

PHY101 ELEMENTARY MECHANICS SUMMARY

Everything in the universe is in_____motion

Constant

The objects in the universe move relative to one another.

True

A body is said to be at_____when it does not change its position with time.

Rest

A body is said to be at rest when_____

It does not change its position with time

All bodies in our earth move with respect to the earth.

True

The position or motion of an object can be designated with reference to a fixed point in a rigid frame work called the_____

Origin

The rigid or fixed frame work relative to which the position and movements of a particle or of a system of particles or of a rigid body may be measured is called_____

Frame of reference

A_____of reference is a set of coordinate axes used to describe the motion of an object.

Frame

The coordinate system in which the motion of any object depends only on the interactions of the constituent particles among themselves is called an_____.

Inertial frame of reference

The coordinates referred to either rectangular or oblique axes are called_____.

Cartesian co-ordinates

The coordinates of any point in space for example P referred to the axes

XX

The_____of any point on a given plane can be found when its coordinates with reference to two given axes in the plane are given

Position

The position of any point on a given plane can be found when its _____with reference to two given axes in the plane are given

Coordinates

The sun appears to us to move across the sky because of _____

The diurnal rotation of the earth about its polar axis

The sun is said to be in the_____when it reaches the highest position in the course of its apparent journey in the sky.

Meridian

The interval of time between two successive transitions of the centre of the sun's disc across the meridian at any place is called a_____.

Solar day

The mean of the actual solar days averaged over a full year is called the

Mean solar day

A clock, watch or chronometer keeps the mean solar time.

The mean solar day is divided into _____ hours.

24

An hour is divided into 60 minutes and a minute is divided into 60 seconds.

The mean solar day = 24hrs x 60min x 60secs = 86,400 mean solar Seconds

1 second is equal to _____ cesium periods

9, 192,631,170

The _____ is defined as the average length of the feet of 20 German men.

Foot

The _____ was defined as one ten-millionth (10^{-7}) of the distance along Earth's surface between the equator and the North pole.

Metre

The _____ was defined as $1/86,400$ of a mean solar day.

Second

The _____ was defined as the mass of a certain quantity of water.

Kilogram

In _____ French scientists established the forerunner of the international system of measurements.

1791

In _____, an International organization called the General conference on weights and measures was formed.

1889

International System abbreviated SI (meaning in French -Système International).

The metre, the second and the kilogram are the units we use in measuring length, time and mass.

The physical quantities, length, time and mass are known as the _____ quantities.

Fundamental

The unit of measurements of length is the _____.

Metre

The unit of measurement of time is _____

Second

The unit of measurement of mass is _____.

Kilogram

The units of all physical quantities which are based on the three fundamental units are termed _____.

Derived units

Velocity is an example of a physical quantity with a derived unit.

Mathematically, we write

$$\text{Velocity} = \frac{\text{distance (metres, m)}}{\text{time (in seconds, s):}} \quad \text{.....3.1}$$

$\therefore$ The unit of velocity is metres per second written as ms^{-1} (or m/s).

The relation of the unit of any physical quantity to the fundamental units (length, mass and time) is indicated by what is known as the _____ of the unit concerned.

Dimensions

The _____ of a physical quantity is the algebraic combination of [L], [T] and [M] from which the quantity is formed.

Dimension

Volume is not dependent of the units of mass and time.

True

Another example to determine the dimensions of a physical quantity, velocity is as follows:

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}} = \frac{L}{T}$$

∴ The dimensions of velocity is given by $[L]$ or $[LT^{-1}]$.

The equation such as $[V] = [L^3 M^0 T^0]$ or $[v] = [LT^{-1}]$ is called_____.

Dimensional equation

The study of the dimensions of an equation is called_____.

Dimensional analysis

Any physical quantity which requires both magnitude and direction for it to be completely specified is called a_____.

Vector

_____is done by the method of vector addition.

Vector composition

Vector composition is done by the method of_____.

Vector addition

A_____is a vector whose magnitude is zero and whose direction is not defined.

Null vector

A vector of length or magnitude 1 is called a unit vector.

A_____is used to denote direction in space.

Unit vector

A unit vector is used to denote _____ in space.

Direction

A unit vector is used to denote direction in _____.

Space

The _____ is the vector of zero magnitude and unspecified direction

NULL vector

The axes of reference are defined by the _____.

right-hand-rule

Vector A with its origin at O is known as the _____

Displacement vector

There are _____ kinds of products of vectors.

Two

There are two kinds of products of vectors: _____ and _____

Scalar Product and Vector Product

The scalar product denoted by $\vec{A} \cdot \vec{B}$ is sometimes called the _____

Dot product

The vector of two vectors is also known as the _____ of the two vectors.

Cross product

_____ means turning the cork anti clockwise.

Unscrewing

Unscrewing means turning the cork _____.

anti clockwise

_____ may be defined as a continuous change of position with time.

Motion

If you run on a winding path from point A to point B (Figure 3.1a) and travel a distance of 240m in 20 seconds, then your average speed is

$$\text{Speed} = \frac{240\text{m}}{20\text{sec}} = 12\text{m s}^{-1} \quad 3.1$$

Similarly, a car that takes 2 hours to travel from Lokoja to Abuja along a winding road, a distance of 200km is said to have an average speed given by

$$\begin{aligned} \text{Speed} &= \frac{\text{distance}}{\text{time}} = \frac{200\text{km}}{2\text{hrs}} \\ &= 100\text{km h}^{-1} \end{aligned} \quad 3.2$$

An object changes its _____ at a uniform rate without reference to its direction.

Position

An object changes its position at a _____ rate without reference to its direction.

Uniform

An object changes its position at a uniform rate without reference to its _____.

Direction

A particle or car travelling between two locations and limited to make the journey in a specified direction, say 300 due North in some time interval is said to possess velocity, because

$$\text{velocity} = \frac{\text{displacement}}{\text{Time}} \quad 3.3$$

Average velocity is a _____ quantity

Vector

Instantaneous velocity is a vector quantity whose direction is the limiting direction of the displacement vector.

A positive velocity indicates that it is towards the right along the x-axis of the coordinate system.

At a point where the tangent is horizontal its slope is zero and its velocity is _____.

Zero

When a body accelerates in motion it means that its _____

Velocity changes continuously as the motion proceeds

The velocity time graph is a _____ line.

Straight

_____ involves change in the position of an object with time.

Motion

Speed is a _____ quantity

Scalar

Velocity is _____ quantity

Vector

_____ is the acceleration of a particle at someone instant of time

Instantaneous acceleration

The _____ is the direction of the tangent to the curve at the given moment of motion.

Instantaneous velocity

The parameters that describe motion such as velocity and acceleration are called _____.

Kinematics

Kinematics alone cannot predict the possible motion of an object.

True

The studies of the causes of motion are called _____.

Dynamics

A scientist called _____ described the laws that govern motion in 1687.

Sir Isaac Newton

Who postulated the laws that govern motion in 1687?

Sir Isaac Newton

Sir Isaac Newton described the laws that govern motion in _____.

1687

Force is a _____ quantity.

Vector

A force applied to a rigid body is _____

Taken to be acting anywhere along its line of action

_____ occurs when the forces in the displaced position act such that they return the body in its original position

Unstable equilibrium

If the forces act to increase the displacement still further the equilibrium is _____.

Unstable

If the body after being displaced is still in equilibrium the equilibrium is _____

Neutral

The magnitude of the moment of a force P about a point O is defined as the product of the force P and the perpendicular distance OA from O to the line of action of P .

Parallel Forces

If a rod carries loads of 10, 20, 30, 15 and 25N at point O , A , B , C , D respectively, the resultant, R of the weights which are parallel forces for all the forces in Figure (3.7b) is resultant, R

$$R = (10 + 20 + 30 + 15 + 25) \text{ N}$$

$$= 100 \text{ N}$$

The resultant of a number of forces in equilibrium is_____.

Zero

The algebraic sum of the moments of all the forces about any point is _____provided the forces are in equilibrium.

Zero

The algebraic sum of the moments of all the forces about any point is zero provide_____

The forces are in equilibrium

From_____experiments on the motion of objects on smooth planes continuity of motion was established.

Galileo's

Newton's first law or the law of inertia states thatvery body continues in its state or rest or of uniform motion in straight line unless it is compelled to change that state by forces impressed on it.

Newton's second law states that the change of motion of an object is proportional to the force impressed and is made in the direction of the straight line in which the force is impressed.

_____ is defined as one which produces unit acceleration in its direction when it acts on a unit mass.

Unit of force

A force of 200N pulls a box of mass 50kg and overcomes a constant frictional force of 40N. What is the acceleration of the sledge?

The Resultant force, $F = 200\text{N} - 40\text{N} = 160\text{N}$
from

$$F = ma = 50 \times a$$

$$\therefore a = \frac{160\text{N}}{50\text{kg}}$$
$$= 3.2\text{ms}^{-2}$$

$$\text{or } a = 3.2\text{N}$$

Newton's third law of motion states that to every action there is an equal and opposite reaction.

A body can only be in static or dynamic equilibrium if _____

All the forces acting on it cancel each other

The study of the parametres that describe linear motion is called

Kinematics

The stone or object thrown into space is called a _____.

Projectile

Projectile motion is a good example of motion in _____ dimensions.

2

The trajectory of all objects moving with a constant acceleration is

_____.

Parabolic

The path followed by the projectile is known as _____

Trajectory

Projectile motion is a type of motion with _____.

Constant acceleration

The path followed by the projectile is called a _____

Trajectory

The forward component of velocity does not come into play in the projectile flight.

True

Projectile motion is an application of Newton's second law of motion from which we have that $a = F/m$.

Projectile motion is a form of _____ motion.

Parabolic

_____ can be described as a combination of horizontal motion with constant velocity and vertical motion with constant acceleration.

Projectile motion

A force produces a change in _____.

Momentum

A _____ produces a change in momentum.

Force

Momentum during a linear motion is also called _____.

Linear momentum

We often use the symbol P to represent momentum.

$$\text{Momentum} = P = mv$$

The unit of momentum in the S.I system is 1 kilogram metre per second (1 kg ms^{-1}).

Generally, _____ are forces that vary with time.

Impulse

Momentum increases algebraically with increase in positive impulse but decreases with negative impulse.

True

_____ is a force of very short duration

Impulse

_____ is given by the product of the force and velocity.

Linear momentum

_____ is as a result of change of momentum of a particle

Force

The principle of momentum change is applied in rocket propulsion

When two objects collide their _____ must be conserved.

Momentum

When two objects collide their momentum must be _____.

Conserved

_____ is the sudden impact felt between two objects.

Collision

There are _____ types of collisions

Two

There are two types of collisions _____ and a _____

Elastic and inelastic collisions

_____ is a collision between two or more objects during which no energy is lost.

Elastic collision

The total kinetic energy of the objects before collision is equal to the total kinetic energy of the objects after collision.

_____ energy is conserved.

Kinetic

If the kinetic energy is not conserved in a collision the collision is called _____.

Inelastic collision

A situation in which two bodies can collide and coalesce (i.e stick together) , this kind of collision is referred to as _____

Perfectly inelastic collision

Kinetic energy is not conserved during inelastic collision

True

Collisions are described by the _____

Equation

Sir Isaac Newton deduced the law of universal gravitation in 1686 from speculations concerning the fall of an apple toward the earth.

Sir Isaac Newton deduced the law of universal gravitation in _____
1686

Who deduced the law of universal gravitation in 1686 from speculations concerning the fall of an apple toward the earth?

Sir Isaac Newton

_____ is the attraction the earth has for an object

Gravity

This Newton's law of universal gravitation states that every particle of matter in the universe attracts other particles with a force which is directly proportional to the product of their masses and inversely proportional to the square of their distances apart.

G is a constant called the_____.

Universal gravitational constant

Newton law of _____ refers to the force between two particles.

Gravitation

Newton law of gravitation refers to the_____.

Force between two particles

The Cavendish balance is an instrument invented by_____

Rev. John Michell

_____introduced a heliocentric frame with the sun at the centre of the solar system.

Copernicus

Copernicus introduced a _____with the sun at the centre of the solar system.

Heliocentric frame

Copernicus introduced a heliocentric frame with the _____at the centre of the solar system.

Sun

Example

The mass m of one of the small spheres of a Cavendish balance is 0.001kg, the mass m_1 of one of the large spheres is 0.5kg, and the centre-to-centre distance between the spheres is 0.05m. Find the gravitational force on each sphere?

Solution

We apply the law of universal gravitation which stated mathematically is

$$F_g = G \frac{m_1 m_2}{r^2}$$

$$F_g = 6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2} \frac{(0.001 \text{ kg})(0.5 \text{ kg})}{(0.05 \text{ m})^2}$$

$$= 1.33 \times 10^{-11} \text{ N}$$

The _____can be defined more generally as the resultant gravitational force exerted on the body by all other bodies in the universe.

Weight of a body

Thus, assuming the earth to be homogeneous sphere of radius R and mass of M_E , the weight w of a small object of mass M in its surface would be

$$W = F_g = G \frac{mm_E}{R^2}$$

The weight of a body is a force and its unit is the Newton, N

The unit weight of a body is _____

Newton

The density of most rock near the earth's surface such as granites and gneisses is about $3 \text{ g cm}^{-3} = 3000 \text{ kg m}^{-3}$.

When the satellite stays over the same place on the earth while the earth rotate the orbit is called a _____

Parking orbit

There are _____ kinds of fundamental forces.

Three

There are three kinds of fundamental forces: gravitational, electroweak and strong.

_____ include the force between two charged particles at relative rest (electrostatics) or in relative motion (electro-dynamics).

Electromagnetic forces

Acceleration due to gravity g increases with latitude.

True

_____ is that force that tries to or opposes motion.

Frictional force

_____ is a contact force which acts along the surface between two bodies in contact when one tries to move or succeeds in moving.

Friction

Friction opposes motion

True

Friction _____ motion

Opposes

_____ is done when a force moves its point of application along the direction of its line of action.

Work

_____ is the same as the rate at which the machine or appliance converts energy from one form to another.

Power

Energy is measured in _____

Joules

_____ can be taken to be a measure of the quantity of energy transferred between two bodies.

Work done

The unit of power is the _____

Watt (W)

When one joule of work is done in one second it is known as the watt or that energy expended is 1W

$$\therefore 1W = 1 \text{ J s}^{-1}$$

_____ is the energy a body possesses by virtue of its motion.

Kinetic energy

We obtain the expression of kinetic energy by computing the amount of work done by a body while the body is being brought to rest.

The _____ of a system of bodies is the energy the body has by virtue of the relative position of the parts of the body of the system.

Potential energy

_____ arises when a body experiences a force in a region or field.

Potential energy

An example is the gravitational field of the earth is an example of_____

Potential energy

Energy may be transformed from one form to another but it cannot be created or destroyed

The total energy of a system is_____.

Constant

_____ is a measure of the quantity of energy transferred between two bodies.

Work

_____ is the rate of doing work.

Power

The unit of work is the joule

In simple harmonic motion (s.h.m) the position of a point varies with

Time

If the acceleration of a body is directly proportional to its distance from a fixed point and is always directed towards this point the motion is

_____.

Simple harmonic

The_____ sign indicates that acceleration is always in opposite direction to the displacement and directed to a fixed point.

Negative

The following are examples of occurrence of Simple Harmonic Motion

Examples of such a motion can be found in:

- The balance wheel of a watch
- The pistons in a gasoline engine
- The strings in the musical instruments
- The molecules in a solid body vibrating about their mean positions in the crystal lattice
- The beating of the heart
- Light waves and radio waves in space
- Voltages, currents and electric charges etc.

The period T of N is the time it takes N to do one complete to and fro motion ie to go from A to B and back to A

A motion which has a constant period whatever the amplitude is said to be _____

Isochronous

_____ is a periodic vibration of a body whose acceleration is directly proportional to its distance from a fixed point

Simple Harmonic Motion

_____ is the maximum displacement.

Amplitude

_____ occurs in the production of musical sounds from air columns in wind instruments.

Resonance

_____ occurs when a radio circuit is tuned by making its natural frequency for electrical oscillations equal to that of the incoming radio signal

Electrical resonance

Most real oscillators are damped

True

The amplitude of oscillations of a particle in s.h.m. is damped by _____ forces due to the surrounding medium.

Resistive

The _____ of oscillations of a particle in s.h.m. is damped by resistive forces due to the surrounding medium.

Amplitude

When the amplitude is reduced to zero in minimal time the system is said to be critically damped

_____ occurs when the driving frequency is the same as the natural frequency of the oscillator resulting in a maximum amplitude of oscillation.

Resonance

The sharpness of the resonance curve is called the _____

Q-factor

A _____ body is one which has a definite shape.

Rigid

The simplest rotating object that we can contemplate is a _____.

Dumbbell

A _____ consists of two point masses m_1 and m_2 connected by a massless rigid rod of length L

Dumbbell

A _____ consists of two equal and opposite parallel forces whose lines of action do not coincide.

Couple

A _____ is an aggregate of point masses such that the relative separation between any two of these always remains invariant.

Rigid body

A rigid body can execute both translational and rotational motion.

True

A rigid body executes pure translational motion if each particle in it undergoes the same distance as every other particle in a given interval of time.

True

_____ is the analogue of linear momentum (mv) where I is equivalent to mass m and ω replaces velocity V .

Angular momentum

A body rotates when it is acted on by a _____.

Couple

Angular momentum is a vector that points in the same direction as ω .

True

The principle of angular momentum states that the total angular momentum of a system remains constant provided no external torque acts on the system rigid or otherwise.

ω is angular velocity

A symmetrical body rotating about an axis one point of which is fixed is called a _____.

Top

If the fixed point is at the centre of gravity the body is called a _____

Gyroscope

The angular momentum L of a system about an axis is defined as _____

The moment of its momentum about that axis

A _____ is a symmetrical body rotating about its centre of gravity

Gyroscope

The unit of work is the unit of _____ multiplied by the unit of distance.

Force

A system that its boundary allows transfer of mass and energy into or out of the system is known as_____.

Open system

The radiant heat energy could be detected and measured by_____

Thermopile

The reluctance of an object to start or stop moving is known as

Inertia

The heat required to raise the temperature of the body through 1K is called_____

Heat capacity

Forces are called coplanar when all of them acting on body lie in one

_____.
Plane

The locus of the instantaneous centre of a moving rigid body is called

_____.
Centroid

The_____is an aggregate of point masses such as that the relative separation between any two points remains invariant

Rigid body

The general motion of a rigid body is a combination of_____and rotation.

Translation

The specific latent heat of vapourization of a liquid is the quantity of heat in joules required to change 1kg mass of the liquid at its_____to gas at the same temperature.

Boiling point

Radius of_____is the radial distance from any given axis at which the mass of a body is concentrated without changing the moment of inertia of the body about that axis.

Gyration

_____ forces meet at one point and have their lines of action in different planes.

non-coplanar current

Applied force is proportional to extension produced is a statement of _____ law.

Hooke's

A _____ is the turning effect caused by a couple.

Torque

A _____ consists of two equal and opposite parallel forces.

Couple

When a gas is allowed to expand at constant temperature the process is described as ____.

Isothermal

The velocity of a particle at some point of its path is called _____.

Instantaneous velocity

In a circular motion which of the quantities is constant?

Acceleration

_____ is that which enables a body to perform work.

Energy

According to the kinetic-molecular theory, particles of matter are in _____

Motion

Poise is the SI unit of _____

Coefficient of viscosity

An object falling freely through a viscous fluid soon attains a maximum and constant velocity called _____

Terminal velocity

The term_____defines frictional force in fluids

Viscosity

3-vectors are only properly represented in a_____

3-dimensional space