G.C.E.(Advanced Level)

PHYSICS

Teacher's Instructional Manual
(Implemented from 2012)

Grade - 13

Department of Science, Health & Physical Education
Faculty of Science & Technology
National Institute of Education

PRINTING AND DISTRIBUTION BY EDUCATIONAL PUBLICATIONS DEPARTMENT

G. C. E. (Advanced Level)

Physics

Teacher's Instructional Manual

(Implemented from 2012)

Grade 13

Department of Science, Health & Physical Education
Faculty of Science & Technology
National Institute of Education

Physics
Teacher's Instructional Manual
Grade 13

First print - 2010
Second print - 2013

National Institute of Education

ISBN:

Department of Science, Health & Physical Education
Faculty of Science & Technology
National Institute of Education

Director General's Message

The task of introducing the competency based curriculum to the school system reaches completion with the Teacher's Instructional Manual for grade 13.

Due to intense competition to enter the universities, the students in grades 12 and 13 are often under a certain amount of pressure. With the introduction of a new curriculum, the pressure is further increased. An Instructional Manual for teachers of grade 13 in such a context is as important as the syllabus. There are three aspects that a teacher should basically consider here. They are, the Teacher's Instructional Manual totally matches with the syllabus, the syllabus is based on the vision and mission of the curriculum and the expected competencies of the syllabus, the Instructional Manual has been designed to reach the expected proficiency levels of the students in grades 12 and 13. It is the responsibility of the teachers, therefore, to study the instructional manual intently.

The National Institute of Education is actively involved in training the teachers who handle grade 13 in order to create awareness of the above mentioned aspects. It is, therefore, important that teachers taking part in these training sessions conducted regularly, as these are very useful in understanding the learning teaching principles and procedures given in the Manuals. Teachers are especially expected to use the School Based Assessments to ensure the achievement of competencies. Every body involved in education and evaluation should understand that all these interventions are necessary to enhance the skills of the students without limiting teaching to the subject content only.

I wish to thank all the academics and the other staff of the National Institute of Education and the external resource persons who were involved in the tiring exercise of preparing Teacher's Instructional Manuals.

Dr.Upali M. Sedere

Director General

Preface

According to the Curriculum policy of Sri Lanka, the school syllabi should be updated every eight years. As such this syllabus and Teachers' manual are introduced under the programme of Educational Reforms launched in 2007.

In the syllabi implemented so far there were several topics pertaining to a particular subject and subject contents related to each topic. Teaching of these subject content was the task of the teacher. The outcome of this process was the emergence of group of learners who are enriched with much knowledge of the subject content.

In the syllabi introduced under the new curriculum reforms, the skills the pupils should acquire under each subject have been identified and recommended. Through this new approach, since learners are very rich with subject knowledge, it is expected to produce a population of learners who will be equipped with skills more inclined towards the practical aspects moving beyond subject knowledge alone. Hence the teachers who implement the new syllabus should be particularly concerned about this difference.

In the section on the continuity of activities in the Teachers' Manual, a classroom with a new learning-teaching process has been suggested. Under this process it should be possible to notice a culture in which learners learn with an exploratory experience where they use libraries read books and periodicals, observe the environment, gather information from resource persons, learn from friends, help friends with what they know, and collect information from the internet wherever possible. The text book provided by the Educational Publications Department too should be used as a resource material. It is expected of the teacher to get the pupils to group the information so gathered correctly in an organized manner and in complete form. Hence, the role of the teacher too should be enriched with the new knowledge. It should display a versatile form that surpasses all what the learners gather. This activity-based learning environment should be extremely attractive to learners.

In this regard treat the model lessons suggested in the Teachers' Manual as guidance to draw up several other lessons. It is particularly expected of every teacher to draw up new lessons as a creative teacher, using these lessons.

Under the learning teaching process learners are always active. Through this, their skills and strengths are revealed. Value them and encourage the learner. Sometimes you might notice the difficulties they face. In all such situations, help them to overcome those difficulties. Lead them to help their close friends. In this manner the process of assessment undertaken in parallel would lead the lesson to a more effective learning exercise.

Further, you are requested to draw your attention to the way the assignments and exercises aimed at the continuation of learning suggested in this Teachers' Manual, Lead to reinforce what the leaner had learnt. Treat this as a good opportunity to evaluate the performance of learners. Also pay your attention to lead learners to many more similar exercises.

Wimal Siyambalagoda
Assistant Director General
Faculty of Languages, Humanities and Social Science
National Institute of Education

Message of the Commissioner General

While the Government provides textbooks free to all the students, Teacher's Instructional Manuals are also provided free to all the teachers. The aim is to make the process of teaching-learning more fruitful and effective.

The Teacher is the mediator who monitors and directs the students to achieve the competencies contained in the syllabus. Hence, it is your responsibility to understand your duties well and use this Teacher's Instructional Manual to achieve a substantial knowledge of the teaching process. This will enable you to make the students knowledgeable and motivated to derive the maximum benefits from the competency based learning process.

I hope that this Teacher's Instructional Manual will assist the teachers who shoulder the solemn duty of moulding the student population enabling them meet the challenges of contemporary society.

W. M. N. J. Pushpakumara
Commissioner General of Educational Publications

Educational Publications Department,
Isurupaya,
Battaramulla.
21. 07. 2009

Guidance

Dr. Upali M. Sedere	Director General, National Institute of Education
Mr. W. Siyambalagoda	Assistant Director General (Curriculum Development), National Institute of Education

Direction

Mr. C.M.R. Anthony	Director, Department of Science, Health and Physical Education, National Institute of Education.

Subject coordination

Mr. P.Malawipathirana	Project Officer, National Institute of Education
Mr. M.L.S. Piyatissa	Assistant Project Officer, National Institute of Education
Mr. N. Muhunthan	Assistant Project Officer, National Institute of Education

Advisory board

Prof. T.R. Ariyaratne	University of Colombo
Dr. S.R.D. Rosa	University of Colombo
Prof. S.R.D Kalingamudali	University of Kelaniya
Dr. M.K. Jayananada	University of Colombo
Dr. K.P.S.C. Jayaratne	University of Colombo
Dr. J.C.N. Rajendra	Open University of Sri Lanka
Prof. J.K.D.S. Jayanetti	University of Colombo
Prof. W.G.D. Dharmarathna	University of Ruhuna
Dr. P.W.S.K. Bandaranayake	University of Peradeniya
Dr. D.D.N.B. Daya	University of Colombo
Dr. P. Geekiyanage	University of Sri Jayewardenepura

Panel of writers (grade 13 Teacher's Instructional Manual)

Mr. B.A. Tilakarathne	SLEAS-II, Former Project Officer - N.I.E.
Mr. W.A.D. Rathnasuriya	Former Chief Project Officer - N. I.E.
Mr. H.S.K. Wijayathilake	SLEAS-I, Former Principal, Rajasinghe Central College, Hanwella
Mr. A.Sugathapala	Former Teacher Service-I, Ruwanwella Central College, Ruwanwella
Mr. D.S. Withanachchi	Former Chief Project Officer (Education Technology), N.I.E

Cover and type setting

Mrs. R.R.K Pathirana	National Institute of Education

Website: www.nie.lk

Table of Contents

	Page
Director General's Message	iii
Preface	iv
Message of the Commissioner General of Publication	v
Unit 5: Gravitational Field	1
Unit 6: Electrostatic Field	6
Unit 7: Current Electricity	16
Unit 8: Electromagnetism	30
Unit 9: Electronics	40
Unit 10: Mechanical Properties of Matter	55
Unit 11: Matter and Radiation	63
Introduction to School Based Assessment	78
School Based Assessment	81
References	88

Unit 5: Gravitational Field

Competency 5.0 : **Uses laws and principles of gravitational field productively in daily pursuits and scientific work.**

Competency level 5.1: Analyses the effect of gravitational field on objects using Newton's law of gravitation

No of periods : 06

Learning outcomes:

Students will be able to

explain the concept of force field 'as actions at a distance' and to explain this using suitable activities.

use Newton's law of gravitation to find gravitational field intensity due to an isolated mass.

calculate gravitational potential at a point in a gravitational field.

represent graphically the variation of gravitational field intensity and gravitational potential with the distance from the mass.

use the energy equation to determine the total energy of a particle moving along circular path around an isolated mass.

Guidelines:

Concept of force fields

Gravitational force (F_g)

Gravitational field intensity, $g \quad \frac{F_g}{m_i}$

Newton's law of gravitation, $F \quad \frac{m_1 m_2}{r^2}$

$F \quad \frac{G m_1 m_2}{r^2}$

Gravitational field intensity

due to a point mass M, $g \quad \frac{GM}{r^2}$

at a point outside a spherical mass

with graphical representations

Gravitational potential

Expressions for gravitational potential

at distance r from a point mass M, $V \quad \frac{GM}{r}$

at a point outside a spherical mass

with graphical representations

Gravitational potential energy, of a mass m in a gravitational field, $U \quad \frac{GMm}{r}$

Expression for the total energy of a mass m moving on a circular path of radius r, taking centre as the centre of a spherical mass M,

$$E \quad \frac{1}{2}mv^2 \quad \frac{GMm}{r}$$

Suggested learning - teaching activities:

Demonstrate various distant actions to introduce force fields (actions at a distance)

(e.g. attraction of a mass by Earth

attraction of small pieces of rigifoam by a rubbed ebonite rod

attraction of iron nails by a magnet)

Demonstrate a simple activity to show that the gravitational force F_g is proportional to m_i, $(F_g \quad m_i)$

(e.g: a helical spring / rubber band, several equal masses, a pan and a metre ruler can be used for this activity)

$F_g \quad gm_i$

Define gravitational field intensity, $g \quad \frac{F_g}{m_i}$ and derive units and dimensions of g.

Introduce Newton's law of gravitation, $F \quad \frac{m_1 m_2}{r^2}$

$$F \quad \frac{Gm_1 m_2}{r^2}$$

Give the value of G $(6.67 \text{ x } 10^{-11} \text{ N m}^2 \text{ kg}^{-2})$ and direct the students to derive the units and dimensions of G.

Derive the equation for gravitational field intensity at a point outside sphere of mass M and distance r as $\frac{GM}{r^2}$.

Represent graphically the variation of gravitational field intensity with the distance

at a point away from a point mass.

at a point outside a spherical mass.

Introduce the concept of potential.

Define the potential at a point in a gravitational field as the work done in bringing a unit mass from infinity to that point.

Introduce the expression for gravitational potential at a point distance r from a mass M as $V \quad \frac{GM}{r}$.

Obtain the energy equation of a mass m moving with speed v in a circular path of radius r, around a spherical mass M as

$$E \quad \frac{1}{2}mv^2 \quad \frac{GMm}{r}$$

Solve problems related to gravitational field using above equations.

Competency level 5.2: Inquires about the instances of using the knowledge on Earth's gravitational field to fulfil human activities.

No of periods: 06

Learning outcomes:

Students will be able to

use knowledge obtained regarding gravitational fields to deduce corresponding relationships in Earth's gravitational field.

find physical quantities related to satellite motion, describing conditions for such motions.

find escape velocity

Guidelines:

Gravitational field intensity, g at a point on or outside the Earth

$g \quad \frac{GM}{r^2}$ where r is the distance from centre of the Earth to the point

$g \quad \frac{GM}{R^2}$ where R is the radius of the Earth

Gravitational potential due to Earth, $V \quad \frac{GM}{r}$ where r is distance from the centre of the Earth $(r \quad R)$

Relationship between the acceleration due to gravity and gravitational field intensity

Earth satellites

Geostationary satellites

Escape velocity

Suggested learning - teaching activities:

Show that the gravitational field intensity can be expressed as $\frac{GM}{r^2}$ where r is the distance from the centre of Earth $(r \quad R)$.

Explain along with graphical representations the variation of gravitational field intensity due to Earth with the distance from the centre of the Earth.

Show the relationship between the acceleration due to gravity and gravitational field intensity by comparing units, dimensions and values.

Explain that the centripetal force necessary for the circular motion of a satellite around the earth is supplied by the gravitational force of the Earth.

Explain the conditions necessary for satellites to be geostationary.

Determine the radius of the orbit and speed at which the geostationary satellites to be launched.

Derive the expressions for escape velocity $v \quad \sqrt{\frac{2GM}{R}}$, $v \quad \sqrt{2gR}$

Solve problems related to satellite motion.

Unit 6: Electrostatic Field

Competency 6.0 : **Uses laws and principles of electrostatic field for scientific work and daily pursuits effectively.**

Competency level 6.1 : Uses the laws related to electrostatic field appropriately to find the distribution and magnitude of electrostatic field produced by various charged objects.

No of periods : 08

Learning outcomes:

Students will be able to

explain the identification of charges using gold leaf electroscope.

use the equation $F_E \quad EQ$ to find the force on a charge placed in an electrostatic (electric) field.

draw the lines of force in various electric fields.

calculate the field intensity at a point in an electric field using Coulomb's law.

explain the variation of electric field intensity with the distance from a point charge using graphical representation.

Guidelines:

Use of gold leaf electroscope to identify charges

Force on a charge in an electrostatic (electric) field, $F_E \quad Q$

$$F_E \quad EQ$$

Electric field intensity (E), its unit and direction

Lines of force in various electric fields

around a point charge

around two point charges

between two charged parallel plates

$$F \quad \frac{q_1 q_2}{r^2}$$

Coulomb's law

$$F \quad \frac{1}{4} \frac{q_1 q_2}{r^2}$$

Permittivity of a medium ( ), permittivity of free space ($_0$) and relative permittivity ($_r$),

$$_r \quad _0$$

Field intensity at a point away from a point charge

$$E \quad \frac{1}{4}\frac{Q}{r^2}$$

Graphical representation of variation of electric field intensity with distance.

Suggested learning - teaching activities:

Explain the structure of the gold leaf electroscope.

Demonstrate charging of a gold leaf electroscope

- by touching
- by induction

Identify charges using a charged electroscope.

Show that deflection, , is proportional to charge, *Q,* using pith ball activity.

Obtain the equation $F_E \quad EQ$ and define *E* as intensity of the electric field.

- unit of electric field intensity

Identify the direction of field intensity as the direction of force acting on a positive test charge.

Identify the direction of electric force on positive and negative charges according to the direction of electric field intensity.

Explain the following force fields using diagrams.

- around a point charge
- around two point charges
- between two charged parallel conducting plates
- between a point charge and a curved conducting plate
- inside and outside a conducting ring

Introduce the Coulomb's law, $F \quad \frac{q_1 q_2}{r^2}$

$F \quad \frac{1}{4}\frac{q_1 q_2}{r^2}$ where is the permittivity of the medium

Introduce relative permittivity ε_r as $\varepsilon = \varepsilon_r \varepsilon_0$ where ε_0 is permittivity of free space.

$$\varepsilon_0 = 8.854 \times 10^{-12}\ \mathrm{C^2\ N^{-1}\ m^{-2}} \quad (\mathrm{F\ m^{-1}})$$

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}\ \mathrm{N\ m^2\ C^{-2}}$$

Use Coulomb's law to show that the electric field intensity at a point, r distance from a point charge as $E = \frac{1}{4\pi\varepsilon}\frac{Q}{r^2}$.

Represent graphically the variation of electric field intensity with the distance.

Calculate the resultant field intensity at a given point formed by several point charges.

Solve related problems using above equations.

Competency level 6.2: Quantifies the electrostatic field using the flux model.

No of periods : 08

Learning outcomes:

Students will be able to

explain the flux model using suitable examples

draw electric field lines around and between different charged objects.

apply the Gauss's theorem to find electrostatic field intensity around charged conducting and non-conducting symmetrical objects.

represent graphically the variation of field intensity with distance from the centre of the sphere.

calculate electric field intensity due to different charged objects using relevant expressions.

Guidelines:

Flux of the electric field (electric lines of force), $_{E}(\; EA)$ where E is the electric field intensity and A is the area normal to the electric flux lines

Total flux emitted by a point charge, $_{E} \quad E.4 \; r^2$

(Note:

Although the quantity, $E(4 \; r^2)$ corresponds to a certain kind of flux associated with the electric field, it should not be interpreted as the standard flux, D. Introduction of the concept of D is not necessary.)

Gauss's theorem, $_{E} \quad Q$

Electric field intensity

around a point charge, $E \quad \frac{1}{4}.\frac{Q}{r^2}$

near an infinite charged conducting plate, $E \quad -$ where is the surface charge density

around a charged conducting sphere, $E \quad \frac{1}{4}\frac{Q}{r^2}, \; r \quad R$ (radius of sphere) $E \quad 0, \; r < R$

around a non-conducting uniformly charged sphere, $E \quad \frac{1}{4}\frac{Q}{r^2}, \; r \quad R$

$$E \quad \frac{1}{4}\frac{Qr}{R^3}, \; r < R$$

between two charged identical parallel plates, $E \quad -$

Graphical representation of the variation of field intensity, with distance from the centre of a charged sphere.

Field intensity at a point distance r from an infinitely long charged thin straight wire, $E \quad \frac{}{2 \quad r}$, where is the charge per unit length

Suggested learning - teaching activities:

Explain the characteristics of the electric flux model.

Explain the characteristics of the lines of flux.

Introduce $_E \quad EA$

Introduce Gauss's theorem.

For any closed surface,

$_E \quad Q$ where Q is the algebraic sum of the charges enclosed within that surface.

Obtain electric field intensity (E) using Gauss's theorem

around a point charge $E \quad \frac{1}{4}\frac{Q}{r^2}$ where r is the distance and Q is the charge.

near an infinite thin charged conducting plate, $E \quad -$ where is the surface charge density.

around a charged conducting sphere

outside the sphere, $E \quad \frac{1}{4}\frac{Q}{r^2}$, $r > R$

on the surface , $E \quad \frac{1}{4}\frac{Q}{R^2}$, $r = R$

inside the sphere $E = 0$, $r < R$

around a non-conducting uniformly charged sphere

outside the sphere $E \quad \frac{1}{4}\frac{Q}{r^2}$, $r>R$

on the surface of the sphere $E \quad \frac{1}{4}\frac{Q}{R^2}$, $r = R$

inside the sphere $E \quad \frac{1}{4}\frac{Qr}{R^3}$, $r < R$

at a point, distance r from infinitely long charged thin straight wire

$E \quad \frac{}{2 \quad r}$ where is the charge per unit length.

Represent graphically the variation of field intensity with the distance from the centre of the sphere.

Competency level 6.3: Quantifies the potential energy of charges placed in an electrostatic field.

No of periods : 08

Learning outcomes:

Students will be able to

find the potential at a point due to a point charge and distribution of point charges.

illustrate graphically the variation of potential with the distance from the centre of conducting sphere.

describe potential energy of a charge at a point due to distribution of point charges.

draw equipotential surfaces in different fields.

express the relation between potential gradient and electric field intensity.

Guidelines:

Definition of potential at a point in an electrostatic (electric) field.

Potential at a point due to a point charge, $V \quad \frac{1}{4}\frac{Q}{r}$

Potential due to a charged spherical conductor.

outside the sphere, $V \quad \frac{1}{4}\frac{Q}{r}, \quad r \quad R$ (R is the radius of the sphere)

on the surface of the sphere, $V \quad \frac{1}{4}\frac{Q}{R}, \quad r \quad R$

inside the sphere, $V \quad \frac{1}{4}\frac{Q}{R}, \quad r \quad R$

Graphical representation of variation of potential with the distance

Potential at a point due to distribution of point charges.

Potential difference between two points in an electric field.

Potential energy of a charge in an electric field.

Potential energy of a charge at a point in a system with charge distribution.

Work done in moving a charge across a potential difference

Equipotential surfaces in different fields

near a point charge

near like point charges

near unlike point charges

Relationship between potential gradient and electric field intensity, $E \quad \frac{dV}{dx}$

Suggested learning - teaching activities:

Define potential at a point in an electrostatic (electric) field.

Introduce an expression for a potential at a point distance *r* from a point charge *Q,*

$$V \quad \frac{1}{4}\frac{Q}{r}$$

Introduce expressions for the potential due to a charged spherical conductor of radius *R* and distance *r* from its centre,

$$V \quad \frac{1}{4}\frac{Q}{r}, \quad r > R$$

$$V \quad \frac{1}{4}\frac{Q}{R}, \; r \quad R$$

Illustrate graphically the variation of potential with the distance from the centre of a conducting sphere.

Explain the potential difference between two points in an electrostatic field.

Represent diagrammatically equipotential surfaces in different fields.

Obtain the relation $E \quad \frac{dV}{dx}$ between potential gradient and electric field intensity.

Give numerical problems related to electrostatic potential.

Competency level 6.4: Uses capacitors appropriately in electrical circuits

No of periods : 06

Learning Outcomes:

Students will be able to

derive the expression for capacitance of a parallel plate capacitor.

obtain the equivalent capacitance of capacitors in series and capacitors in parallel.

derive expressions for energy stored in a charged capacitor.

interpret diagrammatically the charge distribution of conductors having different shapes.

explain the action of a lightning conductor.

solve problems related to capacitors.

Guidelines:

Capacitance

Definition of capacitance, $C \quad \frac{Q}{V}$

Parallel plate capacitors

Capacitance of a parallel plate capacitor, $C \quad \frac{k\ _{0}A}{d}$ where $k \quad _{r}$

Capacitance of a spherical conductor, $C \quad 4 \quad _{0}r$

Combination of capacitors

capacitors in series, $\frac{1}{C} \quad \frac{1}{C_1} \quad \frac{1}{C_2} \quad ... \quad \frac{1}{C_n}$

capacitors in parallel, $C \quad C_1 \quad C_2 \quad ... \quad C_n$

Energy stored in a charged capacitor, $E \quad \frac{1}{2}QV \quad \frac{1}{2}\frac{Q^2}{C} \quad \frac{1}{2}CV^2$

Distribution of charges on conductors having different shapes

spherical conductor

pear shaped conductor

cubic conductor

Point discharge (corona discharge)

Action of a lightning conductor

Suggested learning - teaching activities:

Explain the action of a capacitor.

Define capacitance, $C \quad \frac{Q}{V}$.

Introduce parallel plate capacitor and derive an expression for the capacitance,

$C \quad \frac{k \ {}_0 A}{d}$ where $k \quad {}_r$.

Obtain the capacitance of a spherical conductor, $C \quad 4 \quad {}_0 r$.

Derive expressions for equivalent capacitance of capacitors in series and in parallel,

$$\frac{1}{C} \quad \frac{1}{C_1} \quad \frac{1}{C_2} \quad \cdots \quad \frac{1}{C_n},$$

$$C \quad C_1 \quad C_2 \quad \cdots \quad C_n$$

Derive the expression for energy stored in a charged capacitor,

$E \quad \frac{1}{2}QV \quad \frac{1}{2}\frac{Q^2}{C} \quad \frac{1}{2}CV^2$.

Explain distribution of charges.

spherical conductor

pear shaped conductor

cubic conductor

Point discharge (corona discharge)

Describe diagrammatically the action of a lightning conductor.

Laboratory practical:

Charging and discharging of a capacitor (graphical representations) and simple applications.

Unit 7: Current Electricity

Competency 7.0 : Uses the laws, principles and effects of current electricity productively and appropriately.

Competency level 7.1: Manipulates the physical quantities related to current electricity wherever appropriate.

No. of periods: 08

Learning outcomes:

Students will be able to

explain electric current as rate of flow of charges.

distinguish the differences between electrical conductors and insulators.

explain the mechanism of conduction, current density and drift velocity of electrons.

describe resistance, resistivity, conductivity and superconductivity.

explain ohmic and non-ohmic conductors using Ohm's law.

obtain the equivalent resistance of simple networks.

solve related problems.

Guidelines:

Electric current as $I \quad \frac{Q}{t}$.

Free electron density in conductors and insulators

Derivation of $I \quad nAev$

Current density, $J \quad \frac{I}{A}$

Resistance , $R \quad \frac{V}{I}$ and unit V A^{-1} ( )

Resistivity, is defined by $R \quad \frac{l}{A}$ and unit of is Ω m .

Conductivity, $\frac{1}{}$ and unit $^{-1}m^{1}$ (S m^{-1})

Superconductors

behaviour

properties (Meissner effect)

superconducting materials

uses

Ohm's law and conditions

V-I curves

ohmic conductors

non-ohmic conductors

Variation of resistance with temperature, $R \quad R_0(1 \qquad)$

Effective resistance, R

connected in series, $R \quad R_1 \quad R_2 \quad \ldots \quad R_n$

connected in parallel, $\frac{1}{R} \quad \frac{1}{R_1} \quad \frac{1}{R_2} \quad \ldots \quad \frac{1}{R_n}$

effective resistance of simple networks

Potential divider

Suggested learning - teaching activities:

Explain the electric current by discharging charged capacitor through a milliammeter.

Derive the formula for drift velocity by describing the mechanism using a relevant diagram $I \quad nAev$.

Introduce current density as $J \quad \frac{I}{A}$.

Define resistance as $R \quad \frac{V}{I}$.

Introduce the unit of resistance V A^{-1} as .

Describe that the resistance (R) of a conductor depends on length (l) and cross sectional area (A),

$$R \quad l$$

$$R \quad \frac{1}{A}$$

Introduce the formula, $R \quad \frac{l}{A}$ where   is the resistivity.

Define resistivity.

Introduce the unit of resistivity as Ω m .

Introduce electrical conductivity as $\frac{1}{\;}$ and its unit as $^{-1}$m ^{1} (S m^{-1}) .

Explain superconductivity.

Draw the temperature-resistance graph for superconducting materials.

Explain the Meissner effect of superconductors.

Name few superconducting materials.

Explain critical (transition) temperature. (T_c).

Material	Critical (Transition) temperature(K)
Al	1.19
Hg	4.15
Pb	7.18
YBa_2Cu_2O	100
$Tl_2Ba_2Ca_2Cu_3O_{10}$	125
$HgBa_2Ca_2Cu_3O_8$	138

Discuss the uses and importance of superconductors.

State Ohm's law.

Explain the conditions for validity of Ohm's law.

Draw the relevant graphs to explain ohmic and non-ohmic conductors.

metalic conductor

filament of an electrical bulb

semiconductor diode

water voltameter

Explain the variation of resistance with temperature.

Introduce the equation $R \quad R_0(1 \quad\quad)$

where α is the temperature coefficient of the material

Temperature coefficient can be negative or positive. For example, normally temperature coefficient of resistance is positive for metallic conductors and negative for semiconductors.

Derive equations for effective resistance (R)

onnected in series, $R \quad R_1 \quad R_2 \quad ... \quad R_n$

connected in parallel, $\frac{1}{R} \quad \frac{1}{R_1} \quad \frac{1}{R_2} \quad ... \quad \frac{1}{R_n}$

Direct students to find the effective resistance of simple networks.

Explain the action of the potential divider using suitable circuit diagrams.

Solve related problems.

Competency level 7.2: Quantifies the energy and power in direct current (dc) circuits.

No. of periods **:** 04

Learning outcomes:

Students will be able to

express formulae for energy dissipation due to flow of charges.

express formulae for rate of dissipation of energy.

apply above formulae for any electrical appliance.

find the dissipation of heat for passive resistors.

solve related problems.

Guidelines:

Electrical energy and its units.

Energy dissipated (*W*) due to flow of charges.

$W = QV$

$W = VIt$

Commercial electrical energy unit, kW h

Electrical power and its units

Rate of dissipation of energy (*P*), $P = VI$ for any electrical appliance.

Derive formulae for passive resistors.

$P = I^2R$

$P = \frac{V^2}{R}$

and

$W = I^2Rt$

$W = \frac{V^2}{R}t$

Suggested learning - teaching activities:

Demonstrate heating effect of current using simple activities.

Obtain expressions for energy dissipated due to flow of charges

$W \quad QV$

$W \quad VIt$

Explain the commercial energy unit, kW h

Obtain the expression for rate of dissipation of energy (*P*)**,**

$P \quad VI$

Search and compare the values of electrical power used in home appliances in day-to-day life.

Obtain the equations for energy dissipation in passive resistors.

$W \quad I^2Rt$

$W \quad \frac{V^2}{R}t$

Obtain the equation for rate of dissipation of energy for passive resistors.

$P \quad I^2R$

$P \quad \frac{V^2}{R}$

Solve related problems using above equations.

Laboratory practical:

Determination of specific heat capacity of a liquid using Joule's calorimeter.

Competency level 7.3: Quantifies the power source of electric circuits.

No. of periods : 06

Learning outcomes:

Students will be able to

explain the direction of conventional electric current using a simple cell.

describe the energy transformation in different types of sources of electromotive force (emf).

express the voltage drop across a source of emf with internal resistance in a closed circuit.

express the effective emf of combination of cells.

explain the condition for maximum power transfer using graphical representation of power versus resistance.

Guidelines:

Different sources of emf.

Transformation of different forms of energy in various sources of emf.

Electrode potential and emf of an electrochemical cell.

Direction of conventional electric current.

Internal resistance of an emf source.

Definition of electromotive force.

Law of conservation of energy applicable to an electrical circuit with a source of emf. $EI \quad I^2R \quad I^2r$

Equations, $E = I(R + r)$ and $V = E - Ir$ for a simple closed circuit.

Combination of sources of emf

series connection

equivalent electromotive force (E_e),

$$E_e \quad E_1 \quad E_2 \quad ... \quad E_n$$

equivalent internal resistance (r_e),

$$r_e \quad r_1 \quad r_2 \quad ... \quad r_n$$

parallel connection of identical sources

equivalent electromotive force (E_e),

$$E_e \quad E$$

equivalent internal resistance (r_e),

$$r_e \quad \frac{r}{n}$$

where n is the number of cells.

Graphical representation of power transfer versus load resistance.

Condition for maximum power transfer

Suggested learning - teaching activities:

Describe transformation of different forms of energy in sources of emf.

e.g.

electrochemical cell

solar cell

dynamo

piezoelectric crystal

thermocouple

photoelectric cell

Describe the potential difference of a simple cell (using electrode potentials) and introduce the direction of conventional current.

Define electromotive force and potential difference.

Compare potential difference and electromotive force

Introduce internal resistance.

Explain how to apply the law of conservation of energy to a closed circuit.

$$EI \quad I^2R \quad I^2r$$

Deduce the equations $E = I\,(R + r)$ and $V=E-Ir$ for a simple closed circuit.

State expressions for equivalent emf and equivalent internal resistance of sources of emf.

series connection

$$E_e \quad E_1 \quad E_2 \quad \ldots \quad E_n$$

$$r_e \quad r_1 \quad r_2 \quad \ldots \quad r_n$$

parallel connection of identical sources.

$$E_e \quad E$$

$$r_e \quad \frac{r}{n}$$ where n is number of cells.

Represent graphically the relationship between resistance and power.

Use above relation to explain the condition for maximum power transfer.

Laboratory practical:

Determination of emf and internal resistance of a cell (graphical method).

Competency level 7.4: Uses the laws and principles related to current electricity for designing circuits.

No. of periods : 10

Learning outcomes:

Students will be able to

explain Kirchhoff's first law on the basis of conservation of charge.

describe Kirchhoff's second law as one form of conservation of energy.

derive relationship among resistances of a balanced Wheatstone bridge.

use metre bridge accurately to measure / compare resistances.

apply circuit laws to electrical networks for solving problems.

Guidelines:

Kirchhoff's first law, I 0

conservation of charge

Kirchhoff's second law, E IR

conservation of energy

Application of Kirchhoff's laws to electrical circuit networks.

Relationship among resistances of a balanced Wheatstone bridge.

Metre bridge as one practical form of Wheatstone bridge

facts to be considered in using metre bridge

safety of the galvanometer

end correction

precautions for minimizing errors

Suggested leaning - teaching activities:

Introduce Kirchhoff's laws

Explain that Kirchhoff's first law as a form of conservation of charge.

Explain that Kirchhoff's second law as a form of conservation of energy.

Apply Kirchhoff's laws to electrical circuit networks.

Derive the relationship among resistances for balanced Wheatstone bridge.

Introduce meter bridge as one practical form of Wheatstone bridge.

- Explain facts to be considered in using metre bridge;
    - safety of the galvanometer
    - end correction
    - precautions for minimizing errors
- Discuss advantages and disadvantages of metre bridge
- Explain the uses of meter bridge.
    - comparison of two resistances.
    - determination of the temperature coefficient of resistance.

Laboratory practical:

Comparison of resistances

Determination of temperature coefficient of resistance using metre bridge

Competency level 7.5: Selects suitable instruments according to the quantity to be measured and uses electrical measuring instruments accurately and protectively.

No. of periods **:** 04

Learning outcomes:

Students will be able to

- convert moving coil galvanometer to ammeter or voltmeter according to the needs.
- use ammeters and voltmeters correctly and protectively according to the needs.
- describe the structure and use of ohmmeter.
- solve numerical problems on conversion of moving coil galvanometer to ammeter, voltmeter and ohmmeter.
- use multimeter correctly according to the appropriate situations.

Guidelines:

- Converting a moving coil galvanometer to an ammeter.
- changing the range of an ammeter
- properties of ideal ammeter
- Converting a moving coil galvanometer to a voltmeter
- changing the range of a voltmeter
- properties of an ideal voltmeter
- Converting a moving coil galvanometer to an ohmmeter
- Multimeter

(as a combination of ammeter, voltmeter and ohmmeter)

Suggested learning - teaching activities:

- Explain the modification of moving coil galvanometer to an ammeter using a suitable shunt.
- Explain the modification of galvanometer to a voltmeter using a suitable multiplier.
- Describe multi-range ammeters and voltmeters using relevant circuit diagrams.
- Explain the properties of an ideal ammeter and ideal voltmeter.
- Explain the circuit of an ohmmeter and its scale.
- Measure current, voltage and resistance using multimeter.

Competency level 7.6: Uses potentiometer appropriately by setting up suitable circuits.

No. of periods **:** 10

Learning outcomes:

Students will be able to

describe the principle of potentiometer.

explain the facts to be considered in using potentiometer.

use potentiometer to compare electromotive forces and to compare resistances.

use potentiometer to determine internal resistance and to determine very small electromotive forces.

solve problems related to potentiometer.

Guidelines:

Principle of potentiometer

Calibration of potentiometer

Important facts to be considered in using potentiometer.

Describe the uses of potentiometer to

compare electromotive forces

compare resistances

determine internal resistances

determine very small electromotive forces.

Advantages and disadvantages of potentiometer

Suggested learning - teaching activities:

Describe the principle of potentiometer.

Explain the calibration of potentiometer using relevant circuit diagrams.

Describe the facts to be considered in using potentiometer.

sensitivity

connecting cells in correct way

end correction

precautions to be taken in obtaining the balance point

- Explain the uses of potentiometer with relevant circuit diagrams
  - comparison of electromotive forces
  - comparison of resistances
  - determination of internal resistances of a cell
  - determination of very small electromotive forces
- Discuss the advantages and disadvantages of potentiometer.

Laboratory practical:

- Uses of potentiometer
  - Comparison of electromotive forces
  - Comparison of resistances
  - Determination of internal resistance of a cell
  - Determination of very small electromotive forces

Unit 8: Electromagnetism

Competency 8.0 : **Uses the effects of inter-relationships between electricity and magnetism for scientific work and daily pursuits.**

Competency level 8.1 : Manipulates the variables to control the force acting on a current carrying conductor and moving charge placed in a magnetic field.

No. of periods : 10

Learning outcomes:

Students will be able to

explain the magnetic force acting on a current carrying conductor placed in a magnetic filed.

deduce the expression for force acting on a moving charge in a magnetic field.

find the direction of the above magnetic force by Fleming's left hand rule.

explain Hall effect.

solve related problems.

Guidelines:

Magnetic effect of current

Force acting on a current carrying conductor placed in a magnetic field.

$F \quad I$

$F \quad l$

$F \quad BIl$

Magnetic flux density (B)

Fleming's left hand rule

$F \quad BIl\sin$

Force acting on a charge moving in a magnetic field, $F \quad Bqv\sin$

Hall effect

Hall voltage, $V_H \quad BVd \quad \frac{BI}{net}$

Applications

Suggested learning - teaching activities:

Explain magnetic effect of current using Oersted's experiment.

Demonstrate the factors which affect the force acting on a current carrying conductor placed in a magnetic field using current balance.

$F \quad I$, $F \quad l$, $F \quad BIl$

Define flux density using $B \quad \frac{F}{Il}$.

Introduce the units.

Introduce Fleming's left hand rule.

Introduce, $F \quad BIl\sin$ when the conductor is placed at an angle to the magnetic filed.

Deduce the expression for the force $F \quad Bqv\sin$ for a charge moving in a magnetic field.

Explain Hall effect.

Derive the expression for Hall voltage, $V_H \quad BVd \quad \frac{BI}{net}$.

Discuss the applications of Hall effect.

Solve problems related to the above equations and describe applications.

Laboratory demonstration:

Demonstration of the nature of electromagnetic force using current balance

Competency level 8.2: Generates suitable magnetic fields by manipulating variables for the needs.

No. of periods : 06

Learning outcomes:

Students will be able to

- interpret Biot-Savart law by relevant expression
- derive the expression for magnetic flux density at the centre of a current carrying circular coil.
- mention the expressions for magnetic flux density outside an infinitely long straight conductor and along the axis of a long solenoid carrying currents.
- derive the force between two parallel infinitely long current carrying conductors.
- solve related problems.

Guidelines:

- Biot- Savart law and corresponding expression,

  $B \propto \frac{I \Delta l \sin\theta}{r^2}$, $B = \frac{\mu_0}{4\pi}\frac{I \Delta l \sin\theta}{r^2}$ with a diagram

- Magnetic flux lines due to current carrying conductors
  - around a straight wire
  - through a circular coil
  - through a solenoid
- Magnetic flux density
  - at a point away from a infinitely long current carrying straight wire,

    $B = \frac{\mu_0 I}{2\pi r}$

  - at the centre of a current carrying circular coil, $B = \frac{\mu_0 NI}{2r}$
  - along the axis of a long current carrying solenoid, $B = \mu_0 \frac{N}{l} I$, $B = \mu_0 nI$
- Force between two infinitely long parallel current carrying conductors,

  $F = \frac{\mu_0 I_1 I_2 l}{2\pi r}$

- Definition of ampere

Suggested learning - teaching activities:

Introduce Boit-Savart law as the relationship, $\Delta B \propto \dfrac{I\,\Delta l \sin\theta}{r^2}$ where ΔB is the magnetic flux density at a point distance r from a current element $I\,\Delta l$, θ is the angle between the direction of the current element and the line joining the point and current element.

State expression for Biot-Savart law as $\Delta B = \dfrac{\mu_0}{4\pi}\dfrac{I\,\Delta l \sin\theta}{r^2}$ where μ_0 is permeability of free space.

Derive an expression for magnetic flux density (*B)* at the centre of a current carrying circular coil, $B = \dfrac{\mu_0 N I}{2r}$, where N is the number of turns.

Mention that the expression for magnetic flux density

at a point distance r from an infinitely long current carrying conductor is given by, $B = \dfrac{\mu_0 I}{2\pi r}$.

along the axis of a current carrying long solenoid is given by $B = \mu_0 \dfrac{N}{l} I$, $B = \mu_0 n I$ where n is number of turns per unit length.

(Proofs are not expected)

Explain the occurrence of the mutual forces between two conductors carrying currents in

the same direction.

the opposite direction.

Derive the magnetic force between two infinitely long current carrying parallel conductors as $F = \dfrac{\mu_0 I_1 I_2 l}{2\pi r}$.

Hence, define the ampere and the value of μ_0.

Solve related problems.

Competency level 8.3: Inquires the rotational effect due to the inter-relationship of electricity and magnetism.

No. of periods: 06

Learning outcomes:

Students will be able to

derive expressions for torque acting on a current carrying rectangular coil placed in a uniform magnetic field.

explain the structure and the function of moving coil galvanometer.

describe the structure and function of a direct current motor.

solve related problems.

Guidelines:

Torque acting on a current carrying rectangular coil placed in a uniform magnetic field, $BINA$ cos where is the angle between plane of coil and direction of the magnetic field.

Expression for deflection of a moving coil galvanometer where the magnetic field is radial, C $BINA$ where C is the restoring torque per unit twist and is the angle of deflection of the coil, I .

Structure and function of direct current motor

Suggested learning - teaching activities:

Derive an expression for the torque acting on a current carrying rectangular coil in a uniform magnetic field, $BINA$ cos where is the angle between plane of the coil and direction of the magnetic field.

Explain that if is the angle between normal to the plane of the coil and the magnetic field, then the above expression becomes,

$BINA$ cos(90) $BINA$ sin .

Discuss the structure and function of moving coil galvanometer,

C $BINA$ where is the angle of deflection of the coil.

Explain the necessity to have a radial field, and formation of such a field using

cylindrical pole pieces

cylindrical soft iron core at the centre

Explain the factors affecting current sensitivity number of turns of the coil

area of the coil

flux density

restoring couple for unit twist / torsion constant

Describe the structure and function of a dc motor.

Competency level 8.4: Uses the laws and rules in electromagnetic induction for technical needs.

No. of periods : 12

Learning outcomes:

Students will be able to

- demonstrate the laws of electromagnetic induction.
- derive expressions for induced electromotive force of a rod, disc and rectangular coil moving / rotating in a magnetic field.
- describe the structure and function of alternating current (ac) generator and direct current (dc) generator.
- explain the structure and function of a transformer.
- explain elements of alternating current.
- solve related problems.

Guidelines:

- Phenomenon of electromagnetic induction
- Laws of electromagnetic induction
  - Faraday's law
  - Lenz's law
  - $E \quad \frac{d}{dt}$ where E is the induced electromotive force and is the normal flux linkage
- Electromotive force (emf) induced in a straight rod
  - moving perpendicularly in a magnetic field, $E \quad Blv$
  - general expression, $E \quad Blv\sin$
- Fleming's right hand rule
- Electromotive force induced in a straight rod rotating in a magnetic field,

$$E \quad \frac{Br^2}{2} \quad B \;\; r^2 f$$

- Electromotive force induced in a disc rotating in a magnetic field,

$$E \quad \frac{Br^2}{2}, \; E \quad B \;\; r^2 f$$

Electromotive force induced in a rectangular coil rotating in a magnetic field

maximum value, $E \quad NAB$

Alternating current generator

structure

graphical representation of the variation of electromotive force with time

Direct current generator

structure

graphical representation of the variation of electromotive force with time.

Eddy currents and their uses

Back electromotive force (back emf) of an electric motor.

Effect of the back emf on the armature current,

$$I_a \quad \frac{E_s \quad E_b}{r_a}$$

Controlling the initial current – starter switch as rheostat

Transformers

structure

relationship between the number of turns and the voltages of primary and secondary coils, $\frac{N_S}{N_P} \quad \frac{V_S}{V_P}$

Step-up and step-down transformers

Energy losses in a transformer

due to Joule heating

due to eddy current

Uses of transformers in

welding work, dc power supply units (power packs), CRO, power transmission, etc.

Transmission of electric power

Elements of alternating current

sinusoidal waves form of voltage and current of an alternating current source

peak value and root mean square (rms) value,

$$V_{rms} \quad \frac{V_P}{\sqrt{2}}$$

$$I_{rms} \quad \frac{I_P}{\sqrt{2}}$$

average power in watts in a resistive circuit

$$P \quad V_{rms} \quad I_{rms}$$

$$P \quad (I_{rms})^2 R$$

$$P \quad \frac{(V_{rms})^2}{R}$$

Suggested learning - teaching activities:

Demonstrate activities to demonstrate electromagnetic induction.

State Faraday's law

State Lenz's law

Demonstrate the laws of electromagnetic induction using a solenoid, a centre zero galvanometer and a magnet.

Derive expressions giving the magnitude of the emf induced in a

straight rod moving in a magnetic field, $E \quad Blv$

rod rotating in a magnetic field, $E \quad \frac{Br^2}{2} \quad B \ r^2 f$

disc rotating in a magnetic field (the same voltage as above rod but very less internal resistance), $E \quad \frac{Br^2}{2}$, $E \quad B \ r^2 f$

rectangular coil rotating in a magnetic field (for the maximum value),

$E \quad NAB$

Show the structure of a dc generator using a model dc generator available in the laboratory.

graphical representation of the variation of electromotive force with time

Explain how eddy currents are created

Describe the uses of eddy currents

for damping

for heating

Explain back emf in electric motor (dynamo action).

Explain the starter switch which is controlling the initial current.

Show the structure of a transformer.

Discuss the relationship between the number of turns and the voltages of primary and secondary coils.

explain the direction of secondary current according to the direction of primary current using relevant diagrams.

step-up and step-down transformers.

Discuss the power loss due to Joule heating and eddy current.

Discuss the remedies to minimize the power loss.

Introduce the uses of transformers (action only)

welding work (arc/ spot), dc power supply unit (power pack), ac power distribution

Discuss transmission of electric power.

National grid and its performance

Discuss sinusoidal wave form of voltage and current of an ac source.

Explain V_{rms}, V_P, I_{rms} and I_P.

Give equations, $V_{rms} = \frac{V_P}{\sqrt{2}}$

$$I_{rms} = \frac{I_P}{\sqrt{2}}$$

$$P = V_{rms} \times I_{rms}$$

$$P = (I_{rms})^2 R$$

$$P = \frac{(V_{rms})^2}{R}$$

Use the formulae, $P = VI$, $P = I^2 R$ and $P = \frac{V^2}{R}$ for appliances where heat is produced in resistors. (Name such resistors as passive resistors).

Laboratory demonstration:

Demonstration of the laws of electromagnetic induction

Unit 9: Electronics

Competency 9.0 : Uses electronic circuits to fulfil human needs efficiently.

Competency level 9.1: Inquires about the principle and action of semiconductor diode.

No. of periods : 06

Learning outcomes:

Students will be able to

- describe the function of *p-n* junction using the properties of semiconductors.
- represent graphically the characteristic of a diode.
- explain with relevant diagrams the uses of diode as a rectifier.
- describe other types of diodes with symbols and their uses.
- solve problems related to diodes.

Guidelines:

- Intrinsic semiconductors
- Extrinsic semiconductors
  - majority and minority carriers
  - *n*-type
  - *p*-type
- *p-n* junction
  - depletion layer
  - potential barrier
  - forward bias
  - reverse bias
- Characteristic of a diode
  - *I-V* curves of real and ideal diodes
- Uses of diode as
  - a switch
  - a rectifier
    - half-wave rectification
    - full-wave rectification

Smoothing circuits

Demonstration of rectification and smoothing using a CRO

Other types of diodes and their uses

Zener diode

Zener voltage

voltage regulation

Light emitting diode

Photodiode

Suggested learning - teaching activities:

Introduce semiconductors which have the value of ρ approximately in between

10^{-3} m 10^{5} m at room temperature.

Explain the hole-electron pair generation of Si or Ge using crystal lattice.

Introduce intrinsic semiconductors.

Introduce *p*-type and *n*-type extrinsic semiconductors by doping impurities into intrinsic semiconductors.

Introduce majority and minority carriers in extrinsic semiconductors.

majority carriers in *p*-type and *n*- type semiconductors.

the donor atom concentration (N_D) and acceptor atom concentration (N_A)

State that for silicon, intrinsic carrier density is $N_i = 10^{10}$ cm^{-3} at room temperature.

Show that the doping level of 1 ppm gives N_A 10^{17} cm^{-3} because the atomic density for silicon is 10^{23} cm^{-3}.

Explain the increase of electron-hole pair generation with rise of temperature in intrinsic semiconductor.

Describe the function of *p-n* junction using the properties of semiconductors.

Illustrate the function of *p-n* junction with aid of suitable diagrams.

Explain the formation of depletion layer due to the diffusion and drift of majority carriers.

Explain the formation of a constant built-in potential difference as a result of a dynamic equilibrium being established between diffusion and drift of carriers.

Explain how the diode could be made forward biased and reversed biased using circuit diagrams.
Explain that in the forward biased condition, a flow of current occurs when the potential barrier is exceeded by applying an external voltage.
Explain that in the reverse biased condition, the width of depletion layer increases, resulting no flow of majority carriers, but a small leakage current flows due to minority carriers.
Introduce the circuit symbol of a junction diode.
Illustrate *I-V* characteristic curve of a junction diode.
Explain the main features of the *I-V* curve.

Dynamic resistance (R_F and R_R)

Knee voltage

Peak Inverse Voltage (PIV)

Introduce *I-V* characteristic curve of an ideal diode.
Describe the function of an ideal diode as a switch.
Explain graphically half-wave rectification of a diode using a suitable circuit diagram.
Explain graphically full-wave rectification of a bridge rectifier using a suitable circuit diagram.
Describe the way of smoothing of rectified wave form using a capacitor.
Represent graphically the change of rectified wave form after smoothing.
ripple voltage of smoothed wave form.
frequency of ripple voltage (from the graph)
Describe how to select the correct PIV of diodes used in a half wave and full wave rectifier circuits.
without a smoothing capacitor
with a smoothing capacitor
Explain the action of a Zener diode

symbol

Zener voltage (V_z)

Avalanche and Zener breakdown

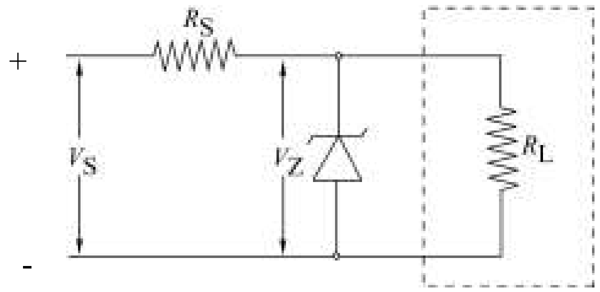
Explain the use of Zener diode as a voltage regulator.

Show the suitable value for R_s is given by $R_s \quad \frac{V_s \quad V_Z}{I_m}$

where V_s is the unregulated voltage

R_S is the safety resisitor

I_m is the maximum current possible to flow through the zener diode without damaging



Introduce the symbol and external view of an LED.

Describe briefly the function of an LED.

Discuss the uses of LED (indicators, light sources, etc.)

Describe the action of photodiode and solar cell.

Laboratory practical / demonstration:

Sketch *I-V* curve of a real diode

Demonstration of rectification and smoothing using a CRO

Use of Zener diode as a voltage regulator

Use of three terminal IC voltage regulators (e.g. 78xx and 79xx series)

Competency level 9.2: Uses transistor for practical needs.

No. of periods **:** 12

Learning outcomes:

Students will be able to

- explain the biasing of *npn* and *pnp* transistors with suitable diagrams.
- describe with appropriate diagrams, the common base, common emitter and common collector configuration of a transistor.
- interpret graphically the input, output and transfer characteristics of common emitter configuration of a transistor.
- describe the action and uses of a transistor in common emitter configuration as an amplifier and as a switch.
- explain the structure, action, and characteristics and voltage amplification of an FET.
- solve problems related to transistors.

Guidelines:

- Transistor is a device having two *p-n* junctions
  - *npn* transistor
  - *pnp* transistor
- Base, Collector and Emitter of a transistor.
- Circuit symbol of *npn* and *pnp* transistor
- Use of transistor as a four-terminal device and the circuit configurations
  - common base
  - common emitter
  - common collector
- Action of a transistor using common emitter configuration
- Characteristics of common emitter configuration of the transistor
  - Input characteristic, I_B vs V_{BE}
  - Output characteristic, I_C vs V_{CE}
  - Transfer characteristics, I_C vs I_B

I_C vs V_{BE}

Modes of operation of a transistor (active, cutoff and saturation)

Necessity of biasing a transistor (use common emitter configuration)

biasing from a single voltage source

Base biased resistor

Potential divider

Process of current amplification using *npn* transistor (use common emitter configuration)

Current amplification using I_C vs I_B graph

d.c. current gain, $\frac{I_C}{I_B}$

Relationship between I_B, I_C, V_C, V_{BE} and V_{CC} (using Kirchhoff's law) in common emitter amplifier circuit.

Quiescent point

Biasing condition, $V_C \quad \frac{V_{CC}}{2}$

Voltage variation through R_C

Voltage amplification

Necessity of coupling capacitors for inputs and outputs

Transistor as a switch

Unipolar Transistors

Field Effect Transistors (FETs) [Limit discussion only to Junction FETs]

introduction

symbol (*n*-channel and *p*-channel)

terminals (Source, Gate, Drain)

characteristic curves

I_{DS} vs V_{DS}

action of an *n*- channel FET

voltage amplification using an FET (qualitatively)

Suggested learning - teaching activities:

Describe *npn* and *pnp* bipolar transistors as a combination of two *p-n* junctions with relevant diagrams.

Introduce base, collector and emitter.

Introduce the circuit symbol of *npn* and *pnp* transistor.

Represent diagrammatically the ways of biasing *npn* transistor.

Describe the following circuit configurations using relevant diagrams.

common-base

common-emitter

common-collector

Interpret graphically the input, output and transfer characteristics of a common emitter configuration of a transistor.

Input characteristic I_B vs V_{BE}

Output characteristic I_C vs V_{CE}

Transfer characteristics I_C vs I_B

I_C vs V_{BE}

Identify cutoff, active and saturation regions using the output and transfer characteristic curves.

$I_C = \quad I_B$ for active region

$I_C < \quad I_B$ for saturation region

I_C □ 0 for cut-off region

Explain the modes of operation of a transistor (active, cutoff and saturation)

Explain the action of an *npn* transistor using common emitter configuration operating in the active mode.

Explain the purpose of biasing a transistor.

External base-emitter voltage necessary to exceed the barrier potential (approximately 0.7 V for Si transistors approximately 0.3 V for Ge transistors)

Explain the effective methods of biasing an *npn* transistor in common emitter configuration using a single voltage source

Base resistor method

Potential divider method

Introduce the quiescent point using the graph of I_C vs I_B

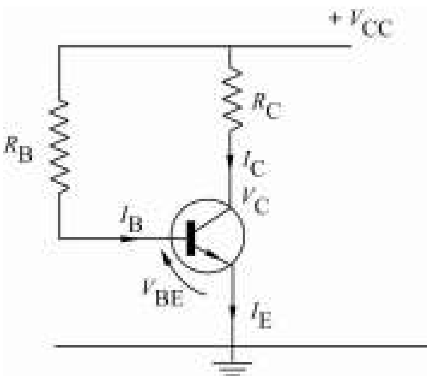
Discuss the advantages of selecting the quiescent point as $\frac{V_{CC}}{2}$

Describe current amplification using I_C vs I_B graph.

Introduce d.c. current gain (β), $\frac{I_C}{I_B}$

Obtain the equations for relevant voltages such as V_C, V_B, etc. using Kirchhoff's laws and Ohm's law.

e. g. 1. Using base resistors



$I_B R_B \quad V_{BE} \quad V_{CC}$

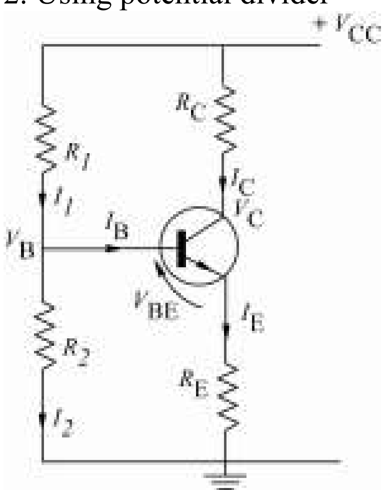
(V_{BE} 0.7 V for Si or 0.3 V for Ge)

$V_C \quad V_{CC} \quad I_C R_C$

Select $V_C \quad \frac{V_{CC}}{2}$

$I_C \quad I_B$

2. Using potential divider



$V_B \quad (\frac{V_{CC}}{R_1 \quad R_2})R_2$

I_B 0 ; very small

$I_1 \quad I_2$

$I_1 R_1 \quad V_{BE} \quad I_E R_E \quad V_{CC}$

$V_{BE} \quad V_B \quad I_E R_E$

Explain the way of conversion of the current amplification produced by a transistor to a voltage amplification using a collector resistor.
Interpret graphically the variation of output voltage with time for a given sinusoidal input.
Compare the input and output waveforms

Explain the phase variation.
Discuss voltage gain.

Describe the necessity of coupling capacitors for input and output with related circuit diagrams.

Explain the use of transistor as a switch in common emitter configuration with relevant circuit diagrams.

Distinguish the operation of bipolar and unipolar transistors.

Bipolar transistor depends on the action of two types of charge carriers (holes and electrons)

Unipolar transistor depends on the action of only one type of charge carriers (either holes or electrons).

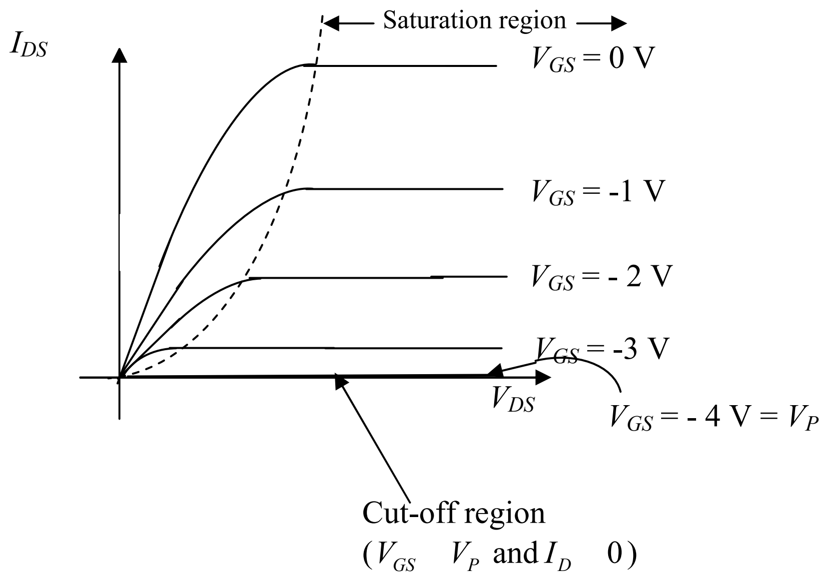
Introduce Field Effect Transistor (FET) [Junction FET (JFET)] as a unipolar transistor.

Introduce the types of JFETs (*n*-channel and *p*-channel)

Illustrate the structure and terminals of *n*-channel and *p*-channel of JEET (Source, Gate, Drain)

Explain the physical operation of *n*-channel of JFET.

Characteristic curves, I_{DS} vs V_{DS}



Explain voltage amplification using an FET (common source configuration).

State the major difference between JFET and MOSFET.

Laboratory practical:

Investigating the characteristics of common emitter configuration of a transistor

Common emitter transistor amplifier
Transistor as a switch and a simple application.

Competency level 9.3: Investigates the uses of operational amplifier.

No. of periods **:** 06

Learning outcomes:

Students will be able to

identify the pins of operational amplifier using data sheets.

describe the open loop characteristic of an operational amplifier.

interpret graphically and with suitable circuit diagrams the action of inverting and non-inverting operational amplifier.

explain the Golden rules I and II regarding of an operational amplifier (for a close loop state)

solve problems related to characteristics and uses of operational amplifier.

Guidelines:

Integrated circuits (ICs)

SSI, MSI, LSI, VLSI

Brief explanation

Advantages

Numbering system of pins.

Types of ICs

Analogue

Digital

Operational Amplifier (Op-Amp)

Circuit symbol
The meaning of inverting and non-inverting inputs
Output voltage, $V_o = A(V_+ - V_-)$

where

V_0 is the output terminal voltage

V_+ is the non-inverting input terminal voltage

V_- is the inverting input terminal voltage

A is the open-loop voltage gain

- Properties of Op-Amp (Ideal)
    - Voltage gain (open-loop)
    - Input resistance
    - Output resistance
    - Bandwidth
- Identification of pins using data sheet of 741 IC.
- Comparison of properties between ideal and real Op-Amps

Characteristics of Op-Amp at open-loop mode

- Maximum possible input voltage difference for linear mode operation
- Linear and saturation regions

Necessity of negative feedback

Golden rules

Expression for output voltage of Op-Amp

- Inverting amplifier, $V_o \qquad (\frac{R_f}{R_i})V_i$
- Non-inverting amplifier, $V_o \quad (\frac{R_i \quad R_f}{R_i})V_i$

    R_f is the feedback resistance

    R_i is the external input resistance

Uses of Op-Amp

- as a switch
- as an amplifier (inverting and non-inverting)
- unity gain amplifier
- voltage comparator

Suggested learning - teaching activities:

Introduce integrated circuit.

Name the chips as

SSI (Small Scale Integrated circuits); approximately less than 10^2 transistors

MSI (Medium Scale Integrated circuits); approximately 10^2-10^3 transistors

LSI (Large Scale Integrated circuits); approximately 10^3-10^5 transistors

VLSI (Very Large Scale Integrated circuits); approximately 10^5-10^6 transistors

Advantages of using ICs.

Numbering pins of ICs.

Introduce Operational Amplifier (Op-Amp)

Describe characteristics of Op-Amp at open- loop mode.

Explain the meaning of inverting and non-inverting inputs

Introduce linear and saturation regions

Describe the relationship between input and output voltages.

$V_0 \quad A(V \quad V\ )$

Explain the properties of ideal Op-Amp

Input resistance is infinite

Output resistance is zero.

Voltage gain is infinite.

Bandwidth is infinite.

Explain the necessity of feedback to control the output voltage.

Explain the closed loop state of the Op-Amp.

Introduce Golden Rules I and II.

Derive the expressions for output voltage of inverting and non-inverting amplifiers.

$$V_o \qquad (\frac{R_f}{R_i})V_i$$

$$V_o \quad (\frac{R_i \quad R_f}{R_i})V_i$$

Obtain the equation for voltage gain.

Explain the identification of numbering pins, use of pin connections and circuit symbol of Op-Amp using the data sheet - 741 IC

Explain the uses of Op-Amp

as a switch

as an amplifier (inverting and non-inverting)

unity gain amplifier

voltage comparator

Direct students to solve problems related to Op-Amp.

Laboratory practical:

Investigating the performance of inverting and non-inverting amplifier

Competency level 9.4: Uses logic gates to control the action of digital circuits.

No. of periods **:** 06

Learning outcomes:

Students will be able to

- write Boolean expression and truth table of AND, OR, NOT, NAND, NOR, Ex-OR, and Ex-NOR logic gates.
- develop logic expressions for simple digital logic circuits having two or three inputs.
- convert given logic expressions into logic circuits and truth tables.
- design simple logic circuits to suit given conditions.
- explain single memory element with NAND/NOR gates.
- describe basic SR (Set-Reset) flip-flop (bistable).

Guidelines:

- Difference between analogue and digital signals
- Logic state using binary numbers
- Representation of binary numbers with voltage levels.
- Basic logic gates (maximum of three inputs)
  - AND, OR, NOT, NAND, NOR, Ex-OR and Ex-NOR logic gates
    - Symbol
    - Truth table
    - Boolean expressions
- Conversions among truth table, logic circuit and Boolean expression.
- Designing simple logic circuits for given conditions (maximum of 6 logic gates)
- Electronic memory
- Single memory element with NAND / NOR gates
- Basic SR flip-flop (bistable)

Suggested learning - teaching activities:

- Differentiate analogue and digital signals using graphical representation.
  e.g. Analogue signals – voltage obtained from a microphone
  Digital signals – rectangular wave output from a signal generator
- Discuss the advantages of using binary numbers in digital electronics.

Represent binary numbers with voltage levels.

Represent some digital signals using two different voltage levels.

Convert the decimal numbers into binary numbers.

Introduce the basic logic gates AND, OR, NOT, NOR, NAND, Ex-OR, Ex-NOR.

Give symbols, Boolean expressions and truth tables of each logic gate.

Identify the pins of IC corresponding to the terminals of a gate, using the data sheet.

Mention logic IC families.

- TTL (Transistor-Transistor Logic circuit)
- CMOS (Complimentary Metal Oxide Semiconductor logic circuit)

Build up the following gates

- OR, AND (using diodes)
- NOT (using transistors)

Obtain the truth table for a given Boolean expression.

Write down the Boolean expression for a given truth table.

Design the logic gate circuit for a given truth table.

Obtain the truth table for a given logic gate circuit.

Write down a Boolean expression for a given logic circuit.

Design logic gate circuits for a given Boolean expression.

Design simple logic circuits to fulfil given needs.(maximum of 6 logic gates)

Distinguish between sequential logic circuits and combinational logic circuits.

Describe the flip-flop using NAND or NOR gates (S-R flip-flop)

Introduce the flip-flop as a circuit in which the output does not depend only on the current state of inputs but also on the previous inputs.

Describe the action of S-R flip-flop using the truth table.

Draw the timing diagram for S-R flip-flop.

Discuss the application of S-R flip-flop as a memory element.

Laboratory practical:

Investigating the truth tables of basic logic gates and simple applications.

Unit 10: Mechanical Properties of Matter

Competency 10.0 : **Applies the knowledge on mechanical properties of matter quantitatively in scientific activities and daily pursuits.**

Competency level 10.1 : **Selects relevant materials for scientific work and day-to-day needs in life using the knowledge of elasticity**.

No of periods : 10

Learning outcomes:

Students will be able to

- distinguish between elastic and inelastic materials
- define the terms stress, strain and Young's modulus
- explain the behavior of materials based on stress-strain graph
- determine the Young's modulus of a metal wire using the load-extension graph
- give an expression for energy stored in a string / a spring under a stress
- do calculations related to elasticity

Guidelines:

- Elastic and inelastic materials
- Tension and extension
- Defining tensile/compressive stress, tensile/compressive strain and Young's modulus, $E \quad \frac{F/A}{e/l}$
- Explaining the following facts using stress-strain graph
  - Proportional limit
  - Elastic limit
  - Yield point
  - Breaking point
  - Distinguish between ductile and brittle materials
- Presenting Hooke's law for the proportional limit
- Determining Young modulus of a metal using the load-extension graph
- Presenting the energy stored in a string / a spring under a stress as $\frac{1}{2}Fe$ or $\frac{1}{2}ke^2$
- Force built up due to change in temperature of clamped rods and strings

  $F \quad EA$

Suggested learning-teaching activities

Distinguish between elastic and inelastic materials

Demonstrate the variation of extension with load of a rubber wire / a helical spring

Define tensile / compressive stress, tensile / compressive strain and Young modulus

Explain the following properties using the stress-strain graph

- Proportional limit
- Elastic limit
- Yield point
- Breaking point
- Differentiating between ductile and brittle materials

Present Hooke's law for the proportional limit.

Introduce force constant (*k*).

Direct students to conduct experiments to determine Young's modulus of a metal wire using the load-extension graph.

Demonstrate the energy is stored in a string / a spring under a stress and deduce the expression for the energy as $\frac{1}{2}Fe$ or $\frac{1}{2}ke^2$

Obtain an expression for force built up due to change in temperature of clamped rods and strings

$$F \quad EA$$

Direct students to solve simple numerical problems related to elasticity of solids

Discuss various applications of elasticity of day-to-day life

Laboratory practical:

Determination of Young's modulus of a metal using a wire

Competency level 10.2: **Uses the knowledge on viscosity in scientific work and daily pursuits.**

No of periods: 10

Learning outcomes:

Students will be able to

- explain the steady and turbulent flows using diagrams.
- relate tangential stress and velocity gradient for a liquid flow.
- write Poiseuille's formula for a liquid flow.
- conduct experiment to determine coefficient of viscosity of water by capillary flow method.
- explain terminal velocity using $v - t$ graph of a body moving through a viscous media .
- solve simple numerical problems related to viscosity.

Guidelines:

- Steady flow
- Laminar flow
- Turbulent flow
- Newton's equation, $\frac{F}{A} \quad \frac{dv}{dx}$
- Definition of coefficient of viscosity
- Poiseuille's formula, $\frac{V}{t} \quad \frac{a^4 p}{8 \quad l}$
  - condition of validity
  - verification of correctness using dimensions
- Determination of coefficient of viscosity by capillary flow method
- Motion of an object through viscous media
  - forces acting on the object
  - *v-t* graph for the motion
  - terminal velocity
- Stokes' law, $F \quad 6 \quad av$
  - condition of validity
  - verification of correctness using dimensions

Derivation of expressions for terminal velocity for

object moving upward

object moving downward

through a fluid under gravity

Comparison of coefficient of viscosity of different liquid using Stokes' / Poiseuille's method.

Change of viscosity according to the temperature.

Applications of viscosity.

Suggested learning - teaching activities

Explain steady and turbulent flows.

Introduce velocity gradient between two close liquid layers in laminar flow.

Give the relation $\frac{F}{A} \quad \frac{dv}{dx}$ for laminar flow of a liquid and mention it as Newton's equation.

Define coefficient of viscosity and give the units and dimension.

Give Poiseuille's formula for the steady flow of a liquid through a narrow horizontal tube with uniform cross section, $\frac{V}{t} \quad \frac{a^4 p}{8 \; l}$.

Show the correctness of the formula using dimensions.

Direct the student to conduct experiment to determine coefficient of viscosity of water by capillary flow method.

Discuss the motion of a spherical object through viscous media highlighting,

forces acting on the object

$v - t$ graph for the motion

terminal velocity

State Stokes' law with validity conditions, F 6 av

Show the correctness of the formula using dimensions.

Describe an expression for terminal velocity of a small spherical object moving through viscous media.

Describe methods of comparing coefficient of viscosity of different liquid using Stokes' / Poiseuille's method.

Show how the viscosity changes with temperature.

Discuss applications of viscosity.

Laboratory practical:

Determination of coefficient of viscosity by using Poiseuille's formula

Competency level 10.3: Uses the knowledge on surface tension to explain the natural phenomena and to fulfil the daily pursuits.

No of periods : 12

Learning outcomes:

Students will be able to

demonstrate the behaviour of free surface of a liquid using simple activities

describe the angle of contact with the help of diagrams.

explain capillary rise using surface tension phenomena.

derive an expression for pressure difference across spherical meniscus in terms of surface tension and the radius of the meniscus.

derive an expression for capillary rise in terms of surface tension, angle of contact and radius of the meniscus.

explain the relationship between surface energy and surface tension

conduct experiments to determine surface tension by capillary rise method and Jaeger's method

solve problems related to surface tension.

Guidelines:

Behaviour of free surface of liquid in terms of inter – molecular forces

Definition of surface tension

Angle of contact

Free surface energy

Expression for the work done in increasing the surface area of a liquid film isothermally

Relationship between free surface energy and surface tension

Expression for pressure difference across spherical meniscus, $\frac{2T}{r}$

Expression for excess pressure inside a soap bubble, $\frac{4T}{r}$

Expression for capillary rise, $\frac{2T\cos}{r} \quad h \quad g$

Determination of surface tension

using microscopic slide

using a soap film on a frame

capillary rise method

Jaeger's method

Applications of surface tension

Suggested learning - teaching activities:

Demonstrate the behaviour of free surface of liquid using simple activities.

Explain the behaviour of free surface of liquid using inter-molecular forces.

Explain cohesive forces and adhesive forces.

Define surface tension.

Relate the nature of a liquid meniscus with angle of contact.

Explain the capillary rise and capillary depression using surface tension phenomena.

Give expression for work done in increasing the surface area of a liquid film isothermally.

Relate surface energy and surface tension.

Derive an expression for pressure difference across a spherical meniscus, $\frac{2T}{r}$.

Deduce an expression for excess pressure inside a soap bubble, $\frac{4T}{r}$

Derive an expression for capillary rise, $\frac{2T\cos}{r} \quad h \quad g$

using pressure difference method

using force equilibrium method

Direct the students to determine surface tension by direct methods

using microscopic slide

using soap film on a frame

Direct the students to determine surface tension by

capillary rise method

Jaegar's method

Direct students to solve problems related to surface tension.

Discuss applications of surface tension.

Laboratory practical:

Determination of surface tension

using microscopic slide

using a soap film on a frame

capillary rise method

Jaegar's method

Unit 10: Mechanical Properties of Matter

Competency 10.0 : **Applies the knowledge on mechanical properties of matter quantitatively in scientific activities and daily pursuits.**

Competency level 10.1 : **Selects relevant materials for scientific work and day-to-day needs in life using the knowledge of elasticity**.

No of periods : 10

Learning outcomes:

Students will be able to

- distinguish between elastic and inelastic materials
- define the terms stress, strain and Young's modulus
- explain the behavior of materials based on stress-strain graph
- determine the Young's modulus of a metal wire using the load-extension graph
- give an expression for energy stored in a string / a spring under a stress
- do calculations related to elasticity

Guidelines:

- Elastic and inelastic materials
- Tension and extension
- Defining tensile/compressive stress, tensile/compressive strain and Young's modulus, $E \quad \frac{F / A}{e / l}$
- Explaining the following facts using stress-strain graph
  - Proportional limit
  - Elastic limit
  - Yield point
  - Breaking point
  - Distinguish between ductile and brittle materials
- Presenting Hooke's law for the proportional limit
- Determining Young modulus of a metal using the load-extension graph
- Presenting the energy stored in a string / a spring under a stress as $\frac{1}{2}Fe$ or $\frac{1}{2}ke^2$
- Force built up due to change in temperature of clamped rods and strings
  $F \quad EA$

Suggested learning-teaching activities

Distinguish between elastic and inelastic materials

Demonstrate the variation of extension with load of a rubber wire / a helical spring

Define tensile / compressive stress, tensile / compressive strain and Young modulus

Explain the following properties using the stress-strain graph

- Proportional limit
- Elastic limit
- Yield point
- Breaking point
- Differentiating between ductile and brittle materials

Present Hooke's law for the proportional limit.

Introduce force constant (k).

Direct students to conduct experiments to determine Young's modulus of a metal wire using the load-extension graph.

Demonstrate the energy is stored in a string / a spring under a stress and deduce the expression for the energy as $\frac{1}{2}Fe$ or $\frac{1}{2}ke^2$

Obtain an expression for force built up due to change in temperature of clamped rods and strings

$$F \quad EA$$

Direct students to solve simple numerical problems related to elasticity of solids

Discuss various applications of elasticity of day-to-day life

Laboratory practical:

Determination of Young's modulus of a metal using a wire

Competency level 10.2: **Uses the knowledge on viscosity in scientific work and daily pursuits.**

No of periods: 10

Learning outcomes:

Students will be able to

explain the steady and turbulent flows using diagrams.

relate tangential stress and velocity gradient for a liquid flow.

write Poiseuille's formula for a liquid flow.

conduct experiment to determine coefficient of viscosity of water by capillary flow method.

explain terminal velocity using $v - t$ graph of a body moving through a viscous media .

solve simple numerical problems related to viscosity.

Guidelines:

Steady flow

Laminar flow

Turbulent flow

Newton's equation, $\frac{F}{A} \quad \frac{dv}{dx}$

Definition of coefficient of viscosity

Poiseuille's formula, $\frac{V}{t} \quad \frac{a^4 p}{8 \ l}$

condition of validity

verification of correctness using dimensions

Determination of coefficient of viscosity by capillary flow method

Motion of an object through viscous media

forces acting on the object

v-t graph for the motion

terminal velocity

Stokes' law, $F \quad 6 \quad av$

condition of validity

verification of correctness using dimensions

Derivation of expressions for terminal velocity for

object moving upward

object moving downward

through a fluid under gravity

Comparison of coefficient of viscosity of different liquid using Stokes' / Poiseuille's method.

Change of viscosity according to the temperature.

Applications of viscosity.

Suggested learning - teaching activities

Explain steady and turbulent flows.

Introduce velocity gradient between two close liquid layers in laminar flow.

Give the relation $\frac{F}{A} \quad \frac{dv}{dx}$ for laminar flow of a liquid and mention it as Newton's equation.

Define coefficient of viscosity and give the units and dimension.

Give Poiseuille's formula for the steady flow of a liquid through a narrow horizontal tube with uniform cross section, $\frac{V}{t} \quad \frac{a^4 p}{8 \;\, l}$.

Show the correctness of the formula using dimensions.

Direct the student to conduct experiment to determine coefficient of viscosity of water by capillary flow method.

Discuss the motion of a spherical object through viscous media highlighting,

forces acting on the object

$v - t$ graph for the motion

terminal velocity

State Stokes' law with validity conditions, $F \quad 6 \quad av$

Show the correctness of the formula using dimensions.

Describe an expression for terminal velocity of a small spherical object moving through viscous media.

Describe methods of comparing coefficient of viscosity of different liquid using Stokes' / Poiseuille's method.

Show how the viscosity changes with temperature.

Discuss applications of viscosity.

Laboratory practical:

Determination of coefficient of viscosity by using Poiseuille's formula

Competency level 10.3: Uses the knowledge on surface tension to explain the natural phenomena and to fulfil the daily pursuits.

No of periods : 12

Learning outcomes:

Students will be able to

demonstrate the behaviour of free surface of a liquid using simple activities

describe the angle of contact with the help of diagrams.

explain capillary rise using surface tension phenomena.

derive an expression for pressure difference across spherical meniscus in terms of surface tension and the radius of the meniscus.

derive an expression for capillary rise in terms of surface tension, angle of contact and radius of the meniscus.

explain the relationship between surface energy and surface tension

conduct experiments to determine surface tension by capillary rise method and Jaeger's method

solve problems related to surface tension.

Guidelines:

Behaviour of free surface of liquid in terms of inter – molecular forces

Definition of surface tension

Angle of contact

Free surface energy

Expression for the work done in increasing the surface area of a liquid film isothermally

Relationship between free surface energy and surface tension

Expression for pressure difference across spherical meniscus, $\frac{2T}{r}$

Expression for excess pressure inside a soap bubble, $\frac{4T}{r}$

Expression for capillary rise, $\frac{2Tcos}{r} \quad h \quad g$

Determination of surface tension

- using microscopic slide
- using a soap film on a frame
- capillary rise method
- Jaeger's method

Applications of surface tension

Suggested learning - teaching activities:

Demonstrate the behaviour of free surface of liquid using simple activities.

Explain the behaviour of free surface of liquid using inter-molecular forces.

Explain cohesive forces and adhesive forces.

Define surface tension.

Relate the nature of a liquid meniscus with angle of contact.

Explain the capillary rise and capillary depression using surface tension phenomena.

Give expression for work done in increasing the surface area of a liquid film isothermally.

Relate surface energy and surface tension.

Derive an expression for pressure difference across a spherical meniscus, $\frac{2T}{r}$.

Deduce an expression for excess pressure inside a soap bubble, $\frac{4T}{r}$

Derive an expression for capillary rise, $\frac{2T\cos}{r} \quad h \quad g$

- using pressure difference method
- using force equilibrium method

Direct the students to determine surface tension by direct methods

- using microscopic slide
- using soap film on a frame

Direct the students to determine surface tension by

- capillary rise method
- Jaegar's method

Direct students to solve problems related to surface tension.

Discuss applications of surface tension.

Laboratory practical:

Determination of surface tension

- using microscopic slide
- using a soap film on a frame
- capillary rise method
- Jaegar's method

Unit 11: Matter and Radiation

Competency 11.0 : **Inquires the modern theories in physics**

Competency level 11.1 : Applies the quantum theory to explain the intensity distribution of black body radiation.

Number of periods : 04

Learning outcomes:

Students will be able to

explain the thermal radiation.

explain the black body radiation, Stefan's law and the intensity distribution of black body radiation.

describe the modification of the Stefan’s law for non-black body radiation.

describe the failure of classical physics in explaining the black body radiation.

describe Planck’s hypothesis using the appropriate terms.

Guidelines:

Thermal radiation, black body radiation, black body, characteristics of black body radiation

Stefan’s law, Stefan’s law for non-black bodies,

$E \quad T^4$, $E \quad\quad T^4$

Intensity distribution curve of a black body against wavelength, the important features in the curve

Wien’s displacement law, $_m T \quad C$

The failure of classical physics in black body radiation - efforts made by Raleigh-Jean & Wien to explain the intensity distribution curve based on the classical concepts.

Plank’s hypothesis and his approach to explain the black body radiation.

Suggested learning - teaching activities:

Explain the thermal radiation and its range (1 µm - 1 mm) and mention that it is based on the infrared radiation (*IR*) with suitable examples.

Explain the black body radiation, black body, characteristics of black body radiation using a diagram of a model black body.

Explain Stefan's law, $E \quad T^4$.

Explain modification of Stefan's law for non-black bodies, $E \quad T^4$ where is the surface emissivity of the body.

Explain the intensity distribution curve of a black body against wavelength and describe the important features in the curve.

Explain the Wien's displacement law, $_{m}T \quad C$ (C = 2.89 x 10^{-3} m K).

Solve problems using Stefan's law and Wien's displacement law.

Explain the failure of classical physics in black body radiation - efforts made by Raleigh-Jean and Wien to explain the intensity distribution curve based on the classical concepts comparing with the experimental results.

Explain Planck's hypothesis and his approach to explain the black body radiation.

Competency level 11.2: **Applies the quantum theory to explain the photoelectric effect.**

Number of periods : 04

Learning outcomes:

Students will be able to:

explain the phenomenon of photoelectric effect using photoelectric effect experiment.
describe the threshold frequency (or cutoff frequency) and work function.
introduce the stopping potential and able to relate this stopping potential with maximum kinetic energy of photoelectrons.
explain the difficulty of understanding the results of the photoelectric effect with classical physics.
explain Einstein's photoelectric equation by introducing its terms.
explain that the photoelectric effect could be explained through quantum properties.

Guidelines:

Photoelectric experiments and their results using the graphs of

I vs V (constant frequency and different intensities)
I vs V (constant intensity and different frequencies)
I vs V (constant intensity, constant frequencies and different materials)
V_S vs f (for different target materials)

The threshold frequency (or cutoff frequency)

The stopping potential and the maximum kinetic energy of photoelectrons,

$K_{max} \quad eV_S$

$$eV_s \quad \frac{1}{2}mv_{max}^2$$

Hypothesis put forward by Einstein

The work function of a metal

Einstein's photoelectric equation, $K_{max} \quad hf$

Relationship between work function and threshold frequency, hf_o

Uses of Einstein's photoelectric equation to find the work function of a material.

Suggested learning - teaching activities:

Describe the photoelectric effect phenomenon which was identified in 1887 by Heinrich Hertz.

Describe different experiments done on Photoelectric effect and explain the features observed in these experiments using the following graphs

Photoelectric current (I) versus accelerated potential (V) for different intensities ($I_1 < I_2 < I_3$) of monochromatic light of wavelength .

Photoelectric current (I) versus accelerated potential (V) for monochromatic light of same intensity but of different wavelengths ($_1 >$ $_2 >$ $_3$)

Photoelectric current (I) versus accelerated potential (V) for different target material (K, Na, Zn) when illuminated by a particular monochromatic light of wavelength with constant intensity.

Stopping potential versus frequency, for different target materials (K, Na, Zn).

Define and explain the threshold frequency (f_0) and the stopping potential (V_s) from the investigation performed through photoelectric experiments.

State the Einstein's hypothesis to explain the photoelectric effect.

Introduce the Einstein photoelectric equation, and explain its each term

$$K_{\max} \quad hf$$

where hf is the energy of the each incident photon of frequency, f,

is the work function of the material and

$K_{\max}$ is the maximum kinetic energy of the emitted electron

Explain the observations drawn from detailed investigations of the photoelectric effect based on the above hypothesis.

Explain that the threshold frequency (f_0) is determined by the work function ( ) when $V_{\max} = 0$, so that

$$hf_0$$

Explain that if V_S is the stopping potential then the work done by an electron in moving against the stopping potential is eV_S,

$$eV_S \quad hf$$

Show that the Einstein photoelectric equation could be written in the following form,

$$V_S \quad \frac{h}{e} f \quad \frac{\ }{e}$$

and the value for Planck's constant (*h*), and the work function ( ) can be obtained by the gradient and the intercept of the graph of V_s verses *f*.

Competency level 11.3: Inquiries about wave particle duality.

Number of periods: 02

Learning outcomes:

Students will be able to

- give evidence about wave nature of matter.
- relate the concept that any particle of momentum *p* has an associated wavelength called the de Broglie wavelength.
- apply the de Broglie hypothesis for determination of the de Broglie wavelength of matter waves associated with a moving particle.
- explain the principle of electron microscope.

Guidelines:

- Properties of a wave.
- Wave nature of particle
- The de Broglie hypothesis and the associated de Broglie wavelength ($\frac{h}{p} \quad \frac{h}{mv}$).
- The principle of electron microscope
  (details not needed).

Suggested learning - teaching activities:

- Describe the discovery of electron diffraction by Davisson and Germer.
- Explain the de Broglie hypothesis and associated equation describing the de Broglie wavelength for a particle having mass of *m*, its velocity *v* and its momentum *p,*

$$\frac{h}{p} \quad \frac{h}{mv}$$

  where *h* is the Planck's constant. (h 6.635 10 ^{34} J s)
- Explain the principle of electron microscope.
- Explain that the resolving power can be increased by accelerating an electron beam with a wavelength shorter than that of visible light.

Competency level 11.4: Uses X-rays to fulfil human needs.

Number of periods : 02

Learning outcomes:

Student will be able to

explain the discovery of X-rays

describe the method of production of X-rays

explain the properties of X-rays

explain how X-rays can be used in different fields (medical, industrial, etc….).

Guidelines:

Discovery of X-rays

Production of X- rays

Properties of X-rays

Uses of X- rays in different fields.

Suggested learning - teaching activities:

Explain the discovery of X-rays.

Explain the production of X- rays.

Introduce the important parts in the X-ray tube and clearly state their use in the X-rays production.

Explain the X-ray region in the electromagnetic spectrum $(0.05\ \mathring{A}$ to $10^{6}\ \mathring{A})$.

Explain the hard X-rays and soft X-rays and their penetrating power.

Explain that the energy (*E*) of an X-ray photon is related to its frequency (*f*) [or wavelength ( )] in the same way as for photons of light

$$E \quad hf \quad \frac{hc}{\ }$$

where *h* is Plank's constant and *c* is the velocity of light

Explain the important properties possessed by X-rays.

Explain the use of X-rays in the following fields.

medicine

industry

scientific research

examining the luggage for illegal or dangerous materials/weapons at airports, customs etc.

Competency level 11.5: Inquires about radioactivity to fulfil human needs.

**Number of periods : ** 06

Learning outcomes:

Students will be able to

- explain the natural radioactivity and its properties.
- describe the radioactive decay, the radioactive disintegration law and the graph.
- explain the decay constant, activity and half-life time.
- explain the use of radioactivity in medicine, industry, agriculture and radioactive dating.
- explain the background radiation, the health hazards and safety precautions.

Guidelines:

- Discovery of radioactivity
- Natural radioactive decay
    - emission of α-particles
    - emission of β -particles
    - emission of γ-rays
- Properties of α-particles, β -particles and γ-rays
- Radioactive disintegration law ($N \quad N_0 e^{\quad t}$) and its graphical representation
- Decay constant (   ), activity (A) and half-life ($T_{1/2}$)
- Units of activity, (Bq , Ci).
- Use of radioactivity in medicine, industry, agriculture and radioactive dating with examples.
- Measurements used in radiation.
- Health hazards of radiation and its safety precautions.

Suggested learning - teaching activities:

Explain the Becquerel's discovery of spontaneous emission of radiation from nuclei as radioactivity.

Explain the emission of α-particles, β-particles and γ-rays and mention that there are two types of β-particles.

Explain the properties of α-particles, β-particles and γ-rays.

Introduce natural radioactive elements such as Uranium, Polonium and Radium.

Describe the radioactive decay; α, β, γ decay with examples.

$^{A}_{Z}X$ $\quad$ $^{A-4}_{Z-2}Y$ $\quad$ $^{4}_{2}$ $\quad$ energy

$^{238}_{92}U$ $\quad$ $^{234}_{90}Th$ $\quad$ $^{4}_{2}He$ $\quad$ energy

There are two types of -decay; - decay and - decay. Energy is also released in the process and called disintegration energy.

$^{A}_{Z}X$ $\quad$ $^{A}_{Z+1}Y$ $\quad$ $^{0}_{1}$ $\quad$ energy

$^{14}_{6}C$ $\quad$ $^{14}_{7}N$ $\quad$ $^{0}_{1}$ $\quad$ $\bar{}_{e}$ $\quad$ energy

$^{A}_{Z}X$ $\quad$ $^{A}_{Z-1}Y$ $\quad$ $^{0}_{1}$ $\quad$ energy

$^{11}_{6}C$ $\quad$ $^{11}_{5}B$ $\quad$ $^{0}_{+1}$ $\quad$ $_{e}$ $\quad$ energy

In -decay nucleus merely goes from an excited state to a less excited state by the emission of -rays or -ray photons to become a stable nuclei.

During -decay, the mass number and the atomic number of the nucleus does not change, so the parent and daughter atoms are the same element.

$^{A}_{Z}X^{*}$ $\quad$ $^{A}_{Z}Y$

$^{12}_{5}B$ $\quad$ $^{12}_{6}C^{*}$ $\quad$ $^{0}_{-1}$

$^{12}_{6}C^{*}$ $\quad$ $^{12}_{6}C$

where * is the exited state

Explain the radioactive disintegration law, $N \quad N_0 e^{\quad t}$

(solving numerical problems is not expected)

Describe the above equation using the graph of N versus t and mention the half-life.

Introduce decay constant ( ), activity (A) and half-life ($T_{1/2}$)

Explain the units of activity; curie (Ci), SI unit: becquerel (Bq).

State that, 1 Ci = 3.7 x 10^{10} decays in one second, 1Bq = 1 decay per second, and 1 Ci = 3.7 x 10^{10} Bq

Describe the use of radioactivity in medicine, industry, agriculture and radioactive dating with examples.

Explain the measurements used in radiation; the unit to measure the radiation dose (as energy per unit mass) called absorbed dose, its SI units – gray (Gy) i.e., a dose of 1 Gy means that each kilogram of object absorbs 1 joule of energy. Older units rad (radiation absorbed dose), 1 Gy = 1 J kg^{-1} = 100 rad.

Effective dose

Effective dose is used in considering the effect to biological things by various radiations.

Effective dose = *Radiation dose* x *Q-Factor*

Values of Q-Factor (Quality Factor) for several radiations are given below.

Radiation	Value of Q-Factor
, , X	1
n	5 - 20
	20

Quality Factor (Q-Factor) is also called Relative Biological Effectiveness (RBE)

Equivalent dose, the SI unit of equivalent dose for human is the Sievert (Sv), older unit is rem, 1 Sv = 100 rem.

Explain the health hazards of radiation.

Describe the safety precautions.

Explain the Giger-Muller counter.

Competency level 11.6: **Inquires about the nuclear energy and its uses.**

**Number of periods : ** 04

Learning outcomes:

Student will be able to

- identify the atomic structure, the nucleus, the isotopes, nuclear notation and the atomic mass unit.
- compare the energy released in chemical reactions and nuclear reactions.
- explain the nuclear fission and the process of chain reaction which may be controlled (nuclear power) or uncontrolled (atomic bomb)
- explain the nuclear fusion, its process, fusion reaction inside the sun/in other stars, and the production of elements

Guidelines:

- Atomic nucleus
  - Atomic structure,
  - Nucleus,
  - Isotopes,
  - nuclear notation as ($^{A}_{Z}\mathrm{X}$)
  - Atomic mass unit.
  - Einstein's mass-energy equation ($E = mc^2$)
  - Binding energy and graph of binding energy vs mass number
  - Stability of nucleus
  - Comparison of the energy released in chemical reactions and nuclear reactions.
- Nuclear Energy
  - Nuclear fission
    - chain reaction
      - controlled (nuclear reactor)
      - uncontrolled (atomic bomb)

Nuclear fusion

conditions necessary for fusion

fusion inside the sun

fusion in other stars and production of elements

attempts of using fusion for producing energy.

Suggested learning - teaching activities:

Review the basics of atomic structure, the nucleus, the isotopes, nuclear notation and the atomic mass unit.

Explain the mass-energy concept and the equation proposed by Einstein, $E = mc^2$.

Introduce binding energy and graph of binding energy verses mass number.

Explain the stability of nucleus.

Give the idea that the binding energy of nucleons are in the range of millions of eV compared to tens of eV for atomic electrons. Also compare the difference between the nuclear binding energy and the binding energy of an electron in an atom.

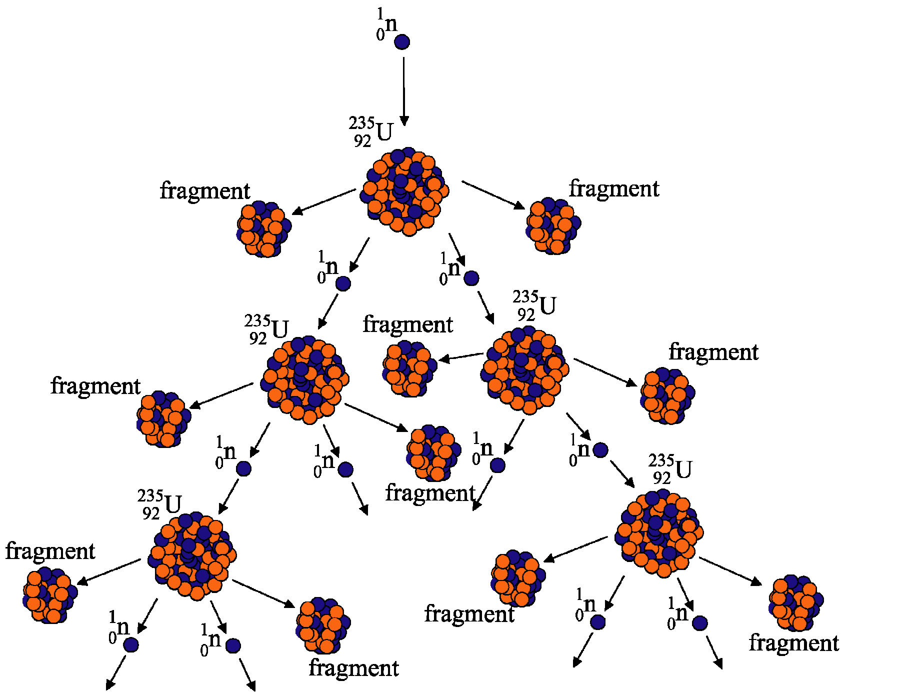
Describe the nuclear fission and the process of chain reaction.

A typical reaction

$$^{1}_{0}\mathrm{n} \quad ^{235}_{92}\mathrm{U} \qquad ^{236}_{92}\mathrm{U} \qquad ^{141}_{56}\mathrm{Ba} \quad ^{92}_{36}\mathrm{Kr} \quad 3\,^{1}_{0}n \qquad \text{energy}$$

Mention that most of the neutrons produced in the above reaction escapes from the piece of uranium $^{235}_{92}\mathrm{U}$.

Explain that if the mass of piece of uranium is greater than a certain critical size (critical mass), the emitted neutrons collide with other uranium atoms and chain reaction occurs.



A nuclear chain reaction

Mention that uncontrolled chain reaction occurs in a very short time in an atomic bomb explosion.

Explain that neutrons emitted in the above reaction can be controlled by neutron absorbers such as boron / iron rods. And that this process takes place in nuclear reactors, and also heat generated by the controlled reaction produces steam under high pressure and pressurized steam is used to run a turbine which operates a dynamo and generate electricity.

Explain the nuclear fusion, its process, fusion reaction inside the Sun and in other stars, the production of elements; the following are the basic reactions called the proton-proton cycle, occurs in the Sun with an abundance of hydrogen.

$$^1_1H \quad ^1_1H \quad ^2_1H \quad ^0_1e \quad \text{energy}$$

$$^1_1H \quad ^2_1H \quad ^3_2He \quad \text{energy}$$

$$^3_2He \quad ^3_2He \quad ^4_2He \quad ^1_1H \quad ^1_1H \quad \text{energy}$$

The Nuclear fusion process which fuels the Sun, (production takes place at the interior of the sun) have core temperatures around 15 million Kelvin. A reaction cycle yields about 25 M eV of energy.

Mention that nuclear fusion occurs at temperatures in excess of 10^8 K with light elements such as hydrogen whose nuclei fuse together and form heavier nuclei such as helium.