# Unit 2: MECHANICS (108 periods)

Mechanics is a branch of Physics concerned with the behaviour of physical bodies when subjected to forces or displacements and the subsequent effects of the bodies on their environment.

## General Unit Objectives

By the end of this unit, the learner should be able to:

- measure physical quantities accurately and express them to required number of significant figures.
- explain behaviour of objects in terms of their motion and forces acting on them.
- explain the state of fluids and equilibrium of systems.

## Sub-Unit 1: Physical Quantities and their Units

A physical quantity is a property that can be quantified by measurement such as mass, time, and length.

| Specific Objectives | Content |
|---|---|
| The learner should be able to:<br>• use the basic measuring instruments.<br>• state the basic (fundamental) physical quantities.<br>• state the basic SI units.<br>• define derived quantities.<br>• define dimensions of physical quantities.<br>• derive the dimensions of physical quantities.<br>• check the consistency of equations using dimensions.<br>• define scalar and vector quantities and mention examples of each<br>• add and subtract vectors using component method.<br>• find the resolved components of a vector in two perpendicular directions. | • Measuring instruments<br>• Physical quantities<br>• Fundamental<br>• SI units<br>• Derived quantities<br>• Dimensions of physical quantities:<br>• definition<br>• derivation<br>• Use of dimensions (Not to derive equations)<br>• Scalar and vector quantities<br>• Addition and subtraction of vectors<br>• Resolution of vectors in two perpendicular directions<br>• Numerical problems |

| | |
|---|---|
| • solve numerical problems. | |

**Suggested Teaching and Learning Strategies**

- Practically measure quantities using the measuring instruments.
- Practically estimate the value of a fraction of the smallest division.
- Demonstrate the use of vectors in day to day life experiences.

**Notes**

- Measuring instruments include:
  - Vernier calipers
  - Micrometer screw gauge
  - Meter rule
  - Measuring cylinder
  - Circular scales
  - Stop watches and clocks
  - Ammeters and voltmeters
  - Thermometers
- Emphasise the techniques of reading the scales accurately and proper recording.
- Express measured values to appropriate number of decimal places.
- Use of dimensions to derive equations is not required.
- Emphasise correct symbolic use of vector signs.
- It is useful to have knowledge of solutions to triangles; sine and cosine rules.

**Teaching/Learning Resources**

- Different types of measuring instruments
- Applications
- Tailoring
- Carpentry and joinery
- Building
- Industry

**Assessment**

- Project for making a metre rule, a protractor, a measuring cylinder, a vernier scale (use locally available materials)
- Correct notation for units
- Exercise on measuring using vernier calipers and a micrometer screw gauge
- Exercise on definition of terms and derivation of expressions involved

**Sub-Unit 2: Kinematics**

Kinematics is the branch of Physics which deals with the motion of bodies (objects) and systems (group of objects) without consideration of the forces that cause the motion.

| Specific Objectives | Content |
|---|---|
| The learner should be able to:<br>• define displacement, speed, velocity and acceleration.<br>• distinguish between speed and velocity.<br>• define uniform velocity and uniform acceleration.<br>• derive the equations of uniformly accelerated motion in a straight line.<br>• define uniform acceleration.<br>• draw and interpret different motion graphs.<br>• determine distance travelled and acceleration from a velocity-time graph.<br>• define acceleration due to gravity.<br>• measure acceleration due to gravity using different methods.<br>• define time of flight and range.<br>• calculate time of flight, maximum height and range.<br>• describe applications of projectile motion. calculate relative velocity and<br>• closest distance of approach.<br>• solve numerical problems. | • Motion in a straight line<br>• Displacement, speed, velocity and acceleration<br>• Distinction between speed and velocity<br>• Uniform velocity<br>• Equations of uniformity<br>• Uniform acceleration<br>• Motion graphs<br>• Distance travelled and acceleration<br>• Free fall<br>• Acceleration due to gravity<br>• Measurement of acceleration due to gravity<br>• Projectiles (Projectile motion on an<br>• inclined plane is beyond the scope)<br>• Time of flight, maximum height and range (range along a horizontal plane only)<br>• Applications of projectile motion<br>• Relative velocity and closest<br>• distance of approach (Only simple cases for relative velocity |

| | |
|---|---|
| | and closest distance of approach should be considered)<br>• Numerical problems |

**Suggested Teaching and Learning Strategies**

- Practical determination of acceleration due to gravity using the free fall methods.
- Demonstration of the projectile motion by throwing an object.
- Learner-based graphical methods.

**Notes**

- Real life examples should be used in solving problems using the equations of motion.
- Drawing of graphs should be a learner-based activity.
- Emphasise graphing techniques including use of workable scales.
- Use free fall methods.
- Simple cases only for projectile motion.
- Range along a horizontal plane only.
- Use vector approach and the analytical methods.
- Only simple cases for relative velocity and closest distance of approach should be considered.
- Knowledge of trigonometrical identities and of resolution of vectors is essential.
- Elementary differentiation and integration is necessary.
- Knowledge of cross and dot vector products is not required.
- Projectile motion on an inclined plane is beyond the scope.

**Teaching/Learning Resources**

- Ball
- Stop watch/stop clock
- Tape measure

- Trolleys
- Graph paper
- Ticker timer

**Applications**
Playing football (especially free kicks), military (artillery section), navigation (air and marine), speedometer, javelin, short put, speed guard, crossing roads and overtaking.

**Assessment**
- Drawing of velocity-time graphs and displacement-time graphs using information practically obtained by the learners
- Interpretation of graphs
- Calculations on projectiles, linear motion, relative velocity and distance of closest approach
- Definitions and derivations of equations of uniformly accelerated motion
- Experimental determination of acceleration due to gravity

**Sub-Unit 3: Newton's Laws of Motion**
These laws describe the relationship between the forces acting on a body and the subsequent motion caused by the forces.

| Specific Objectives | Content |
|---|---|
| The learner should be able to:<br>• define mass and inertia.<br>• define linear momentum and state its units.<br>• state the principle of conservation of momentum.<br>• describe some applications of momentum.<br>• state Newton's laws of motion.<br>• derive the relation F = ma.<br>• calculate resultant force in a physical situation .<br>• define impulse. | • Mass and inertia<br>• Linear momentum units<br>• Principle of conservation of momentum (cases of oblique collisions are not required)<br>• Applications of principle of conservation of momentum (treatment requiring use of coefficient of restitution is outside the scope of the syllabus)<br>• Newton's laws of motion |

| | |
|---|---|
| • state and verify the law of conservation of momentum for collisions along a straight line.<br>• distinguish between elastic and inelastic collisions.<br>• solve numerical problems. | • Resultant force, F = ma<br>• Concept of a Newton Resultant Force<br>• Concept of impulse<br>• Law of conservation of momentum<br>• Elastic and inelastic collisions<br>• Numerical problems |

**Suggested Teaching and Learning Strategies**

- Discuss Newton's laws of motion
- Demonstration of inertia using a paper card, a coin and an empty bottle.
- Demonstration of Newton's third law using colliding bodies.
- Guided discovery on derivation of F= Ma.

**Notes**

- Concept of gravitational mass and inertial mass should be clarified.
- Cases of oblique collisions are not required.
- Relationship between impulse and change in momentum is essential.
- Verify the law of conservation of momentum for collisions along a straight line using Newton's Third law.
- Treatment requiring use of coefficient of restitution is outside the scope of the syllabus.

**Teaching/Learning Resources**

- Trolleys, balls of the same size, coins, paper cards, empty bottles, ticker timer Applications
- Pool table game, table tennis, firing a bullet from a gun, rockets, seat belts, traffic accident scenes

**Assessment**

- Learners should design and carry out an experiment to verify the principle of conservation of linear momentum.

- Definition of terms, derivation of expressions involved and related calculations.

**Sub-Unit 4: Solid Friction**

Solid friction deals with forces opposing the relative sliding motion between two solid surfaces in contact.

| Specific Objectives | Content |
|---|---|
| The learner should be able to:<br>• define friction.<br>• investigate the factors that affect<br>• solid friction between surfaces.<br>• state the laws of solid friction.<br>• measure coefficients of static and kinetic friction.<br>• explain the laws of friction.<br>• describe some applications of solid friction.<br>• solve numerical problems. | • Solid friction<br>• Factors that affect solid friction<br>• Static and kinetic friction<br>• Coefficients of static and kinetic friction<br>• Laws of friction<br>• Explanation of laws of solid friction (Molecular theory explanation of solid friction required)<br>• Applications of solid friction<br>• Numerical problems |

**Suggested Teaching and Learning Strategies**

- Discuss the applications of solid friction in daily life.
- Practically
  - investigate of frictional forces using a wooden block, a pulley, masses and a scale pan.
  - determinate of the coefficient of limiting friction using an inclined plank and a block.
- Discuss methods of increasing and reducing friction (limiting and kinetic).

**Notes**

- Molecular theory explanation of solid friction required.
- Mention applications of friction in daily life.

**Teaching/Learning Resources**

Wooden blocks, pulleys, scale pans, plank or metre rule, beam balance and masses.

**Applications**

- Walking
- Lighting a match stick or firestone
- Applying brakes in a vehicle or bicycle
- Grinding
- Peeling
- Cutting

**Assessment**

- Learners should carry out an experiment to investigate the types of solid friction and determine the coefficient of solid friction (static and dynamic).
- Exercise on description of experiments to investigate the factors that affect solid friction between surfaces in contact.
- Exercise on stating and explaining the laws of friction, ways of reducing solid friction and its applications.

**Sub-Unit 5: Work, Energy and Power**

The application of a force on an object may result in motion of the object in the direction of the force through a specified distance in a given time. The energy supplied is used to do the work. The faster the work is done the more power is expended.

| Specific Objectives | Content |
|---|---|
| The learner should be able to:<br>• define work and energy.<br>• calculate work done from a force-distance graph.<br>• state the work-energy theorem.<br>• mention different types of energy.<br>• derive the expressions<br>$K.E = \frac{1}{2}mv^2$<br>$P.E = mgh$ | • Work and energy (work as a product of force and distance moved in direction of force and as a transfer of energy)<br>• Concept of work and energy<br>• Work done from a force-distance graph<br>• Work-energy theorem<br>• Types of energy |

| | |
|---|---|
| • describe different energy transformations in different situations.<br>• state the principle of conservation of energy.<br>• define conservative and non-conservative fields and forces and mention examples of them.<br>• define power.<br>• derive the expression P = F. V.<br>• solve numerical problems. | • Expressions for types of mechanical energy<br>• (kinetic energy due to explosive forces not required.)<br>• Transformation of energy<br>• Conservation of energy<br>• Conservative and non conservative fields and forces<br>• Concept of power<br>• Formulae for power<br>• Numerical problems |

**Suggested Teaching and Learning Strategies**

- Discuss the different forms of energy with the class.
- Prove the principle of conservation of energy using mechanical energy.
- Determine work and power practically by one running through a measured distance for a known time.
- Projects by learners for energy transformations.
- Mention many practical examples.
- Take field trips to power generating stations.
- Discuss how the law of conservation of energy applies to a body in free fall.

**Notes**

- 0 level knowledge of this sub-unit is essential.
- Proof of the principle of conservation of energy using mechanical energy is required.
- Kinetic energy due to explosive forces is not required.
- Work as a product of force and distance moved in the direction of a force and as a transfer of energy.
- Ample calculations should be given.

**Teaching/Learning Resources**

- Stop clock/stop watch, tape measure, bicycle dynamo, torch bulb, wires, electric motor, weights (loads), a model system engine, aluminium foil (to form a concave reflector).

**Applications**
- Production of electricity
- Windmills
- Engine
- Motors
- Loud speakers
- Solar energy
- Bicycle dynamo
- Bio mass and bio gas

**Assessment**
- Project for any energy transformation such as a model steam engine to lift a load, solar water heater and a solar concentrator
- Descriptions of energy converters
- Exercise on definitions, calculation and derivations involved.

**Sub-Unit 6: Statics**

Statics is a branch of mechanics concerned with the action of forces on a stationary body in equilibrium.

| Specific Objectives | Content |
|---|---|
| The learner should be able to:<br>• calculate the resultant of parallel forces.<br>• define moment of force.<br>• state the principle of moments.<br>• describe applications of principle of moments.<br>• define a couple.<br>• define the torque.<br>• calculate the work done by a couple.<br>• describe applications of couples. | • Parallel forces - resultant of parallel forces and couples<br>• Moment of a force<br>• Principle of moments<br>• Applications of principle of moments<br>• Couple<br>• Torque (T)<br>• Work done by a couple<br>• Applications of a couple<br>• Centre of gravity |

| | |
|---|---|
| • define centre of gravity.<br>• locate the centre of gravity of objects including a lamina of uniform thickness.<br>• describe applications of knowledge of centre of gravity.<br>• state the conditions for a rigid body to be in equilibrium under action of a number of coplanar forces.<br>• define density and relative density.<br>• measure the densities and relative densities of different materials.<br>• define pressure.<br>• derive the expression $P = h\rho g$ for pressure at a point in a fluid.<br>• describe applications of pressure in fluids.<br>• state Archimedes' principle.<br>• verify Archimedes' principle.<br>• state the law of floatation.<br>• describe applications of Archimedes' principle.<br>• solve numerical problems. | (Mathematical treatment of centre of mass is beyond the scope of the syllabus)<br>• Concept of centre of gravity<br>• Centre of gravity of objects<br>• Practical applications of knowledge of centre of gravity<br>• Coplanar forces equilibrium of forces and triangle of forces (Treatment of forces in different planes not required)<br>• Fluids in static equilibrium<br>• Density and relative density<br>• Measurement of density and relative density<br>• Pressure<br>• Expression for pressure in fluids of uniform density<br>• Applications of pressure in fluids<br>• Archimedes' Principle<br>• Verification of Archimedes' principle.<br>• Applications of Archimedes' principle. |

**Suggested Teaching and Learning Strategies**

- Emphasise a learner-based practical approach.
- Use different approaches to measure density.
- Demonstration of couples and coplanar forces.
- Practical verification of Archimedes Principle and law of floatation.
- Field trips to sites to observe hydraulic lifters.
- Guided discovery to derivation of expressions, description of principles and applications.
- Use of animations and video clips where applicable.

**Notes**

- Mathematical treatment of centre of mass is beyond the scope of the syllabus.
- Knowledge on solutions of triangles and resolution of forces is useful.
- Experimental determination of relative density of solids and liquids using various methods should be emphasised.
- Treatment of forces in different planes is not required.
- Mathematical treatment of the law of floatation is required.
- Use examples based on daily experience such as see-saw, beam balance, lever balance, ruler, timber and/or iron bars.
- $W=\tau\theta$
- Significance of knowledge of centre of gravity.
- The relationship between force and pressure in fluids should be brought out.
- Archimedes' Principle should be experimentally verified.
- Demonstration of coplanar forces in equilibrium is necessary.

**Teaching/Learning Resources**
- Seesaw, beam balance, lever balance, ruler, knife edge, plumb-line, retort stand, thread and some solid objects

**Applications**
- Seesaw, beam balance (weighing scale) stability in vehicles, steering wheel, water tap turning, opening doors and windows

**Assessment**
- Practically determining relative density of solids and liquids, verifying Archimedes' Principle and determining the centre of gravity of both regular and irregular objects.
- Project work to make a lever balance and a seesaw and use the seesaw to classify members in the class with similar masses.
- Experimental verification of the law of floatation.
- Exercise on description of application of pressure in fluids the principle of moments, definitions of terms involved, derivation of relevant expressions and calculations

**Sub-Unit 7: Fluid Flow**

Fluid flow is a branch of fluid mechanics that deals with fluids (gases and liquids) in motion. It is subdivided into:

– Aerodynamics (study of air and other gases in motion).

– Hydrodynamics (study of liquids in motion).

| **Specific Objectives** | **Content** |
|---|---|
| The learner should be able to:<br>• define streamlines, streamline flow and turbulent flow.<br>• derive the expression $A_1v_1 = A_2v_2$ for an incompressible fluid.<br>• derive Bernoulli's equation: $p+\frac{1}{2}\rho v^2+\rho gh = constant$<br>• state Bernoulli's principle.<br>• describe applications of Bernoulli's principle.<br>• describe experiments to measure fluid velocity.<br>• explain the design of aerodynamic shapes.<br>• define viscosity.<br>• describe the effects of viscosity on an object moving in a fluid.<br>• define the terms velocity gradient and coefficient of viscosity.<br>• derive Stokes' formula.<br>• derive the formula, $\frac{V}{t}=\frac{\pi p a^4}{8\eta l}$<br>• measure coefficient of viscosity of a liquid.<br>• explain effect of temperature on viscosity of liquids and gases using molecular theory.<br>• solve numerical problems. | • Streamline and turbulent flow<br>• Equation of continuity<br>• Bernoulli's Principle<br>– Derivation<br>• Statement of Bernoulli's principle<br>• Applications of Bernoulli's principle<br>• Measurement of fluid velocity<br>• Design of aerodynamic shapes<br>• Viscosity<br>• Effect of viscosity on motion in a fluid<br>• Velocity gradient and coefficient of viscosity<br>• Stokes' formula<br>• Poisseuille's formula<br>• Coefficient of viscosity of a liquid<br>• Effect of temperature on viscosity of liquids and gases<br>• Numerical problems |

## Suggested Teaching and Learning Strategies

- Demonstrate the following:
  - streamline and turbulent flow (may be done using digital technology).
  - Bernoulli's Principle by blowing a stream of air above a piece of paper.
  - determination of coefficient of viscosity (may be done using digital technology or web animations).
  - the effect of temperature on viscosity of liquids.
  - determination of the coefficient of viscosity.
  - the effect of temperature on viscosity of liquids.

**Notes**
- Applications should cover aerofoils and sprays among others.

**Teaching/Learning Resources**
- Paper to demonstrate the aerofoil lift
- Capillary and delivery tubes
- Funnel and a light ball to demonstrate Bernoulli's Principle

**Applications**
- Bunsen burner, filter pump, aerofoil lift in aircrafts, suction effect, sprays, ventri-meter, domestic water installation, spinning ball, carburetor for petrol engines and fuel injector for diesel engines

**Assessment**
- Demonstration on the coefficient of viscosity.
- Describing an experiment to distinguish between laminar flow and turbulent flow.
- Derivation of Stoke's Formula, Bernoulli's Principle, equation of continuity and Poisseuilli's Formula.
- Definitions of terms used and explanation of temperature effects on viscosity in liquids and gases using the molecular theory.

## Sub-Unit 8: Mechanical Properties of Matter

| Specific Objectives | Content |
|---|---|
| The learner should be able to:<br>• investigate the behaviour of a wire/spring under stress to bring | • Stress-strain curves for a stretched wire/spring (Include |

| | |
|---|---|
| out the concept of Hooke's law.<br>• state Hooke's law.<br>• explain the special features of a stress-strain curve.<br>• define and investigate ductility, brittleness, stiffness and strength of materials.<br>• define stress, strain and Young's Modulus.<br>• measure stress, strain and Young's Modulus.<br>• derive an expression for the work done during an extension or compression process of an elastic material.<br>• describe applications of deformation of solids.<br>• solve numerical problems. | necking, work hardening)<br>• Hooke's law<br>• Features of a stress- strain curve for a ductile material<br>• Investigate ductility, brittleness, stiffness and strength<br>• Stress, strain and Young's Modulus (Ignore bulk modulus and shear rigidity)<br>• Measurement of stress, strain and Young's Modulus<br>• Work done during an extension or compression process (area under a stress -strain curve)<br>• Elastic potential energy<br>• Applications<br>• Numerical problems |

**Suggested Teaching and Learning Strategies**

- Practically determine Young's Modulus and verify Hooke's law.
- Demonstrate elasticity using a rubber cord.
- Graphical representation and calculation of total work done in stretching an elastic material.
- Verify Hooke's law, practically, using various materials.

**Notes**

- Ignore shear (rigidity stress) and bulk modulus.
- Necking (breaking stress), work hardening, proportional limit, elastic limit, yield point and breaking point included.
- Emphasis should also be put on experimental determination of Young's Modulus.
- Comparison of behaviour of brittle, ductile and elastic materials and their applications.

**Teaching/Learning Resources**

- Spiral spring

- Rubber cord
- Retort stand
- Catapult
- Masses
- Meter rule
- Two thin and identical wires
- Micrometer screw gauge
- A glass rod

**Applications**

- Spring balance
- Catapult
- Sliding a carpet by moving a rack
- Force meter (as used in gyms)
- Selection of materials to use in construction and in manufacturing industries

**Assessment**

- Project of making a weighing scale using a spring or rubber.
- Graphical interpretation of results obtained from the experiment to verify Hooke's law.
- Exercise on definitions of terms, explanations of special features of a stress-strain curve and derivation of expressions involved.

## Sub-Unit 9: Surface Tension

This sub-unit deals with the effects that suggest that the surface of a liquid behaves as a stretched elastic skin that is, it is in a state of tension. For example, a steel needle will float if it is gently placed on the surface of water contained in a bowl despite its greater density.

| Specific Objectives | Content |
|---|---|
| The learner should be able to:<br>• define surface tension.<br>• explain surface tension in terms of molecular theory. | • Surface tension<br>• Molecular theory<br>• Common surface tension |

| | |
|---|---|
| • explain some common surface tension phenomena.<br>• derive an expression for the excess pressure inside a spherical bubble.<br>• define angle of contact.<br>• derive the expression $h = \frac{2\gamma \cos\theta}{\rho g r}$<br>• explain the phenomenon of capillary rise.<br>• measure surface tension.<br>• explain the factors that affect surface tension.<br>• describe some effects and applications of surface tension.<br>• solve numerical problems. | phenomena<br>• Pressure difference across a spherical surface<br>• Angle of contact<br>• Capillary rise<br>• Explanation of capillary rise<br>• Measurement of surface tension<br>• Factors that affect surface tension<br>• Effects of surface tension and applications of surface tension<br>• Numerical problems |

**Suggested Teaching and Learning Strategies**

- Practically demonstrate factors affecting surface tension and to measure surface tension and measurement of angle of contact.
- Guided discovery to derivation of the expression of excess pressure inside a spherical bubble and
- Measure surface tension and explain the factors affecting surface tension should be emphasised.
- Demonstrate different methods to measure surface tension.
- Demonstrate factors that affect surface tension.

**Notes**

- Emphasise simple phenomena, including angle of contact, capillary rise, and pressure difference across a spherical surface.
- The following are included:
  - cohesion and adhesion
  - liquid drop
  - tensional balance

**Teaching/Learning Resources**

- Capillary tubes
- Liquids such as water, oil
- Trough (basin or dish)
- Detergents
- Wire frames
- Thread
- Protractor

**Applications**

- Soldering: a good joint is formed only if the molten solder (a tin-lead alloy) melts and spreads over the metal involved
- Motion of insects on water surface
- Painting and spraying where the paint must not form drops but remain a layer once spread-out
- Lubrication of machines (surface tension assists oils to adhere to axles and bearings)
- Applied in umbrellas and other water proof objects
- Bubble machine
- Use of detergents in washing dirty items

**Assessment**

- The description for measuring the angle of contact and experiments to measure surface tension.
- Definitions of terms, derivation of expressions and calculations involved.

**Sub-Unit 10: Uniform Motion in a Circle**

This sub-unit deals with motion of objects in circular paths or moving in a curve about some point such as a bicycle or car turning round corners or racing cars going round circular tracks.

| Specific Objectives | Content |
|---|---|
| The learner should be able to: | |

| | |
|---|---|
| • define angular velocity.<br>• derive the expression $v = \omega r$.<br>• define centripetal and centrifugal forces.<br>• derive the expression $a = \frac{v^2}{r} = \omega^2 r$<br>• explain the equilibrium of forces in circular motion.<br>• identify the forces acting on a car moving round a circular track.<br>• explain the conditions for skidding by a car or a cyclist moving round a circular track.<br>• identify the forces acting on a car moving on a banked circular track.<br>• explain the advantage of banking a track for racing cars.<br>• derive the expression $\tan\theta = \frac{v^2}{rg}$ for a conical pendulum.<br>• describe some other applications of circular motion.<br>• define moment of inertia.<br>• derive the expression for rotational kinetic energy of a rigid body about an axis.<br>• distinguish between rotational kinetic energy and translational kinetic energy.<br>• solve numerical problems. | • Angular velocity<br>• Expression for<br>• velocityangular<br>• Acceleration and force in<br>• circular motion<br>• The expression $a = \frac{v^2}{r} = \omega^2 r$<br>• Motion of a bicycle rider, car around a circular track<br>• Forces in a circular track<br>• Conditions for skidding<br>• Banked tracks (with or without friction)<br>• Advantage of banking<br>• The conical pendulum<br>• Applications of circular<br>• motion<br>• Motion of rigid bodies (simple treatment)<br>• Moment of inertia<br>• Rotational kinetic energy<br>• Distinction between rotational kinetic energy and translational kinetic energy<br>• Numerical problems |

**Suggested Teaching and Learning Strategies**

- Practical whirl of an object to demonstrate motion in a circle either vertical or horizontal.
- Guided discovery to derive $a = \frac{v^2}{r} = \omega^2 r$; $v = \omega r$ and $\tan\theta = \frac{v^2}{rg}$

- Practically demonstrate the action of centrifuges.

**Notes**

- Use practical examples such as a bicycle rider, an object on a string whirled either vertically or horizontally.
- Simple treatment of banked tracks (with or without friction).
- Distinguish between centripetal and centrifugal forces.
- Introduce the radian measure.
- The following are included: a cycle rider, car moving on a circular track and motion in a vertical circle.
- Simple treatment of banked tracks (with and without friction).
- Simple treatment of rigid bodies.
- Rotational kinetic energy and moment of inertia should be emphasised.

**Teaching / Learning Resources**

- A string
- A pendulum bob
- Marbles
- Toy cars (model car)
- Ply wood/cardboard

**Applications**

- Banked tracks for racing cars
- Bicycles and cars turning round corners
- Ice skaters, ballet dancers, acrobats and drivers use the principle of angular momentum
- The earth and other planets moving around the sun
- Satellites moving round planets
- Roller coaster
- Rotor
- Looping the loop at an amusement park
- Centrifuge is used for training astronauts and in laboratories for separating liquids

**Assessment**

- Derivation of the expressions, definition of terms and calculations involved.
- Learners should demonstrate centripetal force using water in a bucket and whirled in a vertical plane without any water pouring out.

**Sub-Unit 11: Gravitation**

In gravitation you will deal with the motion of planets around the sun, communication satellites placed round the earth and moon satellites. It also discusses gravitational potential energy and its application to the escape velocity from planets.

| Specific Objectives | Content |
|---|---|
| The learner should be able to:<br>• state Kepler's laws.<br>• state Newton's law of gravitation.<br>• define gravitational field intensity.<br>• describe the principle of laboratory determination of the gravitational constant, G.<br>• derive the dimensions of G.<br>• derive Kepler's third law using Newton's law of gravitation.<br>• derive expressions for masses of sun and earth.<br>• explain the variation of g with latitude.<br>• explain weightlessness in a satellite.<br>• derive expressions for g above and below the earth's surface.<br>• define parking orbit.<br>• derive an expression for the period of a satellite in a parking orbit.<br>• define gravitational potential and velocity of escape. | • Kepler's laws<br>• Newton's law of gravitation<br>• Gravitational field intensity<br>• Laboratory determination of the gravitational constant, G<br>• Dimensions of G<br>• Derivation of Kepler's third law<br>• Masses of the earth and moon<br>• Variation of acceleration due to gravity, g, with latitude<br>• Weightlessness in a satellite<br>• Variation of acceleration due to gravity, g, with distance from the centre of the earth<br>• Orbits round the earth<br>• Parking orbits<br>• Expression for the period of a satellite in a parking orbit<br>• Variation of acceleration due to gravity, g, with distance from the centre of the earth<br>• Orbits round the earth<br>• Parking orbits |

| | |
|---|---|
| • derive expressions for:<br>• Gravitational potential and velocity of escape.<br>• Kinetic energy, potential energy and total energy of a satellite in the earth's orbit.<br>• explain the effect of friction on orbits of satellites.<br>• describe applicationsof<br>• communication satellites.<br>• solve numerical problems. | • Expression for the period of a satellite in a parking orbit<br>• Effect of friction on orbits of satellites<br>• Communication satellites<br>• Numerical problems |

**Suggested Teaching and Learning Strategies**

- Guided discovery on:
  - derivations of Kepler's third law from Newton's law of gravitation
  - dimensions of G.
  - expressions of the mass of the sun and the earth.
  - g above and below the earth's surface.
  - expression for the period of a satellite in a parking orbit, gravitational potential of a satellite.
  - relationship between potential energy, kinetic energy and total energy of a satellite in the earth's orbit.

**Notes**

- All cases should be supported by adequate examples and problems.
- Kepler's laws, Newton's law of gravitation and relation between G and g should be clearly brought out.
- Give a similarity between gravitational potential and electric potential (Analogy between gravity and electricity).

**Teaching / Learning Resources**

- Web animations and video clips
- Atlas

**Applications**

- Motion of planets around the sun, the moon, the earth and satellites around the earth.

**Assessment**

- Statement of Newton's law of gravitation
- Derivation of Kepler's third law
- Description of the laboratory determination of the gravitational constant
- Related calculations and derivations of related formulae
- Sketching variation of g with distance from the centre of the earth

**Sub-Unit 12: Simple Harmonic Motion**

This is one of the types of vibrations in day to day life. It is important because all other vibrations can be treated as if they are composed of simple harmonic vibrations. It is the way in which the acceleration of a body depends on its displacement and is directed towards the equilibrium position.

| Specific Objectives | Content |
|---|---|
| The learner should be able to:<br>• define simple harmonic motion (SHM).<br>• derive the expressions for acceleration, velocity and displacement in SHM.<br>• draw sketch graphs to show<br>– variation of displacement, velocity, acceleration and with time<br>– acceleration and force with displacement.<br>• verify that the resulting motion of a system, when slightly displaced, is SHM.<br>• derive expressions for period, T, in each of the cases above.<br>• determine acceleration due to | • Simple harmonic motion, (SHM)<br>• Expressions for acceleration, velocity and displacement in SHM<br>• Graphical representation of SHM<br>• Examples of SHM:<br>– simple pendulum<br>– floating cylinder<br>– liquid in a U-tube<br>– mass at the end of a vertical spring or a horizontal spring on a smooth surface<br>– mass at the end of a vertical string<br>– mass between two coupled springs on a smooth horizontal surface<br>– mass at the end of two coupled |

| | |
|---|---|
| gravity, g, using<br>• a simple pendulum.<br>• a loaded helical spring/rubber band.<br>• derive expressions for kinetic energy, potential energy and total energy in SHM.<br>• draw sketch graphs for kinetic energy, potential energy and total energy in SHM.<br>• describe the interchange of energy in SHM.<br>• describe situations where SHM is applied.<br>• solve numerical problems. | vertical springs<br>– mass at the end of two parallel vertical springs of the same spring constant.<br>• Expressions for period in SHM<br>• Determination of acceleration due to gravity, g using SHM methods<br>• Energy in SHM<br>• Graphical representation of energy in SHM<br>• Interchange of energy in SHM<br>• Applications of SHM<br>• Numerical problems |

**Suggested Teaching and Learning Strategies**

- Practical approach demonstrating examples of SHM.
- Experimental determination of g using SHM method.
- Guided discovery on derivations involved.
- Bring out relationship between SHM and circular motion, that is, use of motion of a body moving in a circle to derive the defining equation and other related equations.
- Verification of motions of the following being SHM when slightly displaced:
  - simple pendulum.
  - floating cylinder.
  - liquid in a U-tube.
  - mass at the end of a vertical and horizontal spring on a smooth surface.
  - mass between two coupled springs on a smooth horizontal surface.
  - mass at the end of two coupled vertical springs.
  - mass at the end of two parallel vertical springs.
- An experimental approach should be emphasised.
- Discuss limitations.
- Discuss the principle of conservation of energy in SHM.
- Emphasise the significance of the negative sign in the expressions for acceleration in SHM.

**Notes**

- Ignore the compound pendulum.
- Graphical representation of SHM is required.
- Total energy in SHM and applications are required.
- Treatment restricted to springs of the same spring constant.
- Treatment for elastic strings only for cases where a mass hangs at the end of the string(s).

**Teaching/Learning Resources**

- Pendulum bob
- Slotted masses
- Spiral springs
- U-tubes
- Cylinder
- Stop clock/stop watch
- Rubber bands
- Ruler
- Wire ring and a bead
- Watch glass and marble

**Applications**

- Shock absorbers in cars.
- Stop clocks/measuring instruments such as voltmeters, ammeters, galvanometers.
- Swings

**Assessment**

- Practical exercise on determination of acceleration due to gravity using SHM
- Identification of a simple harmonic motion
- Definitions of terms, derivation of expressions, calculations and practical applications of SHM