limitations and applications. **Solid state welding:** Ultrasonic, Friction , Explosive, Forge, , Friction stir welding **Special welding processes:** Laser, electron Beam welding, Thermit welding. **Inspection and testing of welding**: visual inspection, destructive & non-destructive testing. Protection and safety in welding.

Unit V: Non-conventional machining process (07)

Detail study with respect to working principle , process parameter, theoretical analysis, experimental results & comparative assessment of Abrasive jet machining, Ultrasonic machining, Chemical machining, Electrochemical machining, Electro discharge machining, Electron beam machining, laser beam machining, Plasma arc machining, Ion Beam machining, wire cut EDM, Numerical based on above processes

Unit VI: Manufacturing through robot applications (07)

Loading and/or unloading of parts in machining operations, hazardous work environment for human: forging, casting, press working , spot and arc welding operations etc., repetitive work cycle operations, assembly operations

References:

1. Rao P.N., "Manufacturing Technology, Foundry, Forming and welding", Tata McGraw-hill publishing, 2006, ISBN 0-07-463180-2.
2. Dieter, "Mechanical Metallurgy", Mc-graw hill ,ISBN0071004068.
3. Rowe G.W., "Principles of Industrial Metal Working Process", Edward Arnold, ISBN8123904282.
4. Dr. R. Narayanswamy, Metal Forming Technology, Ahuja Book Co., ISBN8176190020
5. Kalpakjian Serope and Schmid Steven, "Manufacturing Engineering & Technology", 2004. ISBN 10: 0131976397 ISBN 13: 9780131976399
6. Little Richard., "Welding & Welding Technology", Tata Mc-graw hill, 1992, ISBN 0-07-099409-9.
7. Parmar R.S., "Welding Process and Technology", 2ed.,Khanna Publishers, ISBN-10: 8174091262, ISBN-13: 978-8174091260

Material Science and Engineering Metallurgy
211503

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory:03	In-Sem: 30 Marks End-Sem : 70 Marks

Prerequisites: Physics, Chemistry

Course Outcomes: On successful completion of the course students should be able to-

1. Define the mechanical properties of materials and conduct destructive and non destructive tests to evaluate and test the properties of materials
2. Draw and explain equilibrium diagrams for various alloy systems
3. Work with Iron-Iron carbide equilibrium diagram and apply this knowledge for classification of steels from microstructure observations
4. Select proper Heat Treatment, Surface Hardening technique & Isothermal Treatments for the steels considering properties and service requirements
5. Distinguish different Alloy Steels and Cast Irons based on chemical compositions and microstructures
6. Familiarize with different types of non-ferrous alloys and Composites with their need scope and applications

Unit I: Introduction and testing of materials **(07)**

Introduction to material science and metallurgy, Classification of Engineering Materials; Crystal Structures, indexing of planes and directions, imperfections in crystal, Plastic deformation – slip and twinning mechanisms, deformation of single crystal and polycrystalline materials; strain or work hardening, effect of strain hardening on properties; Cold and Hot working of metals

Material testing : Tensile test – stress-strain curve and evaluation of properties; compression test, fatigue and creep tests, Erichsen cupping test, Hardness tests – Brinell, Rockwell, Vickers, Poldi; Impact tests; Nondestructive tests – Dye penetrant, Magna flux, Ultrasonic, Eddy current tests, Radiography.

Unit II: Equilibrium diagrams **(07)**

Related terms and definitions, Hume Rothery's rule of solid solubility, Gibb's phase rule, Polymorphism, Solidification, Dendritic growth, Cooling curves, plotting of equilibrium diagrams, Lever rule, Isomorphous system. Coring, Eutectic systems, Partial eutectic systems, Uses of eutectic alloys, Layer type system, other transformation, non-equilibrium cooling and its effects

Unit III: Powder Metallurgy **(07)**

Process in brief, powder characteristics, powder manufacturing, Advantages and limitations, Production of sintered structural components such as self lubricated bearing, cemented carbide tools, cermets, refractory metals, electrical contact materials, friction materials, Diamond impregnated tools etc.

Unit IV: Steels and Cast Irons **(07)**

Iron-iron carbide equilibrium diagram, Critical temperatures, Classification and applications of steels, Specifications of steels like BIS, EN, AISI, SAE; Alloy Steels -Effects of alloying elements, classification of alloying elements. Stainless Steels, Sensitization of stainless steel, weld decay of stainless steel. Tool steels and tool materials; Cast Irons: Classification, Effects of various parameters on structures and properties of cast irons, Applications

Unit V: Heat treatment of steels **(07)**

Introduction to heat treatment furnaces and Furnace atmospheres; Transformation products of austenite, Time-temperature- transformation diagrams, Critical cooling rate, Continuous cooling transformation diagrams; Quenching media; Annealing, Normalizing, Hardening, Effects and Elimination of retained austenite, Tempering, Hardenability testing Carburizing, Nitriding, Carbonitriding, Flame hardening and Induction hardening; Isothermal heat treatments such as austempering, patenting, iso-forming, martempering, ausformning.

Unit VI: Non-ferrous and Modern Engineering Materials (07)

Copper alloys – brasses and bronzes, Aluminum alloys, Solders, Bearing materials and their applications, Precipitation hardening alloys. High Temperature materials such as Nimonics, Super alloys, Ti-alloys etc.; Composites- Types, Characterization, Production techniques & Applications, Metal -Matrix composites, Particulate & Fibre composites; Biomaterials; Nano Materials; Sports materials.

Text-books:

1. Kodgire V. D., "Material science and metallurgy for Engineers", Everest Publishing House, Pune, ISBN 81 86314 00 8.
2. K. G. Bundinski, M. K. Bundinski , "Engineering Materials" Prentice Hall of India Pvt. Ltd., New- Delhi.
3. Higgins "Engineering Metallurgy", Part I Applied Physical Metallurgy, English Language book Society / Edward Arnold.
4. Smith W. F., "Principles of Material Science and Engineering", McGraw- Hill Inc. Book Company ISBN 0 07 122920 5.

Reference Books:

1. Rollason E. C., "Metallurgy for Engineering", ELBS Publishing.
2. Clark D.S.and Varney W. R. "Physical Metallurgy for Engineers", East-West Press Pvt. Ltd., New Delhi.
3. Avner, *"An* introduction to physical metallurgy", TMH publication.
4. Donald R. Askeland & Pradeep Phule. ," The science and engineering of materials", Thomson Asia Pvt.LTD, ISBN 981 243 855 6.

Industrial Electronics and Electrical Technology Lab
211504

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	Term Work: 25 Marks

List of Practicals: (Any 4 out of 1 to 6 and any 4 out of 7 to 12)

Electrical Engineering

1. Speed control of DC shunt motor.
2. Brake test on DC shunt motor.
3. No load and blocked rotor test on 3 phase Induction Motor.
4. Load test on 3 phase Induction Motor.
5. Load test on single phase Induction Motor.
6. Study of starters for AC and DC motors

Electronics Engineering

7. Interfacing of LED to blink after every 1 sec.
8. Display data using serial communication.
9. Interfacing of LCD to display the message and interface with keypad to display the key pressed.
10. Interfacing of temperature sensor (LM35) and show output on LCD/serial terminal.
11. Interfacing of strain gauge sensor and LVDT to measure the parameters.
12. Study of interfacing accelerometer to change the speed of DC Motor

Strength of Materials Lab
211086

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	Oral: 25 marks

List of Practical

1. Stress and Deflection Analysis of Cantilever beam.
2. Stress and Deflection analysis of Simply Supported beam using ANSYS.
3. To draw Shear stress and Bending moment diagram for a Beam using ANSYS.
4. Stress and Deflection Analysis of Column using ANSYS
5. Computer program for truss subjected to plane forces.
6. Computer program for beams subjected to transverse forces and moments

Manufacturing Technology Lab
211505

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical:01	Practical:50 Marks

List of Experiments

Students have to perform mini-projects in workshop related to following topics

Job 1: Making simple solid pattern involving wood turning operation and preparing mould. (one job)

Job 2: Demonstration on MMA, TIG, MIG, Resistance welding (spot welding) and fabricate a job involve various welding processes like manual metal arc welding (MMA),TIG, MIG.(one job)

Job 3: Job involving various operations on lathe (step, taper turning, drilling, chamfering knurling etc.) and at list one operation on drilling machine, milling machine and cylindrical grinding. (one job)

Job 4: Prepare prototype using 3D Printing/additive manufacturing

Material Science and Engineering Metallurgy Lab
211506

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical:01	OR: 25 Marks

List of Experiments:

1. Brinell and Poldi hardness test
2. Vickers and Rockwell hardness test
3. Erichsen Cupping test
4. Impact tests
5. Non- destructive testing - magnaflux testing, dye penetrant test, ultrasonic testing, eddy current testing
6. Tensile test on mild steel and aluminium test pieces.
7. Study and drawing of microstructures of various steels and cast irons
8. Study and drawing of microstructures of hardened steel, tempered steel.
9. Jominy hardenability test on steel
10. Hardening and tempering of steel

C-Programming Lab
211507

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 04 hours / week	Practical: 02	Term Work: 50 Marks

1. Syntax and structure of C-programming.
2. Data types, Operators and Expressions in C
3. Formatted and unformatted I/O in C with preprocessor directives
4. Programming knowledge using Decision Statements (if, if-else, if else if ladder, switch and GOTO)
5. Loop & nested loop Statements (for, while, do-while)
6. Programming with Pointer, String and Function call by reference.
7. Programming with Structure.
8. Creating data files and file handling in C.
9. Minimum 2 case studies of C-Programming related to Production Engineering

Mandatory Audit Course 3: Road Safety

211090

Road transport remains the least safe mode of transport, with road accidents representing the main cause of death of people. The boom in the vehicle population without adequate road infrastructure, poor attention to driver training and unsatisfactory regulation has been responsible for increase in the number of accidents. India's vehicle population is negligible as compared to the World statistics; but the comparable proportion for accidents is substantially large.

The need for stricter enforcement of law to ensure greater safety on roads and an environment-friendly road transport operation is of paramount importance. Safety and security are growing concerns for businesses, governments and the traveling public around the world, as also in India. It is, therefore, essential to take new initiatives in raising awareness, skill and knowledge of students as one of the ibid stake holders who are expected to follow the rules and policies of the government in order to facilitate safety of individual and safe mobility of others.

Course Contents:

1. Existing Road Transport Scenario
2. Accident Causes & Remedies
3. Road Accident Investigation & Investigation Methods
4. Vehicle Technology – CMVR & Road Safety
5. Regulatory / Legislative Provisions for Improving Road Safety
6. Behavioral Training for Drivers for Improving Road Safety
7. Road Safety Education
8. Road Engineering Measures for Improving Road Safety

Industrial Engineering and Management
211508

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Prerequisites: Knowledge of machines used in manufacturing organizations

Course Outcomes:

Students will be able to

1. Describe Principles and Types of Management
2. Interpret Theories of Motivations and leadership
3. Develop Entrepreneurship skills
4. Apply various Tools and techniques of Industrial Engineering for Productivity improvement
5. Apply Method study and examine the recorded facts and propose new method
6. Apply Work Measurement techniques to determine standard time

Unit I: Evolution of Management Practices **(07)**

Characteristics, objectives Functions, Principles and Types of Management., Scientific Management-Contribution of F. W. Taylor, Henry Fayol Gantt, Maynard and Indian contributors to the Management thought. **Organization:** Definition, Principles, Function and Types of organization structure, Different forms of Business—Proprietor, Partnership Firm, Private & Public limited company, Cooperative, Private &Public Trusts.

Unit II: Motivation **(07)**

Human Needs and Types of Motivation, Theories of Motivations-Maslow's theory, McGregor's Theory of X and Theory of Y, Herzberg's Theory of two factor, David C. McCelland's Theory of Achievement, Expectance/valence Theory of Victor Vroom, Porter & Lawler's Model. Group dynamics: Types, characteristics, objectives of Group Dynamics Leadership: Definition, styles & functions of leadership, qualities for good leadership, role of the leader, Theories of leadership, Managerial grid, professional and business ethics.

Unit III: Entrepreneurship development **(07)**

Characteristics of successful entrepreneurs, communications skill, problem solving skill and process, Basic element of Business plans, Sources of finance, Selection of Business location, Record keeping system, Analysis financial performance, Break even analysis, Technology and Business, Strategies for Business Growth, Concept related to start-up and Intellectual Property Rights (IPR).

Unit IV: Industrial Engineering **(07)**

History, Development, Definition, Functions & Applications of Industrial Engineering. Tools and techniques of Industrial Engineering, Introduction to work study and work content.

Productivity Engineering Productivity: factor productivity, total productivity; labour Productivity, measurement of Productivity, Productivity improvement techniques. Productivity improvement programme. **Wages and incentives:** Concept of wages, factors affecting wages, Job evaluation, merit rating.

Unit V: Method Study **(07)**

Steps, Tools and Techniques used in the Method Study, outline Process Chart, Flow process Chart, Symbols, Flow Diagrams, Two Handed Chart, String diagram, Multiple Activity Chart, 5W and 1 H,Use of Motion Pictures and its analysis SIMO chart, cyclegraphChronocylegraph. Developing, Presentation, Installation & Maintenance of new Methods. Principles of motion economy.

Unit VI: Work Measurement Time Study **(07)**

Aim & Objectives, Terminology & Tools, Use of stopwatch procedure in making Time Study. Time Study Forms, Performance rating, allowances and its types. Calculation of Standard Time.

Work Sampling: Introduction to work sampling. Determinations of Standard time using work Sampling. Synthetic & Standard data Methods: Concepts, Introduction to PMTS, MTM1, WFS, and Basic Motion Time Study. MTM2 & Other second Generation Methods, MOST and other advanced work measurement techniques.

Text Books:

1. M. Telsang, Industrial Engineering and Production Management, S. Chand Publication, ISBN 81 219 1773 5.
2. O. P. Khanna, Work StudyII, Dhanpat Rai Publications, New Delhi.
3. Banga& Sharma, Industrial Organisation& Engg. Economics, Khanna Publishers, 2001, ISBN 81-7409-078-9
4. Chabra T. N., Principles & Practices of Management, Dhanpatlal&compony.
5. Mahajan M., Industrial Engineering and Production ManagementDhanpat Rai and Sons Publishers, 2005, ISBN-81-7700-047-0

Reference Books:

1. H. B. Maynard and others, Industrial Engineering Handbook, IVth edition McGraw Hill Publications, ISBN 0-07-041084-4.
2. Introduction to Work Study, ILO Universal Pub. Co,B'bay,ISBN 81 85027 06
3. Ralph M. Barnes,Motion and Time Study: Design and Measurement of Work J. Wiley & Sons.
4. Koontz Harold and Weihrich Heinz, —Essentials of management, 7ed, Tata McGraw Hill publishing, 2008, ISBN 0-07-0623030-x.
5. Luthans f., Organizational Behaviour, McGraw-Hill Company, 2008, ISBN 81-317-0502
6. Cynthia L. Greene, Entrepreneurship: Ideas in Action, Thomson, ISBN-981-243-257-1.

Control System Engineering
211509

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Prerequisites: Algebra, Calculus, Linear algebra, Ordinary differential equations, Signals and systems

Course Outcomes: After completion of this course, the student will be able to:

1. Model a physical system and express its internal dynamics and input-output relationships by means of block diagrams, mathematical model and transfer functions.
2. Understand and explain the relationships between the parameters of a control system and its stability, accuracy, transient behavior.
3. Identify the parameters that the system is sensitive to. Determine the stability of a system and parameter ranges for a desired degree of stability.
4. Plot the Bode, Nyquist, Root Locus diagrams for a given control system and identify the parameters and carry out the stability analysis.
5. Determine the frequency response of a control system and use it to evaluate or adjust the relative stability,
6. Design a P, PD, PI, or PID controller based on the transient and steady state response criteria.

Unit I: Introduction to Control Systems **(07)**

Introduction to Control Systems: Types of Control Systems, Effect of Feedback Systems, Differential equation of Physical Systems – Mechanical Systems, Electrical Systems, Analogous Systems. Block diagrams and signal flow graphs: Transfer functions, Block diagram algebra and Signal Flow graphs.

Unit II: Time Response of feedback control systems **(07)**

Time Response of feedback control systems: Standard test signals, Unit step response of First and Second order Systems. Time response specifications, Time response specifications of second order systems, steady state errors and error constants. Introduction to PI, PD and PID Controllers (excluding design).

Unit III: Stability analysis **(07)**

Stability analysis: Concepts of stability, Necessary conditions for Stability, Routh stability criterion, Relative stability analysis: more on the Routh stability criterion, Introduction to Root-Locus Techniques, The root locus concepts, Construction of root loci.

Unit IV: Frequency domain analysis and stability **(07)**

Frequency domain analysis and stability: Correlation between time and frequency response, Bode Plots, Experimental determination of transfer function. Introduction to Polar Plots, (Inverse Polar Plots excluded) Mathematical preliminaries, Nyquist Stability criterion, (Systems with transportation lag excluded) Introduction to lead, lag and lead-lag compensating networks (excluding design)

Unit V: Digital Control System and PLC **(07)**

Introduction to Digital Control System: Introduction, Spectrum Analysis of Sampling process, Signal reconstruction, Difference equations, Functions of PLC, Advantages, Architecture, working of PLC, Selection of PLC, Networking of PLCs, Ladder Programming, Interfacing Input and Output devices with PLC, PLC based automated systems. High frequency inputs. PLC programming standard IEC61131, Soft PLC techniques

Unit VI: The Design of Feedback Control Systems **(07)**

The Design of Feedback Control Systems: Approaches to System Design**,** Cascade Compensation Networks, Phase-Lead Design Using the Bode Diagram, Phase-Lead Design Using the Root Locus, System Design Using Integration Networks, Phase-Lag Design Using the Root Locus, Phase-Lag Design Using the Bode Diagram, Design on the Bode Diagram Using Analytical Methods.

References:

1. Katsuhiko Ogata, Modern Control Engineering, Fifth Edition, PHI Learning Private Limited, New Delhi, 2010
2. I.J. Nagrath , M.Gopal, Control Systems Engineering, Fifth Edition, New Age International Publishers, New Delhi, 2007
3. Curtis D Johnson, Process Control Instrumentation Technology, Eighth Edition, PHI Private Limited, New Delhi, 2011
4. Richard C. Drof , Robert N. Bishop, Modern Control Systems, Addison Wesley Publishing Company, 2001
5. B.C.Kuo, Digital Control Systems, Second Edition, Oxford University Press, New York, 1992

Design of Machine Elements
211510

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Prerequisites: Basic mechanical Engineering, Engineering Mechanics, Mechanics of Materials,

Course Outcomes:
On successful completion of the course students should be able to-

1. Understand the basic principles and process of machine design
2. Understand the theories of failures and Factor of safety to design mechanical component.
3. Analyze the stress and strain on mechanical components such as shaft, power screws, mechanical springs, gears, and bearings.
4. Understand, identify and quantify failure modes for mechanical parts such as shaft, power screws, mechanical springs, gears, and bearings.
5. Demonstrate knowledge on basic machine elements used in design of machine elements to withstand the loads and deformations for a given practical application.

Unit I: Introduction to Machine Design (07)

Design Process: Machine Design, Traditional design methods, Basic procedure of Machine Design, Requisites of design engineer, Design of machine elements, Sources of design data, Use of standards in design, Selection of preferred sizes. Design of Simple Machine Parts: Factor of safety, Service factor, Design of simple machine parts, Cotter joint, Knuckle joint and lever.

Unit II: Design of shafts, Keys and couplings (07)

Shafts: Design considerations in Transmission shafts with spur gear and pulley, splined Shafts, Shaft design on strength basis, Shaft design on torsional rigidity basis, ASME code for shaft design. Keys: Classification of keys, Design considerations in parallel and tapered sunk keys, Design of square, flat and Kennedy keys. Couplings: Design considerations, Classification, Design of Rigid, Muff coupling, Flange coupling and Flexible bushed pin coupling.

Unit III: Design of Power Screws (07)

Power Screws: Types of screw threads, multiple threaded screws, Torque analysis with square and trapezoidal threads, Self-locking screw, Collar friction torque, Stresses in power screws, design of screw and nut, design of Screw jack.

Unit IV: Design of Springs (07)

Mechanical Springs: Types, Applications and materials of springs, Stress and deflection equations for helical springs, Types of ends, Design of helical compression and tension springs, Springs in series and parallel, Helical torsion spring, surge in spring.

Unit V: Design of Spur Gears (07)

Spur Gears: Various design consideration, Beam Strength, tangential loading module calculations, width calculations, type of gear tooth failures, Estimation of dynamic load by velocity factors and Spott"s equation.

Unit VI: Design of Bearings (07)

Rolling Contact Bearings: Type, static and dynamic loading capacity, stribeck"s equation, concept of equivalent load, load life relationship, selection of bearing from manufacturers catalogue, design for variable load and speeds, bearing probability of survival other than 90%, lubrication and mounting of bearing.

Text Books

1. Shigley J. E. and Mischke C. R., "Mechanical Engineering Design", McGraw- Hill publication Co. Ltd., 1989, ISBN 0-07-049462-2.
2. Spotts M. F. and Shoup T. E., "Design of Machine Elements", 8ed., Pearson Education pvt. Ltd., 2008, ISBN 81 -7758- 4219.
3. Bhandari V.B., "Design of Machine Elements", Tata Mcgraw-hill publishing, 2007, ISBN 978-00-70-681798
4. Kannaiah, "Machine Design", Scitech publications Pvt. Ltd., 2007, ISBN 81- 88429-10-4.
5. RAGHAVENDRA, Design Of Machine Elements I Dme I, CBS Publishers and Distributors, Pvt. Ltd., 2019, ISBN: 978-93-890-1718-2

Reference Books

1. Orthewein and William C. Orthewein, "Machine Component Design".
2. PSG Design data", M/S DPV printers, Coimbatore, 2000.
3. Black paulH.and Adams O. Eugene, "Machine Design", 3ed.,McGraw-hill Book Company, 1999, ISBN 0–07-085037-2.
4. Hall Allens, Holowenko Alfred R., Laughlin Herman G., "Theory & Problems of Machine Design", McGraw-hill Book Company, 2000, ISBN 48333-7

Metrology and Quality Assurance
211511

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem :70 Marks

Pre-requisites:
Engineering Graphics, Machine Drawing, and Manufacturing Technology

Course Outcomes:
After learning this subject, the student will be able to:
1. Describe and work with various linear and angular measuring devices
2. Design limit gauges and work with special measuring devices for gear, screw thread and surface finish measurements
3. Distinguish various comparators and use profile projector
4. Use various control charts and various quality assurance tools
5. Get knowledge of various quality standards and their implementations in industries.
6. Implement TQM and TPM concepts in practice

Unit I: Introduction **(07)**
Meaning of Metrology, Precision, Accuracy, Errors in Measurement, Calibration,
Linear Measurement: Standards, Classification of Standards, Precision and Non Precision Measuring instrument, Slip Gauges. Manufacturing of slip gauges
Angular Measurement: Sine bar, Sine Center, Uses of sine bars, angle gauges, Auto Collimator, Angle Dekkor.
Inspection of Geometric parameters: Straightness, flatness, Parallelism, Concentricity, Squareness and Circularity. Alignment testing- lathe/milling/ drilling m/c
Comparators: Uses, Types, Advantages and Disadvantages of various Comparators.

Unit II: Limits, Fits and Tolerances **(07)**
Meaning of Limit, Fits and Tolerance, Cost -Tolerance relationship, concept of Interchangeability, selective assembly, Indian Standard System. Design of limits Gauges: Types, Uses, Taylor's Principle, Design of Limit Gauges, Introduction to auto gauging systems.
Interferometry: Introduction, Flatness testing by interferometry, NPL Interferometer.

Unit III: Surface Finish Measurement **(07)**
Surface Texture, methods of evaluation of surface roughness,Grades of Roughness, Specifications, Tomlinson's Surface Recorder, Taylor- Hobson SurfaceMeter and Talysurf for measuring all characteristics of surface texture.
Screw Thread Metrology: External Screw Thread terminology, effective diameter measurement methods, Pitch and flank Measurement of External Screw Thread, Application of Tool Maker's Microscope, Use of Profile Projector.
Gear Metrology: Spur Gear Parameters, Gear tooth thickness measurement: Gear tooth Verniercaliper, Constant chord method, Span Micrometer, Base tangent method.
Recent Trends in Engineering Metrology-Universal measuring machine coordinate measuringmachine, laser interferometer.

Unit IV : Introduction to Quality **(07)**
Meaning of Quality, Quality of Product, Quality of Service, Cost of Quality, Value of Quality, Role of Quality in Present day environment. Introduction to Statistical Quality Control: Control Charts,X, R, P and C Charts, Sampling inspection, OC Curves and Sampling Plans, Process Capability Index (PCI), Concept, Methods of determining PCI and uses of PCI.

Unit V: Quality Assurance tools and techniques **(07)**

Total quality management (T.Q.M):- Approaches-Deming's Approach, Juran's Approach, Seven quality tools and new seven quality tools, Q.F.D., Quality Circles, Kaizen, six sigma, T.P.M. Technical Specification (T.S) TS 16949 Standards.

Unit VI: Quality Standards (07)

ISO 9001-2000 Series of Standards- History and Evolution of ISO 9000 Series, importance and overview of ISO 9000- 1998 Series standards, structure of ISO 9000-2000 Series standards, clauses of ISO 9000 series standards and their interpretation and implementation, quality system documentation and audit.

ISO 14000:- Environmental management concepts, and requirement of ISO 14001, benefit of Environmental Management Systems, Environmental, Health and Safety standards.

Text Books:

1. K.J.Hume, "Engineering Metrology", Kalyani publication ISBN8170290015
2. K.W.B.Sharp, "Practical Engineering Metrology", Pitman Publication
3. F. M. Gryna, R. Chua & J. Defco, "Jurans Quality Planning and Analysis for Enterprise Quality", McGraw Hill series. ISBN0070618488

Reference Books:

1. R.K. Jain, "Engineering Metrology", Khanna Publication.
2. I.C.Gupta, "A Text book of Engineering Metrology", Dhanpat Rai and Sons.
3. Kaoru Ishikawa, "Guide to Quality Control", Asian Productivity Organisation, Series,
4. Juran's Quality Handbook

Computer Graphics for Robotics
211512

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem :70 Marks

Prerequisites:

Engineering Mathematics I, Engineering Mathematics II, Engineering Mathematics III, Engineering Graphics, C-programming

Outcomes

- Understand the basics of computer graphics, different graphics systems and applications of computer graphics.
- Use of geometric transformations on graphics objects and their application in robot kinematics analysis.
- Demonstrate the application of Bezier curves and interpolation in robot path planning
- Apply concept of analytic geometry and geometric algebra for modelling in robotic physics

Unit I: Cartesian co-ordinates vector **(07)**
Introduction, Cartesian XY plane,3D co-ordinate,2D vector,3D vector

Unit II: Transforms **(07)**
2D transform, Homogeneous co-ordinate, 3D transforms, transforming vectors, perspective projection. Applications of 2D and 3D transformations in robot kinematics

Unit III: Interpolation **(07)**
Linear interpolation, non-linear interpolation, interpolating curves, Interpolating quaternion

Unit IV: Curves and Patches **(07)**
Bezier curve, spline, surface patches. Use of Bezier and spline curves for robot path planning

Unit V: Analytic geometry **(07)**
2D analytic geometry, intersection points, 3D geometry, equation of planes, Intersecting planes

Unit VI: Geometric algebra **(07)**
Geometric products in 2D, geometric product in 3D, outer product of 3D vectors, axioms, inverse of vectors, reflection and rotation, applied geometric algebra for modeling of robotics physics

References:

1. Roger D, Adams A. J. "Mathematical elements for computer graphics", McGraw Hill Education, ISBN: 978-0070486775
2. Jon Vince, Mathematics for Computer Graphics, Springer, ISBN: : 978-1-84628-034-4
3. Chopra Rajiv, "Computer Graphics", S. Chand and Co. Pvt. Ltd., ISBN: 81-219-3581-4
4. Davis Martin J, "Computer Graphics", Nova science Publishers, ISBN: 9781617618116

Control Systems Engineering Lab
211513

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	Term Work: 25 Marks Practical: 25 Marks

Assignment to be given on the following topics. (Any ten)

1. Find overall transfer function of the system using block diagram algebra.
2. Find determine the stability of a system using Routh Hurwitz Criterion, marginal value of K and frequency of sustained oscillations.
3. Construct the root locus and comment on the stability.
4. Find the time domain specifications of the given system.
5. Find the steady state error and error coefficients of the type 0, 1 and 2 systems for step, ramp and parabolic inputs.
6. Find frequency domain specifications of the system.
7. Draw Bode Plot, find PM and GM and Comment on the stability. Also, find transfer function of the system from given Bode plot.
8. Find stability of the system using Nyquist Criteria.
9. Write State space model of the system and solution.
10. Find State Transition Matrix for given system and verify the properties of the same.
11. Find the Transfer Function of a Digital System.
12. Find the response of first and second order Digital Systems for Step Input.
13. Study the Digital PID Controller with reference to response time, steady state error and offset.

Design of Machine Elements Lab
211514

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	OR: 25 Marks

Term work shall consist of

1) ONE design project. Design project shall consist of two imperial size sheets –one involving assembly drawing with a part list and overall dimensions and other sheet involving drawings of individual components. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified so as to make it working drawing. A design report giving all necessary calculations of the design of components and assembly should be submitted in a separate file. Design projects should be in the form of „Design of Mechanical System" comprising of machine elements studied and topics covered in the syllabus. Design data book shall be used wherever necessary to achieve selection of standardized components.
2) Problem based assignment on each unit.

Metrology and Quality Assurance Lab
211515

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	Practical: 25 Marks

A] Experiments: (Any Eight)

1. Linear Measurement using precision instruments.
2. Measurement of angle by sine bar / Sine center
3. Alignment Test on Lathe/ Drilling/Milling Machine.
4. Measurement of the Surface roughness
5. Measurement of Optical surface using Interferometer.
6. Measurement of Screw thread parameters using Floating Carriage Micrometer.
7. Measurement of Gear tooth thickness using Gear tooth Vernier caliper or Span micrometer
8. Study and Experiment on Profile Projector.
9. Study and Experiment on any type Comparator.
10. Study of Limit Gauges and auto gauging systems.

B] Reports based on Industrial Visit

Computer Graphics for Robotics Lab
211516

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 2 hours / week	Practical:01	Term work: 25 Mark

List of experiments:
Use Turbo C or C++ language to perform following experiments

1. Creating graphics elements: Line, circle, and ellipse
2. 2 D transformations: Translation, Scaling, Rotation, Mirror reflection and Shearing
3. 3 D transformations: Translation, Rotation
4. Curve generation: Bezier, β spline.
5. Animations using transformations
6. Simulation of robot kinematics

Robot Operating System
211517

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 2 hours / week	Practical:01	OR: 25 Mark

List of experiments:

1. ROS Essentials: Introduction to ROS Topics, Services, Actions and Nodes. Simple interaction with the course simulation environment.
2. Building robot environment: Software representation of a Robot using Unified Robot Description Format (URDF), ROS parameter server and adding real-world object representations to the simulation environment.
3. Autonomous Navigation: Map creation with G Mapping package, autonomously navigate a known map with ROS navigation.
4. Manipulation: Motion planning, pick and place behaviors using industrial robots with ROS MoveIt
5. Robot Vision: Object detection, pose estimation.
6. Mini Project: Building production line application with industrial robot

Project Based Learning
211099

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 4 hours / week	Practical: 2	Term Work: 50 marks

Preamble:
For better learning experience, along with traditional classroom teaching and laboratory learning; project based learning has been introduced with an objective to motivate students to learn by working in group cooperatively to solve a problem.
Project-based learning (PBL) is a student-centric pedagogy that involves a dynamic classroom approach in which it is believed that students acquire a deeper knowledge through active exploration of real-world challenges and problems. Students learn about a subject by working for an extended period of time to investigate and respond to a complex question, challenge, or problem. It is a style of active learning and inquiry-based learning.
Problem based learning will also redefine the role of teacher as mentor in learning process. Along with communicating knowledge to students, often in a lecture setting, the teacher will also to act as an initiator and facilitator in the collaborative process of knowledge transfer and development.

Course Outcomes:
1. Project based learning will increase their capacity and learning through shared cognition.
2. Students able to draw on lessons from several disciplines and apply them in practical way.
3. Learning by doing approach in PBL will promote long-term retention of material and replicable skill, as well as improve teachers' and students' attitudes towards learning.

Group Structure:
Working in supervisor/mentor – monitored groups. The students plan, manage and complete a task/project/activity which addresses the stated problem.
- There should be team/group of 5 -6 students
- A supervisor/mentor teacher assigned to individual groups

Selection of Project/ Problem:
The problem-based project oriented model for learning is recommended. The model begins with the identifying of a problem, often growing out of a question or "wondering". This formulated problem then stands as the starting point for learning. Students design and analyze the problem within an articulated interdisciplinary or subject frame.
A problem can be theoretical, practical, social, technical, symbolic, cultural and/or scientific and grows out of students' wondering within different disciplines and professional environments. A chosen problem has to be exemplary. The problem may involve an interdisciplinary approach in both the analysis and solving phases. By exemplarity, a problem needs to refer back to a particular practical, scientific, social and/or technical domain. The problem should stand as one specific example or manifestation of more general learning outcomes related to knowledge and/or modes of inquiry. There are no commonly shared criteria for what constitutes an acceptable project. Projects vary greatly in the depth of the questions explored, the clarity of the learning goals, the content and structure of the activity.
- A few hands-on activities that may or may not be multidisciplinary
- Use of technology in meaningful ways to help them investigate, collaborate, analyze, synthesize and present their learning.
- Activities may include- Solving real life problem, investigation /study and Writing reports of in depth study, field work.

Assessment:
The institution/head/mentor is committed to assessing and evaluating both student performance and program effectiveness. Progress of PBL is monitored regularly on weekly basis. Weekly review of the work is necessary.

During process of monitoring and continuous assessment AND evaluation the individual and team performance is to be measured. PBL is monitored and continuous assessment is done by supervisor /mentor and authorities. Students must maintain an institutional culture of authentic collaboration, self-motivation, peer-learning and personal responsibility. The institution/department should support students in this regard through guidance/orientation programs and the provision of appropriate resources and services. Supervisor/mentor and Students must actively participate in assessment and evaluation processes. Group may demonstrate their knowledge and skills by developing a public product and/or report and/or presentation.

- Individual assessment for each student (Understanding individual capacity, role and involvement in the project)
- Group assessment (roles defined, distribution of work, intra-team communication and togetherness)
- Documentation and presentation

Evaluation and Continuous Assessment:

It is recommended that the all activities are to be record and regularly, regular assessment of work to be done and proper documents are to be maintained at college end by both students as well as mentor (you may call it PBL work book).

Continuous Assessment Sheet (CAS) is to be maintained by all mentors/department and institutes.

Recommended parameters for assessment, evaluation and weightage:

- Idea Inception (5%)
- Outcomes of PBL/ Prob'lem Solving Skills/ Solution provided/ Final product (50%) (Individual assessment and team assessment)
- Documentation (Gathering requirements, design & modeling, implementation/execution, use of technology and final report, other documents) (25%)
- Demonstration (Presentation, User Interface, Usability etc) (10%)
- Contest Participation/ publication (5%)
- Awareness /Consideration of -Environment/ Social /Ethics/ Safety measures/Legal aspects (5%)

PBL workbook will serve the purpose and facilitate the job of students, mentorand project coordinator. This workbook will reflect accountability, punctuality, technical writing ability and work flow of the work undertaken.

References:

- Project-Based Learning, Edutopia, March 14, 2016.
- What is PBL? Buck Institute for Education.
- www.schoology.com
- www.howstuffworks.com

Mandatory Audit Course 4

211100

Students should complete one of the NPTEL courses listed below:

NPTEL Courses:

1. Developing soft skills and personality, T. Ravichandran, IIT Kanpur
   https://swayam.gov.in/nd1_noc20_hs43/preview
2. Innovation by Design, By Prof. B.K. Chakravarthy, IIT Bombay
   https://swayam.gov.in/nd1_noc20_de08/preview
3. Design Thinking - A Primer, By Prof. Ashwin Mahalingam, Prof. Bala Ramadurai, IIT Madras
   https://swayam.gov.in/nd1_noc20_mg38/preview
4. Technical English for Engineers, By Prof. Isha Iqbal, IIT Madras
   https://swayam.gov.in/nd1_noc20_hs56/preview
5. Ethics in Engineering Practice, Susmita Mukhopadhyay, IIT Kharagpur
   https://swayam.gov.in/explorer?searchText=Ethics%20in%20Engineering%20Practice

Industrial visit/expert lectures should be organized for the audit courses undertaken by students. The group of students should be allocated to faculty members to keep the track of students' progress. The performance of the students may be evaluated using any appropriate method.