Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

Syllabus for B. Tech in Robotics

(Applicable from the academic session 2020-2021)

Second Year Fourth Semester

Subject Code : ES-ROB401	**Category:** Engineering Science Courses
Subject Name : Materials Engineering	**Semester** : Fourth
L-T-P : 3-0-0	**Credit:3**
Pre-Requisites: No prerequisite	

Course Objective:

1. Understanding of the correlation between the internal structure of materials, their mechanical properties and various methods to quantify their mechanical integrity and failure criteria.
2. To provide a detailed interpretation of equilibrium phase diagrams
3. Learning about different phases and heat treatment methods to tailor the properties of Fe-C alloys.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Crystal Structure: Unit cells, Metallic crystal structures, Ceramics. Imperfection in solids: Point, line, interfacial and volume defects; dislocation strengthening mechanisms and slip systems, critically resolved shear stress.	6
2	Mechanical Property measurement: Tensile, compression and torsion tests; Young's modulus, relations between true and engineering stress- strain curves, generalized Hooke's law, yielding and yield strength, ductility, resilience, toughness and elastic recovery; Hardness: Rockwell, Brinell and Vickers and their relation to strength.	6
3	Static failure theories: Ductile and brittle failure mechanisms, Tresca, Von-mises, Maximum normal stress, Mohr-Coulomb and Modified Mohr-Coulomb; Fracture mechanics: Introduction to Stress-intensity factor approach and Griffith criterion. Fatigue failure: High cycle fatigue, Stress-life approach, SN curve, endurance and fatigue limits, effects of mean stress using the Modified Goodman diagram; Fracture with fatigue, Introduction to nondestructive testing (NDT)	8
4	Alloys, substitutional and interstitial solid solutions- Phase diagrams: Interpretation of binary phase diagrams and microstructure development; eutectic, peritectic, peritectoid and monotectic reactions. Iron Iron-carbide phase diagram and microstrctural aspects of ledeburite, austenite, ferrite and cementite, cast iron.	6
5	Heat treatment of Steel: Annealing, tempering, normalising and spheroidising, isothermal transformation diagrams for Fe-C alloys and microstructure development. Continuous cooling curves and interpretation of final microstructures and properties- austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening, vacuum and plasma hardening	6
6	Alloying of steel, properties of stainless steel and tool steels, maraging steels- cast irons; grey, white, malleable and spheroidal cast irons- copper and copper alloys; brass, bronze and cupro-nickel; Aluminum and Al-Cu – Mg alloys- Nickel based superalloys and Titanium alloys	8

Course Outcomes:

1. Student will be able to identify crystal structures for various materials and understand the
2. Defects in such structures
3. Understand how to tailor material properties of ferrous and non-ferrous alloys
4. How to quantify mechanical integrity and failure in materials

Learning Resources:

1. W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India.
2. Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 4th Indian Reprint, 2002.
3. V. Raghavan, "Material Science and Engineering', Prentice Hall of India Private Limited, 1999.
4. U. C. Jindal, "Engineering Materials and Metallurgy", Pearson, 2011.

Subject Code : PC-ROB401	**Category:** Professional Core courses
Subject Name : Fluid Power & Control	**Semester** : Fourth
L-T-P : **3-1-0**	**Credit:4**
Pre-Requisites: No-prerequisite	

Course Objective:

1. To learn about the application of mass and momentum conservation laws for fluid flows
2. To understand the importance of dimensional analysis
3. To obtain the velocity and pressure variations in various types of simple flows
4. To analyze the flow in water pumps and turbines.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Definition of fluid, Newton's law of viscosity, Units and dimensions- Properties of fluids, mass density, specific volume, specific gravity, viscosity, compressibility and surface tension, Control volume- application of continuity equation and momentum equation,Incompressible flow, Bernoulli's equation and its applications.	9
2	Exact flow solutions in channels and ducts, Couette and Poisuielle flow, laminar flow through circular conduits and circular annuli- concept of boundary layer – measures of boundary layer thickness – Darcy Weisbach equation, friction factor, Moody's diagram.	9
3	Need for dimensional analysis – methods of dimension analysis – Similitude – types of similitude Dimensionless parameters – application of dimensionless parameters – Model analysis.	6
4	Euler's equation – theory of Rotodynamic machines – various efficiencies – velocity components at entry and exit of the rotor, velocity triangles – Centrifugal pumps, working principle, work done by the impeller, performance curves – Cavitation in pumps- Reciprocating pump – working principle.	8

5	Classification of water turbines, heads and efficiencies, velocity triangles- Axial, radial and mixed flow turbines- Pelton wheel, Francis turbine and Kaplan turbines, working principles – draft tube- Specific speed, unit quantities, performance curves for turbines – governing of turbines.	8

Course Outcomes:

1. Upon completion of this course, students will be able to mathematically analyze simple flow situations
2. They will be able to evaluate the performance of pumps and turbines.

Learning Resources:

1. Fluid Mechanics & Hydraulic Machines, S.S. Rattan, Khanna Book Publishing Co., 2018
2. Fluid Mechanics and Machinery, R.K.Bansal, Laxmi Publication.
3. Introduction to Fluid Mechanics & Fluid Machines, Som and Biswas, TMH.
4. A Textbook on Fluid Mechanics and Machines, S.Pati, McGrawHill.
5. Fluid Mechanics and Machinery, C.S.P.Ojha, R. Berndtsson and P. N. Chadramouli, Oxford University Press, 2010.
6. Hydraulics and Fluid Mechanics, P M Modi and S M Seth, Standard Book House.

Subject Code : PC-ROB402	**Category:** Professional Core courses
Subject Name : Strength of Materials	**Semester** : Fourth
L-T-P : 3-1-0	**Credit:4**
Pre-Requisites: No-prerequisite	

Course Objective:

1. To understand the nature of stresses developed in simple geometries such as bars, cantilevers, beams, shafts, cylinders and spheres for various types of simple loads
2. To calculate the elastic deformation occurring in various simple geometries for different types of loading

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Deformation in solids- Hooke's law, stress and strain- tension, compression and shear stresses- elastic constants and their relations- volumetric, linear and shear strains- principal stresses and principal planes- Mohr's circle.	8
2	Beams and types transverse loading on beams- shear force and bend moment diagrams- Types of beam supports, simply supported and over-hanging beams, cantilevers. Theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, point and distributed loads.	8

3	Moment of inertia about an axis and polar moment of inertia, deflection of a beam using double integration method, computation of slopes and deflection in beams, Maxwell's reciprocal theorems. Buckling of columns, Euler's theory, critical loads for different types of constraints.	10
4	Torsion, stresses and deformation in circular and hollow shafts, stepped shafts, deflection of shafts fixed at both ends, stresses and deflection of helical springs.	8
5	Axial and hoop stresses in cylinders subjected to internal pressure, deformation of thick and thin cylinders, deformation in spherical shells subjected to internal pressure	8

Course Outcomes:

1. After completing this course, the students should be able to recognize various types loads applied on machine components of simple geometry and understand the nature of internal stresses that will develop within the components
2. The students will be able to evaluate the strains and deformation that will result due to the elastic stresses developed within the materials for simple types of loading

Learning Resources:

1. D.S. Bedi, Strength of Materials, Sixth Edition, Khanna Publishing House, 2019
2. Egor P. Popov, Engineering Mechanics of Solids, Prentice Hall of India, New Delhi, 2001.
3. R. Subramanian, Strength of Materials, Oxford University Press, 2007.
4. R.K. Bansal, Strength of Materials, Laxmi Publications
5. Ferdinand P. Been, Russel Johnson Jr and John J. Dewole, Mechanics of Materials, Tata McGraw Hill Publishing Co. Ltd., New Delhi 2005.
6. Debabrata Nag and Abhijit Chanda, Fundamentals of Strength of Materials, Wiley India.

Subject Code : PC-EE403	**Category:** Professional Core courses
Subject Name : Electrical & Electronics Measurements	**Semester** : Fourth
L-T-P : **3-1-0**	**Credit:3**
Pre-Requisites: No-prerequisite	

Objective:

1. To learn methods of measurement, errors in measurement and its classification.
2. To learn the principle of operation of analog and digital meters.
3. To learn the basic principle of operation of instrument transformers.
4. To learn the principle of operation of cathode ray oscilloscope and different sensors and transducers.
5. To learn the principle of measurement of power, energy and different electrical parameters
6. To acquire problem solving skills to solve problems on the topics studied.

Unit	Content	Hrs
1	**Measurements:** • Method of measurement, Measurement system, Classification of instruments, Definition of accuracy, Precision, Resolution, Speed of response, Error in measurement, Classification of errors, loading effect due to shunt and series connected instruments. **Analog meters:** • General features, Construction, Principle of operation and torque equation of Moving coil, Moving iron, Electrodynamometer, Induction instruments Principle of operation of the Electrostatic, Thermoelectric, Rectifier type instruments, Extension of instrument ranges and multipliers.	7
2	**Instrument transformer:** • Disadvantage of shunt and multipliers, Advantage of Instrument transformers, Principle of operation of Current & Potential transformer, errors. **Measurement of Power:** • Principle of operation of Electrodynamic & Induction type wattmeter, Wattmeter errors **Measurement of Energy:** • Construction, theory and application of AC energy meter, testing of energy meters.	9
3	**Measurement of resistance:** • Measurement of medium, low and high resistances, Megger **Potentiometer:** • Principle of operation and application of Crompton's DC potentiometer, Polar and Co-ordinate type AC potentiometer, applications **AC Bridges:** • Measurement of Inductance, Capacitance and frequency by AC bridges	8
4	**Cathode ray oscilloscope (CRO):** • Measurement of voltage, current, frequency & phase by oscilloscope. Frequency limitation of CRO. Sampling and storage oscilloscope, Double beam CRO. • **Electronic Instruments:** Advantages of digital meter over analog meters, Digital voltmeter, Resolution and sensitivity of digital meters, Digital multimeter, Digital frequency meter, Signal generator, Digital Storage oscilloscope	7

5	**Sensors & Transducers:** • Introduction to sensors & Transducers, Strain gauge, LVDT, Temperature transducers, Flow measurement using magnetic flow measurement.	4	

Text books:

1. A course in Electrical & Electronic Measurements & Instrumentation, A.K. Sawhney, Dhanpat Rai & sons.
2. Electrical Measurement & Measuring Instruments, E.W. Golding & F.C. Wides, Wheeler Publishing
3. Sensors & Transducers, D. Patranabis, PHI, 2nd edition.

Reference books:

1. Electronic Instruments, H.S. Kalsi, Tata Mc-Graw hill, 2nd Edition.
2. Digital Instrumentation, A.J. Bouwens, Tata Mc-Graw hill.
3. Modern Electronic instrumentation & Measuring instruments, A.D. Heltric & W.C. Copper, Wheeler Publication
4. Instrument transducers, H.K.P. Neubert, Oxford University press.
5. All-in One Electronics Simplified, A.K. Maini, Khanna Book Publishing Co. (2018)

Course Outcome:

After completion of this course, the learners will be able to

1. Explain the terms accuracy, precision, resolution, speed of response, errors in measurement, loading effect
2. Describe methods of measurement of power, energy by instruments and resistance, capacitance and inductance by bridges and potentiometer
3. Explain the principle of operation of analog meters, instrument transformer, digital multimeter, digital voltmeter, digital frequency meter, signal generator, strain gauge, lvdt and temperature transducers
4. Explain the different building block, principle of operation of oscilloscope and measurement techniques of voltage, current, frequency and phase by oscilloscope
5. Solve numerical problems related to analog meters, instrument transformer, measurement of power, energy, resistance, inductance and capacitance
6. Specify applications of analog and digital measuring instruments, sensors and transducers

Subject Code : PC-EE401	**Category:** Professional Core courses
Subject Name : Electric Machines	**Semester** : Fourth
L-T-P : **3-1-0**	**Credit:3**
Pre-Requisites: Basic Electrical Engineering	

Objective:

To review the concept of magnetic fields and magnetic circuits
To learn the principle of production of electromagnetic force and torque.
To learn the basic principle of operation of DC machine
To learn the principle of operation and characteristics of DC motor and generator
To learn the principle of operation, connections and different tests on Transformers
To acquire problem solving skills to solve problems of DC machines and Transformers

Unit	Content	Hr
1	**Magnetic fields and magnetic circuits:** Review of magnetic circuits - MMF, flux, reluctance, inductance; review of Ampere Law and Biot Savart Law; Visualization of magnetic fields produced by a bar magnet and a current carrying coil - through air and through a combination of iron and air; influence of highly permeable materials on the magnetic flux lines.	3
2	**Electromagnetic force and torque:** B-H curve of magnetic materials; flux-linkage vs current characteristic of magnetic circuits; linear and nonlinear magnetic circuits; energy stored in the magnetic circuit; force as a partial derivative of stored energy with respect to position of a moving element; torque as a partial derivative of stored energy with respect to angular position of a rotating element. Examples - galvanometer coil, relay contact, lifting magnet, rotating element with eccentricity or saliency	5
3	**DC machines:** Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation – Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation Derivation of back EMF equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.	8
4	**DC machine - motoring and generation:** Armature circuit equation for motoring and generation, Types of field excitations – separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Speed control through armature voltage. Losses, load testing and back-to-back testing of DC machines	7

5	**Transformers:** Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency Testing - open circuit and short circuit tests, polarity test, back-to-back test, separation of hysteresis and eddy current losses Three-phase transformer - construction, types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers, Autotransformers construction, principle, applications and comparison with two winding transformer, Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current, Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers - No-load and on-load tap-changing of transformers, Three-winding transformers. Cooling of transformers.	12
6	**Induction Machines:** Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting and Maximum Torque. Equivalent circuit. Phasor Diagram, Losses and Efficiency. Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). Methods of starting, braking and speed control for induction motors. Generator operation. Self-excitation. Doubly-Fed Induction Machines.	5
7	**Single-phase induction motors:** Constructional features, double revolving field theory, equivalent circuit, determination of parameters. Split-phase starting methods and applications	5
8	**Synchronous machines:** Constructional features, cylindrical rotor synchronous machine - generated EMF, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation. Operating characteristics of synchronous machines, V-curves. Salient pole machine - two reaction theory, analysis of phasor diagram, power angle characteristics. Parallel operation of alternators - synchronization and load division.	10
9	**Special Electromechanical devices:** Principle and construction of switched Reluctance motor, Permanent magnet machines, Brushless DC machines, Hysteresis motor, Stepper motor, Tacho generators.	5

Text books:

1. Electrical Machines-I, P.S. Bimbhra, Khanna Publishing House (AICTE)
2. Electrical Machinery, P.S. Bimbhra, 7th Edition, Khanna Publishers
3. Electric machines, D.P. Kothari & I.J Nagrath, 3rd Edition, Tata Mc Graw-Hill Publishing Company Limited
4. Electrical Machines, P.K. Mukherjee & S. Chakrabarty, 2nd edition, Dhanpat Rai Publication.

Reference books:

1. Electric Machinery & Transformers, Bhag S. Guru and H.R. Hiziroglu, 3rd Edition, Oxford University press.
2. Electrical Machines, R.K. Srivastava, Cengage Learning
3. Theory of Alternating Current Machinery, Alexander S Langsdorf, Tata Mc Graw Hill Edition.
4. The performance and Design of Alternating Current Machines, M.G.Say, CBS Publishers & Distributors.
5. Electric Machinery & transformer, Irving L Koskow, 2nd Edition, Prentice Hall India

Course Outcome:
After completion of this course, the learners will be able to

1. Describe the function of different components of magnetic circuit, DC machines and transformers
2. Explain the principle of operation of different types of DC machines and transformers
3. Solve numerical problems of DC machines and transformers.
4. Estimate the parameters and efficiency of transformer.
5. Determine the characteristics of DC machines
6. Recommend methods to control output of DC machines.
7. Describe the arrangement of winding of AC machines.
8. Explain the principle of operation of Induction machines, Synchronous machines and special machines.
9. Solve numerical problems of Induction machines, Synchronous machines and Special machines.
10. Estimate the parameters and efficiency of Induction machines and Synchronous machines.
11. Determine the characteristics of Induction machines and Synchronous machines.
12. Select appropriate methods for starting, braking and speed control of Induction machines

Subject Code : PC-ROB491	**Category:** Professional Core Courses
Subject Name: Robotics Laboratory I (Strength of Materials)	**Semester** : Fourth
L-T-P : 0-0-3	**Credit: 1.5**
Pre-Requisites:	

Course Objectives:

1. To understand the measurement of mechanical properties of material.
2. To understand the deformation behavior of materials.

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

1. Uniaxial tension test on mild steel rod
2. Torsion test on mild steel rod
3. Impact test on a metallic specimen
4. Brinell/ Vickers and Rockwell hardness tests on metallic specimens
5. Bending deflection test on beams
6. Strain measurement using Rosette strain gauge, or like.
7. Microscopic examination of heat-treated and untreated metallic samples
8. Measurement of Cutting Force in Turning
9. Study of the effect of parametric variation in arc welding
10. Testing of moulding sand
11. Testing for Weld Quality
12. Study of and Solving problems on geometry of robot manipulator, actuators and grippers

Course Outcomes:
Students who have undergone the course will be able to understand the measurement of mechanical properties of materials.

Subject Code : MC481	**Category:** Mandatory courses
Subject Name : Environmental Science	**Semester** : Fourth
L-T-P : **0-0-2**	**Credit: 0**
Pre-Requisites: No-prerequisite	

We as human being are not an entity separate from the environment around us rather we are a constituent seamlessly integrated and co-exist with the environment around us. We are not an entity so separate from the environment that we can think of mastering and controlling it rather we must understand that each and every action of ours reflects on the environment and vice versa. Ancient wisdom drawn from Vedas about environment and its sustenance reflects this ethos's. There is a direct application of this wisdom even in modern times. Idea of an activity based course on environment protection is to sensitize the students on the above issues through following two types of activities.

(a) Awareness Activities:

I. Small group meetings about water management, promotion of recycle use, generation of less waste, avoiding electricity waste
II. Slogan making event
III. Poster making event
IV. Cycle rally
V. Lectures from experts

(b) Actual Activities:

I. Plantation
II. Gifting a tree to see its full growth
III. Cleanliness drive
IV. Drive for segregation of waste
V. To live some big environmentalist for a week or so to understand his work
VI. To work in kitchen garden for mess
VII. To know about the different varieties of plants
VIII. Shutting down the fans and ACs of the campus for an hour or so

Subject Code : PC-EE491	**Category:** Professional Core Courses
Subject Name: Electric Machines lab	**Semester** : Fourth
L-T-P : **0-0-2**	**Credit: 1**
Pre-Requisites: None	

Laboratory Experiments:

1. Determination of the characteristics of a separately excited DC generator.
2. Determination of the characteristics of a DC motor
3. Study of methods of speed control of DC motor
4. Determination of the characteristics of a compound DC generator (short shunt)
5. Determination of speed of DC series motor as a function of load torque.
6. Polarity test on a single phase transformer
7. Determination of equivalent circuit of a single phase transformer and efficiency.
8. Study of different connections of three phase transformer.
9. Study of Parallel operation of a single phase transformers.
10. Determination of temperature rise and efficiency of the transformer. (Back to back test)
11. Different methods of starting of a 3 phase Cage Induction Motor & their comparison [DOL,

Auto transformer &Star-Delta]

12. Study of equivalent circuit of three phase Induction motor by no load and blocked rotor test. Study of performance of wound rotor Induction motor under load.
13. Study of performance of three phase squirrel- cage Induction motor –determination of iron-loss, friction & windage loss Speed control of 3 phase squirrel cage induction motor by different methods & their comparison [voltage control & frequency control].
14. Speed control of 3 phase slip ring Induction motor by rotor resistance control
15. Determination of equivalent circuit parameters of a single phase Induction motor.
16. Load test on single phase Induction motor to obtain the performance characteristics.
17. To study the performance of Induction generator

Course Outcome:

After completion of this course, the learners will be able to

1. Identify appropriate equipment and instruments for the experiment.
2. Test the instrument for application to the experiment.
3. Construct circuits with appropriate instruments and safety precautions
4. Validate different characteristics of DC machine, methods of speed control of DC motor and parallel operation of the transformer
   work effectively in a team

Subject Code : PC-ROB492	**Category:** Professional Core Courses
Subject Name: Robotics Laboratory II (Fluid Power & Control)	**Semester** : Fourth
L-T-P : 0-0-3	**Credit: 1.5**
Pre-Requisites: Engineering Thermodynamics and Fluid Mechanics and Fluid Machines	

Course Objectives:

To understand the principles and performance characteristics of flow and thermal devices.
To know about the measurement of the fluid properties

Course Contents (11 experiments/ studies/ problems are to perform from the list given below or relevant others):

1. Measurement of coefficient of discharge of given Orifice and Venturimeters
2. Determination of the density & viscosity of an oil and friction factor of oil flow in a pipe
3. Determination of the performance characteristics of a centrifugal pump
4. Determination of the performance characteristics of Pelton Wheel
5. Determination of the performance characteristics of a Francis Turbine
6. Determination of the performance characteristics of a Kaplan Turbine
7. Determination of the thermal conductivity and specific heat of given objects
8. Determination of the p-V diagram and the performance of a 4-stroke diesel engine
9. Determination of the convective heat transfer coefficient for flow over a heated plate
10. Determination of the emissivity of a given sample
11. Determination of the performance characteristics of a vapor compression system

Course Outcomes:
The students who have undergone the course will be able to measure various properties of fluids and characterize the performance of fluid/thermal machinery

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Subject Code : PC-EE-493	**Category:** Professional Courses
Subject Name : Electrical & Electronics Measurement Laboratory	**Semester** : Fourth
L-T-P : **0-0-2**	**Credit:1**
Pre-Requisites: No prerequisite	

	Laboratory Experiments:
1.	Instrument workshop- Observe the construction of PMMC, Dynamometer, Electrothermal and Rectifier type of instruments, Oscilloscope and Digital multimeter.
2.	Calibrate moving iron and electrodynamometer type ammeter/voltmeter by potentiometer.
3.	Calibrate dynamometer type wattmeter by potentiometer.
4.	Calibrate AC energy meter.
5.	Measurement of resistance using Kelvin double bridge.
6.	Measurement of power using Instrument transformer.
7.	Measurement of power in Polyphase circuits.
8.	Measurement of frequency by Wien Bridge.
9.	Measurement of Inductance by Anderson bridge
10.	Measurement of capacitance by De Sauty Bridge.
11.	Measurement of capacitance by Schering Bridge.

Course Outcome:

After completion of this course, the learners will be able to

1. identify appropriate equipment and instruments for the experiment
2. test the instrument for application to the experiment
3. construct circuits with appropriate instruments and safety precautions
4. evaluate and adjust the precision and accuracy of AC energy meter, moving iron and dynamometer type ammeter, voltmeter and wattmeter by potentiometer
5. measure voltage, current, power, energy, phase, frequency, resistance, inductance, capacitance
6. work effectively in a team