**XI PHYSICS NOTES Set 1**

**CHAPTER # 2**

**SCALARS & VECTORS**

**DIFFERENCE B/W SCALAR AND VECTOR QUANTITIES:**

|  |  |
| --- | --- |
| **SCALAR QUANTITIES** | **VECTOR QUANTITIES** |
| **DEFINITION: -**  Those physical quantities which are completely define by a number in a suitable unit are termed as Scalar Quantities. | **DEFINITION: -**  Those physical quantities which are completely define by a number in a suitable unit as well as direction are called Vector Quantities. |
| **EXAMPLES: -**  Distance, Time, Area, Volume, Temperature, Speed and density are the examples of scalar quantities. | **EXAMPLES: -**  Displacement, Velocity, Acceleration, Momentum, Torque, Force and weight are the examples of vector quantities. |
| **GRAPHICAL REPRESENTATION: -**  It has no graphical representation. | **GRAPHICAL REPRESENTATION: -**  It has graphical representation known as a VECTOR. |
| **APPLICATION OF ORDINARY RULES OF ALGEBRA: -**  They are added or subtracted according to ordinary rules of algebra. | **APPLICATION OF ORDINARY RULES OF ALGEBRA: -**  They are not added or subtracted according to ordinary rules of algebra. |

**VECTOR: -**

The graphical representation of a vector quantity is called a vector.

**REPRESENTATION OF A VECTOR QUANTITY: -**

Vectors are represented by a straight line according to,

1. Some suitable scale.
2. With respect to some reference axis.
3. An arrow head is put on the line to indicate its direction.

**MULTIPLICATION OF VECTOR BY SCALAR (NON-ZERO): -**

When a vector is multiplied by a number ‘m’ the product of number ‘m’ and a vector generates a new vector whose magnitude is m times the magnitude of vector i.e,

**CASE # 1:**

If ‘m’ is positive then the direction of is same as that of Following figure illustrates an idea,

**CASE # 2:**

If ‘m’ is negative then the direction of is opposite to that of .

**DIVISION OF VECTOR BY SCALAR (NON-ZERO): -**

When a vector is divided by a number ‘m’ the division of vector by a number ‘m’ generates a new vector whose magnitude is times the magnitude of vector i.e,

**CASE # 1: -**

If ‘m’ is positive then the direction of is same as that of . Following figure illustrates an idea.

**CASE # 2: -**

If ‘m’ is negative then the direction of is opposite to that of . Following figure illustrates an idea.

**ADDITION OF VECTOR: -**

The process by which we get the resultant of two or more than two vectors is known as Addition of Vectors.

**RESULTANT VECTOR: -**

The resultant of two or more than two vectors is a vector having an equivalent effect as the combined effect of two vectors to be added

**RECTANGULAR COMPONENTS: -**

The components of the vector which are mutually perpendicular to each other are termed as Rectangular components.

**RESOLUTION OF A VECTOR: -**

The process of splitting a vector into two or more components is known as Resolution of a vector.

**EXPLANATION: -**

Consider which makes an angle with the x-axis as shown,

In order to find the x-component, a perpendicular is drawn from the head of the to the x-axis as shown,

From figure it’s clear that

Similarly, in order to get the y-component a perpendicular is drawn from the head of the vector on y-axis as shown,

From figure it’s clear that,

Suppose A, Ax, and Ay are the magnitudes of respectively.

Consider right angle triangle OBD in scalar form,

In triangle,

Also,

**MAGNITUDE OF THE RESULTANT: -**

By using Pythagoras Theorem we can find the magnitude of the resultant as:-

**DIRECTION OF THE RESULTANT VECTOR: -**

Direction of the resultant vector may be computed as:

**COMPOSITION OF A VECTOR: -**

“The process by which a vector can be obtained from its components is called composition of a vector.”

**ADDITION OF VECTOR BY RECTANGULAR COMPONENT METHOD: -**

**DETAIL OF THE PROCEDURE: -**

Let vectors and be the two vectors having angle and with the + ive

x-axis as shown,

By using head to tail method resultant of and is A shown,

Draw x and y components of and

**CONSIDER :-**

The x-component of is and y-component of is . Also the magnitude of and is given as,

**CONSIDER :-**

The x-component of is and y-component of is . Also the magnitude of and is given as,

**CONSIDER RESULTANT VECTOR :-**

The x-component of the resultant vector is and y-component is .

From the figure it’s clear that,

It shows that the x-component of the resultant is the sum of the x-components of the vectors to be added.

In the similar manner,

that the y-component of the resultant is the sum of y-components of the vectors to be added.

**GENERALIZED FORM:**

**MAGNNITUDE AND DIRECTION OF THE RESULTANT: -**

Magnitude and direction of the resultant is found as:

**ADDITION OF n VECTORS: -**

Addition of n vectors may be generalized as,

**STEP NO. 1: -**

x and y components of the vectors are obtained by using following relationship.

**FOR x-COMPONENTS: -**

**FOR y-COMPONENTS: -**

**STEP NO 2: -**

Obtain the algebraic sum of all the x-component of the vectors to be added which shows the magnitude of x-component of the resultant i.e.

**STEP NO 3: -**

Obtain the algebraic sum of all the x-component of the vectors to be added which shows the magnitude of x-component of the resultant i.e.

**STEP NO 4: -**

Magnitude of the resultant vector is calculated

OR

**STEP NO 5: -**

Direction of the resultant vector i.e. (angle of the resultant with + x-axis) is found as,

**NEGATIVE VECTOR: -**

The vector of a vector which is same in magnitude but opposite in direction is called Negative Vector.

EXAMPLE: -

**SUBTRACTION OF VECTORS: -**

“Subtraction of from is defined as the addition of negative of to “

**EXPLAINATION: -**

1. Let and are the two vectors as shown.
2. Which is required to find
3. For this purpose negative of is obtained as shown.
4. Vector is added to

**ADDITION OF VECTORS BY PARALLELOGRAM METHOD**

1. Given two vectors are drawn the two adjacent sides of the parallelogram.
2. The diagonal of the parallelogram represents the resultant.
3. The direction of the resultant vector is away from the origin of the two vectors.
4. The explanation of the method is given in the following figure.
5. Magnitude of the resultant vector is given by using cosine law.
6. The direction of the resultant vector is given by using sine law.

**PROPERTIES OF VECTOR ADDITION: -**

**COMMUTATIVE PROPERTY: -**

Let two vectors and as shown,

Now vector addition by parallelogram method is given as,

From the figure it is clear that.

From eq. no (i) and (ii)

Therefore, commutative property holds good for vector addition.

**ASSOCIATIVE PROPERTY: -**

Let three vectors , and as shown,

Vector addition of , and is given as,

From the figure it is clear that.

From eq. no (i) and (ii)

**UNIT VECTOR: -**

**DEFINITATION: -**

“A vector which has magnitude 1 and used to represent the direction of the certain vector is called a UNIT VECTOR.”

**EXPLAINATION: -**

When a is divided by its magnitude we get the unit vector in the direction of . Following mathematical expression and figure illustrates an idea,

**OR**

In three dimensions , and are used to denoted by the direction of x, y and z axis respectively.

In three dimensions a vectors can be written as

Where,

are the x, y and z components respectively.

As we know that,

Similarly,

Also,

Finally we conclude that in three dimensions a vector can be written as,

**POSITIVE VECTOR: -**

It is a fixed vector which locates the position of a point in space with respect to a fixed point or origin.

**EXPLAINATION: -**

In the adjacent figure is the position vector of point P with respect to origin O.

In three dimensions a position vector may be represented as,

where,

are the x. y and z component of position vector respectively.

If represent the magnitude of the x-component.

Similarly,

and

Where,

are the unit vectors.

The components of position vector are termed as CO-ORDINATES. The magnitude of the position vector is computed as,

Also in three dimensions position vector can be given as,

**SCALAR PRODUCT: -**

If the product of vectors is a scalar quantity then the product of two vectors is called scalar product.

**EXPLAINATION: -**

The dot or scalar product of two vector and is written as, and read as dot , is defined as the product of the magnitude of vector and and cosine of the angle b/w them.

Where,

A and B are the magnitude of vector and and is the angle b/w them.

**EXAMPLE:**

1. Work is a common example of scalar product as it is dot product of force and displacement.
2. Power is the scalar product of force and velocity.

**Q: Prove that**

**OR**

**Explain the commutative property of dot product.**

**OR**

**Prove the commutative law of scalar product.**

**PROOF:**

The scalar product of and is defined as,

“The scalar product of and is equal to the magnitude of times the projection of in the direction of .”

**EXPLAINATION: -**

Suppose two vectors and which makes an angle b/w them as shown,

In order to find the projection of on a perpendicular is drawn from the head of the on so that is the projection of on .

Consider the above triangle in scalar form.

In the above triangle

By definition of scalar product,

In order to find the projection of on a perpendicular is drawn from the head of on , so that is the projection of on . Following figure illustrate an idea,

Consider the above triangle in scalar form.

From the definition of scalar product,

i.e.

from eq. (i) and (ii)

**DISTRIBUTIVE PROPERTY: -**

Explain the distributive property of dot product or prove that,

Consider three vectors , and as shown,

By head to tail method find the resultant of and .

Find the projection , and in the direction of .

Now we find

**HENCE PROVED!**

**VECTOR PRODUCT**

**DEFINITION: -**

“If the product of two vectors is a vector quantity then it is termed as Vector Product.”

**EXPLAINATION: -**

Let two vectors and lying on a plane and making an angle b/w them then their cross product can be given as,

The magnitude of is given as,

**or**

By the definition of unit vector

Where is the unit vector in the direction of .

**OR**

By definition is perpendicular to the plane containing and . It is normally out of the paper when than towards similarly it is into the paper when than towards (acc / to right hand rule or right hand screw rule). Following figure illustrates an idea.

**EXAMPLES: -**

1. Torque is the vector product of force and force arm i.e.
2. Force experienced by a charge particle ‘q’ in a uniform magnetic field is the vector product of velocity of the moving charge and magnetic field i.e.

**APPLICATIONS OF VECTOR PRODUCT: -**

**AREA OF A TRIANGLE: -**

**AREA OF A PARALLELOGRAM: -**

**PROVE THAT: -**

OR

**PROOF:-**

Consider two vectors and lying on a plane making an angle b/w them. Then their cross product is given as,

Where to the unit vector perpendicular to the plane containing and and its direction is along the advancement of the right handed screw when turns towards .

When turn towards then their cross product is given as,

Where is the unit vector perpendicular to the plane containing and and its direction is along the advancement of right handed screw when turns towards .

From the above expression we consider that,

**OR**

**OR**

**CHAPTER # 3**

**“MOTION”**

**MOTION: -**

When body changes its position continuously with respect to its surrounding then the body is said to be in a state of motion.

**REST: -**

When a body does not change its position continuously with respect to its surrounding then the body is said to be in a state of rest.

**DISPLACEMENT: -**

The least distance from one point in the direction of another point is called displacement.

**OR**

Displacement from point A to point B is define as “The distance a long a straight line from point A to B.”

**OR**

The change of position of a body is regarded as displacement.

**EXPLANATION: -**

Suppose a body moves along a curved path as show

From figure it is clear that

Where

and are the position vectors of points A and B respectively denotes the change of position. Vector or change of position is called displacement.

**UNITS: -**

The S.I unit of displacement is metre other units are km, cm, foot etc.

**VELOCITY: -**

The distance covered in unit time is called speed and the distance covered in unit in a particular direction is called velocity.

**OR**

֒ Rate of change of position is known as velocity.

**AVERAGE VELOCITY: -**

Average velocity of a particle is obtained by dividing the total displacement by the total time taken.

Direction of average velocity is along the total displacement.

Time taken for the displacement is given by.

Where and are the position vectors of points 1 and 2 respectively.

Average velocity does not give any information about the changes in motion during the entire journey.

**INSTANTANEOUS VELOCITY: -**

Velocity at a particular point or instant is called instantaneous velocity.

**OR**

It is the average velocity evaluated for a time interval that approaches to zero.

Direction of instantaneous velocity is along the tangent is the curved path at a certain point.

Instantaneous velocity gives all the information about change in motion during the entire journey.

**UNIFORM VELOCITY**

1. If a moving body covers equal distance in equal intervals of time (however small the interval may be) in a particular direction then its velocity is termed as uniform velocity.
2. Average and Instantaneous velocity become equal when a body moves with uniform velocity.
3. S.I unit of velocity is

**VELOCITY FROM DISTANCE – TIME GRAPH**

**UNIFORM VELOCITY: -**

A body is said to be move with uniform velocity. When it covers equal distance in equal intervals of time.

When a body moves with uniform velocity distance time graph is a straight line.

**CALCULATION FROM GRAPH: -**

To determine the velocity at time perpendiculars and are drawn a shown

**NON–UNIFORM VELOCITY (VARIABLE VELOCITY): -**

A body is said to have non-uniform velocity when it does not cover equal distance in equal intervals of time:

When a body moves with non-uniform velocity the distance time graph is a curved

**CALCULATION FROM GRAPH: -**

To determine the velocity at time a tangent is drawn at a point as shown in the following figure.

The above velocity is the instantaneous velocity at time

**ACCELEARATION FROM VELOCITY TIME GRAPH**

**UNIFORM ACCELERATION: -**

A body is said to move with uniform acceleration when the changes in velocity are equal in equal intervals of time.

**GRAPH: -**

When a body moves with uniform acceleration velocity time graph is a straight line.

**CALCULATION FROM GRAPH: -**

To find the acceleration at time perpendicular and are drawn as shown above.

**NON-UNIFORM ACCELERATION (VARIABLE ACCELERATION)**

A body is said to move with non-uniform acceleration when the changes in velocity are un-equal in equal intervals of time.

**GRAPH: -**

When a body moves with non-uniform acceleration velocity time graph is a curved.

**CALCULATION FROM GRAPH: -**

To find the acceleration at time a tangent is drawn to the centre as shown,

This is the instantaneous acceleration at

**UNIFORM ACCELERATION: -**

A body is said to move with uniform acceleration when the changes of velocity are equal in equal interval of time.

Average and instantaneous acceleration become equal when a body moves with uniform acceleration.

**INSTANTANEOUS ACCELERATION: -**

Acceleration at a particular point or instant is called instantaneous acceleration.

OR

It is the average acceleration evaluates for a time interval that approaches to zero.

Instantaneous acceleration gives all the information about the changes in motion, during the entire journey.

**FREE FALL: -**

Vertical motion along a straight line caused by gravitational attraction of earth is called free fall. Registrant of air is ignored.

**TENSION IN A STRING**

**DEFINITION: -**

Tension in a string is define as the force of reaction exerted by the string when ever subjected to any kind of pulling force.

**OR**

The force exerted by a string when it is subjected to pull.

**EXPLANATION: -**

Tension always acts at all the points alongs a string. In the following figure tension at ‘A’ is opposite to the downward force of suspended weight while at ‘B’. it is opposite to the upward pull of hand.

**MOTION OF BODIES CONNECTED BY A STRING**

Motion of bodies connected by string passing over a frictionless pulley.

**WHEN:**

1. **BOTH THE BODIES MOVED VERTICALLY:**

Suppose two bodies of masses connected by 2 light strings which passes over a frictionless pulley. As shown in the figure

The body ‘A’ with mass being heavier move vertically downward with an acceleration ‘a’ & the body ‘B’ with mass being lighter move vertically upward with a same acceleration ‘a’. Suppose that the tension in the string is ‘T’.

Due to frictionless pulley & continuous string tension in the string remain same. Both the bodies ‘A’ & ‘B’ are being acted upon by two forces tension & their weights.

Consider a downward motion of the body ‘A’. The resultant force acting on it is:

According to Newton’s 2nd law of motion

Put the value of ‘F’ in equation (A)

Now, consider the upward motion of the body ‘B’. The resultant force acting on it is given by:

According to Newton’s 2nd law of Motion:

Put the value of F in equation (B)

∴ we have

Acceleration of the system:

Adding equation (1) & (2)

→ which is the required expression for acceleration.

**TENSION IN THE STRING: -**

Using the same equation for the direction of tension.

Dividing eq (1) by (2)

1. **WHEN ONE BODY MOVES VERTICALLY & OTHER IS MOVING HORIZONTALLY:**

Consider two bodies ‘A’ & ‘B’ of masses & connected to the end of the strings passing over a frictionless pulley. The body ‘A’ moves vertically downward while the body ‘B’ moves over a smooth horizontal plane towards the pulley.

Let the acceleration of two bodies be ‘a’ & the tension in the strings be ‘T’

Such as arrangement is shown in following figure.

Consider the downward motion of the body Forces acting on body ‘A’ are shown in following figure.

The resultant force acting on body ‘A’ is given as

According to Newton’s 2nd law of motion

Consider the horizontal motion of the body ‘B’ Forces acting on body ‘B’ are shown in the following figure.

From the figure it is clear that weight of the body ‘B’ is balanced by the normal reaction ‘R’ of the surface so:

(Since there is no vertical motion)

And there is only Tension force which is responsible for the motion.

So the net force acting on the body ‘B’ given by:

According to Newton’s 2nd law of motion;

So the above equation becomes

Acceleration of the system,

Since we have

Adding equation (A) & (B)

→ which is the required expression for acceleration.

**TENSION OF THE SYSTEM: -**

Put the value of ‘a’ in eq no (B)

→ which is the required expression for tension.

**CONCLUSION: -**

Therefore the acceleration & tension of the system are:

**MOMENTUM**

**DEFINITION:**

The property of moving body which depends upon its motion is known as momentum.

The magnitude of momentum is the product of mass & velocity.

**MATHEMATICAL EXPRESSION: -**

If the mass of the moving body is ‘m’ & its velocity is ‘v’ then its momentum is given by

**EXPLANATION: -**

1. The above expression shows that the momentum of the body is depend upon its mass & velocity.
2. The quantity of matter present in a body is called its mass. The S.I unit of mass is
3. The distance covered in unit time in a particular direction is called velocity. The S.I unit of velocity is .

**S.I UNIT OF MOMENTUM: -**

The S.I unit of momentum is

As we know that:

Multiply & divide by sec:

According to Newton’s 2nd law of motion.

∴ the above expression becomes,

**VECTOR QUANTITY:**

Momentum is a vector quantity and its direction is along the dimension of velocity.

* Those physical quantities which are completely define by a no in a suitable unit as well as direction is known as vector quantity.

**RATE OF CHANGE OF MOMENTUM:**

Suppose a body of mass moving with initial velocity then its initial momentum is given by

Suppose a constant force acts on a body during the time interval and its velocity becomes then final momentum of a body is given by,

According to the definition of acceleration

i.e.

Therefore the above expression becomes,

According to Newton’s 2nd law of motion

Therefore the above expression becomes

**CONCLUSION:**

From above expression we conclude that the rate of change of momentum is equal to the force.

**QUANTITY OF MOTION:**

The quantity of motion present in a body is called momentum.

**EXPLANATION:**

1. This means that in heavy body the quantity of motion i.e. momentum is greater as compare to lighter body, if they are moving with same velocities.
2. If two bodies of same masses moving with difference velocities then it is difficult to stop the moving body with greater velocity. It means that the quantity of motion i.e. momentum is greater in the body which is moving with greater velocity as compare to the body moving with lower velocity.

**LAW OF CONSERVATION OF MOMENTUM: -**

**STATEMENT:**

If there is no external force applied to a system then the total momentum of that system remain constant.

**‘OR’**

The total momentum of the system before and after collision remains constant.

**EXPLANATION:**

**ISOLATED SYSTEM**

When the constituents of the system interact with one another and no external agency exerts any force on any one of them then the system is said to be isolated.

**E.g:**

The molecules of gas enclosed in a container at constant temperature can be considered as isolated.

**PROOF:**

Consider two bodies ‘A’ and ‘B’ of masses & moving with initial velocities & respectively. Therefore the initial momentum of the system is given as ,

Suppose & are the velocities of bodies & after collision.

When two bodies collide with each other they come in contact for a time interval .

So the rate of change of momentum of body

The rate of change of momentum of body

As we know that the average force acting on the body is equal to its rate of changes of momentum.

According to Newton’s 2nd law of motion

then

So,

**CONCLUSION:**

From the above expression we conclude that the total momentum of a system before collision is equal to the total momentum of a system after collision.

**ELASTIC COLLISION**

**DEFINITION:**

It is the collision in which the total momentum of the system as well as the kinetic energy of the system before and after collision remains same.

**EXPLANATION:**

Consider two non-rotating sphere of masses and moving with initial velocities and respectively.

After elastic collision suppose and are the velocities of masses and

So the

and

According to the law of conservation of momentum

Since collision is elastic so according to the definition.

Because,

Divide equation (B) by (A)

Put the value of in eq (A)

So,

Consider eq (C) again:

Put the value of in eq (A)

**SPECIAL CASES**

**CASE NO. 1:**

**IF THE MASSES OF TWO BODIES ARE EQUAL:**

i.e.

As we know that,

So,

Put in the expression of

Now,

Put in the expression of

**CONCLUSION:**

**CASE NO 2:**

**IF THE MASSES OF TWO BODIES ARE EQUAL i.e. & THE BODY ‘B’ IS INITIALLY AT REST:**

If the masses of two bodies are equal then.

As we know that:

So,

Put in the expression of

Now,

Put in the expression of

We conclude that:

Since the body ‘B’ is initially at rest:

Put the value of iin eq (2)

and

**CONCLUSION:**

After an elastic collision the body ‘A’ will stop and the body ‘B’ will start moving with the velocity equal to (i.e. the intial velocity of body A)

**CASE NO 3:**

**WHEN A LIGHT BODY COLLIDES WITH A MASSIVE BODY AT REST:**

Under these conditions

and

As we know that:

So it can be neglected and body ‘B’ is at rest

So equation (A) becomes

So equation (B) becomes

**CONCLUSION:**

After an elastic collision the body ‘B’ will remain at rest and the body ‘A’ will rebouns back with its initial velocity.

**CASE NO 4:**

**WHEN A VERY MASSIVE BODY COLLIDES WITH A LIGHT STATIONARY BODY:**

Under these conditions

and

As we know that:

Since,

So, can be neglected

Since body ‘B’ is initially at rest

So eq (A) becomes

and

eq (B) becomes

**CONCLUSION:**

After elastic collision there is no charge in the velocity of the massive body but the lighter body moves in the forward direction with approximately twice the velocity of the massive body.

**INCLINED PLANE**

**DEFINITION:**

The surface which makes an angle . with horizontal is called inclined plane.

**EXPLANATION:**

Consider a block is placed on an inclined plane which makes an angle with the horizontal as shown in the figure.

**FORCES ACTING ON THE BLOCK:**

The forces acting on the block are:

1. The weight in downward direction.
2. Reaction perpendicular to the inclined plane.
3. Frictional force parallel to the inclined plane.

As shown in the figure

The weight of the block can be resolved into rectangular components. Assume x-axis along the inclined plane and y-axis perpendicular to the inclined plane as shown in the figure.

FROM,

Fundamental Geometry

Consider right angle triangle

This component of the weight acts perpendicular to the inclined plane.

Again consider right angle triangle

This component of the weight acts parallel to the inclined plane.

**WHEN THE BLOCK IS AT REST**

According to the first condition of equilibrium

**WHEN THE BODY SLIDES DOWN WITH AN ACCELERATION ON “a”**

1. **IN THE PRESENCE OF FRICTION:**

The net force acting on the block is given as

According to Newton’s 2nd law of motion.

So, above equation becomes

Since,

or

* **ACCELERATION:** The rate of change of velocity is called acceleration.

1. **IN THE ABSENCE OF FRICTION:**

If the friction is not present then,

So eq (1) becomes,

So the above expression shows that in the absence of friction acceleration of the moving body is independence of its mass.

**PARTICULAR CASES**

Since,

When,

When,

Since,

∴ The above expression becomes,

The above expression shows that the body is falling freely.

CHAPTER # 4

**PROJECTILE**

**DEFINITION: -**

“Projectile is an object which moves along a path determine by the gravitational force and frictional forces of air acting or it whenever giving or initial velocity.

**EXAMPLES: -**

Jumping animal, a ball kicked by a player, a mezile shoot by a gun.

**PROJECTILE PATH: -**

The path of the projective is called TRAJECTORY and it is usually PARABOLA.

**EXPLAINATION: -**

To make the analysis of projective motion simple we may use the following assumptions.

1. Air friction is negligible.
2. Value of g is constant throughout the motion.
3. Rotation of earth has no effect on the motion.

Projectile motion is the superposition of the horizontal motion along x-axis and vertical motion along y-axis.

These two motions have no effect on one another.

Since we neglect the air friction therefore the only force acting on the projectile is its weight acting vertically downward.

Acceleration of projectile along x-axis is zero as, there is no force on projectile along x-axis as,

**DERIVATION: -**

To derive formula for projectile motion we assume that air friction is negligible, value of ‘g’ is constant throughout the motion, rotation of earth has no effect on one another. Suppose that a shell is shoot from a gun at an angle from the horizontal with initial velocity as shown.

Initial velocity of the shell can be resolved into its components.

Horizontal components or x-component is given as,

Vertical component or y-component is given as,

Since, we neglect air friction therefore the only force acting on the projectile is its weight which is acting vertically downward along the y-axis therefore,

(b/c x-comp of initial velocity remains constant)

Acceleration along vertical direction is given as,

y-components of the velocity decreases in going up and reduces to zero at maximum height.

**TIME TO REACH THE MAXIMUM HEIGHT: -**

Suppose that denote the time to reach the maximum height.

y-component of the velocity become zero at the maximum height. i.e.,

Consider the vertical motion of the projectile. As we know that,

Time to reach max height = t

**TOTAL TIME OF FLIGHT: -**

It is the time for which the projectile remains in air.

We know that the projectile takes equal time in rising to the max. height and in falling to the ground. Hence the total time of flight is given as,

**MAXIMUM HEIGHT: -**

Consider the vertical motion of the projectile. Maximum height is calculated by using the following relation.

Here,

Equ (i) ⇒

**HORIZONTAL RANGE: -**

The horizontal displacement covered by a projectile from origin ( i.e. the point from where it is projected or launched) to the point where it returns is called horizontal range of the projectile. Following figure illustrates an idea

Consider the horizontal range (motion) of the projectile. As we know that,

Here,

Equ (i) ⇒

**MAXIMUM HORIZONTAL RANGE: -**

As we know that horizontal range of the projectile is given as,

Where ‘g’ is constant quantity. If is kept constant then horizontal range depends only on . Hence, we can get maximum horizontal range () when is maximum. As we know that max value of Sin of any angle is equal to 1. Therefore,

When,

To get maximum horizontal range projectile must be launched at an angle of 45° with the horizontal.

**PROJECTILE TRAJECTORY EQUATION: -**

Consider the motion of the projectile along y = axis

As we know that,

Hence,

֒ the above equation becomes,

Now,

Consider the motion of the projectile along x – axis

As we know that,

Here,

֒ the above ratio becomes,

Put the value of t in eq. no (i)

If and are constant then , and are also constant. Let’s

This is the equation of the path followed by the projectile. From this equation we can find the position of the projectile at an instant.

**APPLICATION: -**

Projectile motion find application in a number of fields: -

1. A tennis player can find the best angle of his servise.
2. A long jumper can find the best angle of his jump with the help of the projectile motion formula.
3. A projectile launched at a higher angle has a high trajectory and longtime of flight that is why in cricket it is easy to catch the ball with high trajectory as the fields has plenty of time to get into position. Similarly, a ball with low trajectory has short time of flight therefore it is difficult to catch it.

**“Circular Motion”**

**MOTION IN TWO DIMENSIONS**

**ANGULAR VELOCITY: -**

Angular displacement per unit time is termed as Angular velocity.

i.e.

**UNIT: -** S.I unit of angular velocity is other units are and rpm.

**AVERAGE ANGULAR VELOCITY: -**

It is equal to the total angular displacement divided by the total time taken.

**EXPLAINATION: -**

Consider a particle moving along a circle of radius ‘r’ having centre at ‘0’.

Suppose that the particle at point at time and at point at time as shown in the figure.

Suppose that angular displacement is at pt and at pt measured anti clock wise with respect to positive x-axis.

When particle goes from pt to pt angular displacement is given as,

And the total time is given as,

Therefore, the average angular velocity is given as,

**DIRECTION OF ANGULAR VELOCITY: -**

Direction of angular velocity is given by simple rule.

“if the fingers of the right hand are curled about the axis of rotation in the direction of rotation then the erect thumb will indicate the direction of .”

Following figures illustrates the idea;

**INSTANTANEOUS ANGULAR VELOCITY: -**

Angular velocity at a particular point as instant is know as INSTANTANEOUS ANGULAR VELOCITY. It is also defined as the limit of the ratio as , approaches to zero i.e.,

**EXPLAINATION: -**

Consider a particle ‘p’ lying on a rotating object. This particle is moving along a circle of radius ‘r’ centred at ‘0’. The axis of rotation passes through centre ‘0’. Let the particle covers angular displacement in time along on arc length as shown.

From the fundamental equation we have

Divided both sides by

Taking limit in both sides as

Since

And,

Or

In vector rotation,

Since linear velocity remains tangent to the circle at all the points therefore it is also known as TANGENTAL VELOCITY.

All the particles on a rotating object have equal angular displacement in a given interval of time, therefore all the points possess same angular velocity. Thus, we say that angular velocity ‘w’ is the characteristics of a rotating body as a whole.

As we move away from the centre of the rotating body ‘r’ is increasing which implies that tangential velocity increases by the relation.

**UNITS: -**

Unit of angular velocity is but and are also used.

In the equation , ‘w’ is measured in .

As this equation is derived from where is measured in radian.

**ANGULAR ACCELERATION: -**

“The rate of change of angular velocity is known as ANGULAR ACCELERATION”

OR

“Change in angular velocity per unit time is called ANGULAR ACCELERATION”

**MATHEMATICAL EXPRESSION: -**

**AVERAGE ANGULAR ACCELERATION: -**

Let and denoted the angular velocity at time and . The average angular acceleration is given as,

i.e.,

**DIRECTION OF ANGULAR ACCELERATION: -**

Angular acceleration is always directed along the axis of rotation. When is increasing it is in the direction of angular velocity and its direction is opposite to that of when is decreasing. Following figure illustrates an idea.

**UNIT: -**

The unit of angular acceleration is

**INSTANTANEOUS ANGULAR ACCELERATION: -**

Angular acceleration at a particular point or instant is called instantaneous angular acceleration. It is also defined as

“The limit of the ratio as .”

**EXPLAINATION: -**

Consider a particle moving in a circle of radius “r” centred at ‘0’ as shown in the figure;

Suppose that in time angular velocity changes by an amount such that the corresponding charge in tangential velocity be

Divided both sides by

Taking limit on both sides as

In vector rotation

Where is the tangential acceleration.

**CENTRIPETAL ACCELERATION: -**

“When a body moves in a circle direction of its velocity changes continuously. Acceleration produced due to this change in direction of velocity is called CENTERIPETAL ACCELERATION which is always directed towards the centre of the circle.”

**EXPLAINATION: -**

Consider a particle moving in a circle of radius ‘r’ centred at ‘0’. Suppose it goes from point to point in time along an arc length . Angular displacement is from point to point as shown:

The change in direction of velocity vector is given as,

The change in direction

From basic geometry we know that the tangent of a circle is a right angle to the radius of the circle, therefore and are perpendicular to the radius of the circle at point and respectively. Hence the angle between and is also and for uniform circular motion.

is similar to because they are isosceles triangle.

Therefore we have,

Divided both side by

Taking limit on both sides as

Since,

And,

Since,

For one complete revolution

**Centripetal Force**

“The force which causes centripetal acceleration in a body is called CENTRIPETAL FORCE. It’s direction is always towards the centre of the circle”.

**DERIVATION: -**

The expression of the centripetal acceleration is given as,

According to Newton’s Second law of motion.

Equation number (II)

In terms of angular velocity centripetal force is given as,

As we know that,

Where,

**DIFFERENCE B/W CENTRIPETAL ACCELERATION AND TANGENTIAL ACCELERATION: -**

**CENTRIPETAL ACCELERATION AND TANGENTIAL ACCELERATION: -**

When a body moves in a circle it possess two acceleration centripetal acceleration and tangential acceleration

|  |  |
| --- | --- |
|  |  |
| DEFINITION:  It is due to change in direction of linear velocity. | DEFINITION:  It is due to change in magnitude of linear velocity. |
| DIRECTION:  It is always directed towards the centre of the circle. | DIRECTION:  It is always tangent to the circle on along the direction of linear velocity. |
| EXPRESSION:  The expression of is given as where ‘V’ is the tangential linear velocity. | EXPRESSION:  The expression of is given as where, is the angular acceleration. |

**IMPORTANT POINTS TO REMEMBER: -**

For uniform circular motion . If are present at the same time then the net acceleration of the moving body is given as,

The magnitude of the net acceleration is given as,

And the direction of the net acceleration is given as,

**COMPARISION: -**

|  |  |
| --- | --- |
| **LINEAR MOTION** | **ANGULAR MOTION** |
| DISPLACEMENT:  S |  |
| ACCELERACTION:  A |  |
| VELOCITY:  V |  |
| FINAL VELOCITY: |  |
|  | |

CHAPTER # 6

**“GRAVITATION”**

**NEWTON’S LAW OF GRAVITATION: -**

**STATEMENT: -**

Every body in the universe attracts another body by a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance b/w their centres.

**MATHEMATICAL FORM: -**

According to law of gravitation, gravitational force b/w two bodies A and B of masses and is represented as

By combining eq no (i) and (ii)

where ‘G’ is called as Universal Gravitational constant and its value is

**FORMULATION OF NEWTON’S LAW OF GRAVITATION CENTRIPETAL ACCELERATION OF THE MOON: -**

Newton begins with the fact that the moon revolves around the earth in almost a circular orbit. He calculated the centripetal acceleration of the moon by using Huygen’s formula.

According to the Huygen’s formula the centripetal acceleration of the body moving in a circular path is given by the equation

where,

is the unit vector directed from the centre of the circle to the instantaneous location of the moving body and (-) sign indicates the direction of towards the centre of the circle. The magnitude of the centripetal acceleration is given as

The centripetal acceleration of the moon by using Huygen’s formula is given as

where ‘R’ is the distance b/w centres of the earth and moon and it is called as the orbit radius of the moon.

As we know that

therefore,

By putting the value of v in eq no (1)

where “T” denotes the time taken by the moon to complete one revolution around the earth and it is equal to 27.3 days.

and

‘R’ represents the distance from the centre of the earth to the centre of the moon and it is known as orbit radius of the moon and its value is

Replacing the value of ‘J’ and ‘R’ in eq (ii)

If this acceleration is due to the gravitational force of the earth then the apple would also experience the same acceleration provided that it is placed at a distance of . From the centre of the earth. But acceleration due to gravity of an object near the surface of the earth is given as

Now,

and

comparing eq (iii) and (iv)

According to Newton’s Second Law of motion force on moon is given as

comparing eq no (v) and (vi)

The above expression shows that the force exerted on moon by the earth is directly proportional to the mass of the moon and inversely proportional to where ‘R’ is the distance b/w the centre of the earth to the centre of the moon.

**GENERALIZATION: -**

Now we generalize the law as follows consider two bodies A and B of masses and respectively let the distance between their centers be ‘r’ as shown below

The force on body A by body B is given as

and

The force on body B by A is given as

According to Newton’s third law of motion.

Combining eq (1), (2) and (4)

or

of

then

where

the distance from the center of body B to the center of body A

**VECTORIAL FORM: -**

In vector form it is given as

Also

Where negative sign shows that forces are acceleration.

**MASS AND AVERAGE DENSITY OF EARTH**

The mass of the earth can be determined by using Newton’s law if gravitation.

Let a body of mass ‘m’ be placed on the surface of the earth. Suppose that the distance b/w the centre of the body and the centre of the earth is equal to the radius of the earth. If is the mass of the earth then the force with which the earth attracts the body towards its centre by using law of gravitation is given as.

As we know that the gravitational force exerted on the body by the earth is equal to the weight of the body therefore

Comparing (i) and (ii)

where ‘g’ is the acceleration due to gravity and in M.K.S system its value is

is the radius of the earth and its value is ‘G’ is the Universal Gravitational Constant and its value is

Putting all the above values in eq no (iii) we get,

**AVERAGE VALUE OF DENSITY OF EARTH**

The average density of the earth i.e. mass per unit volume is defined as

If earth is supposed to be a perfect sphere of radius then its volume is given as

put the and in the above equation

**VARIATION OF ‘g’ WITH ALTITUDE AND DEPTH**

The force on a body of mass ‘m’ which is placed at a distance of ‘R’ from the center of the earth according to Newton’s law of gravitation is given as

Also,

The force with which earth attracts a body towards its centre is known as its weight and is given as

comparing eq (i) and (ii)

Since, the value of and are constant

The above relation shows that ‘g’ varies inversely to the square of the distance from the centre of the earth.

There are two reasons for the variation of ‘g’.

1. Shape of earth i.e. earth is not a perfect sphere.
2. Rotation of earth.

**ALTITUDE: -**

Let ‘g’ be the acceleration due to gravity on the surface of the earth and ‘g’ be the acceleration due to gravity at a height ‘h’ from the surface of the earth.

Consider a body of mass ‘m’ at the surface of the earth. If the mass of the earth is and radius is then according to Newton’s Law of Gravitation.

But this force is also equal to the weight of the body which is placed at a distance of from the centre of the earth.

comparing eq (i) and (ii)

If acceleration due to gravity on the height ‘h’ above the earth surface is ‘g’ then the eq. (iii) can be written as

By divided eq (iv) by (iii) we get

Using binomial expansion formula

Then we can neglect the higher powers of . By neglecting the higher powers of we get

The above equation shows that the value of ‘g’ decreases as we go up from the surface of the earth.

**DEPTH: -**

Suppose ‘g’ denotes the value of acceleration due to gravity on the surface of the earth and ‘g’ denotes the value of acceleration to gravity at depth ‘d’.

If the earth is a perfect sphere of radius and the uniform density of the earth is than the mass of the earth is given as

At a distance ‘d’ below the surface of the earth the mass of the earth effective in exerting attraction is given as

The acceleration due to gravity at a depth ‘d’ below the surface of the earth is given as

By dividing eq. no (ii) by (i) we get

The above equation shows that acceleration due to gravity decreases with depth.

When a body is at the centre of the earth

By using equation no (iii)

The weight of any body is calculated on

Since at the centre of the earth

∴ The weight of the body at the centre of the earth is given as

i.e.

Hence weight of a body is zero at the centre of the earth.

**MASS OF THE SUN: -**

Earth revolves around the sun in almost a circular orbit of radius ‘R’ which is the distance between their centres.

If

Mass of the Sun

then The gravitational force acting between them is given as,

The centripetal force acting on the earth is given as

Comparing eq (i) and (ii)

where as

i.e.

Substituting these values in eq (iii)

**MASS OF THE MOON: -**

According to Newton’s law of gravitation, gravitational force exerted by the moon on the object of mass ‘m’ which is placed at the surface of the moon is given as.

where,

but the force by which moon attracts a body towards its centre is given as

Where is the weight of the body on the surface of the moon.

comparing eq (i) and (ii)

where as,

Substituting these values in equation no (iii)

**WEIGHT**

Weight is a force by which earth attracts a body towards its centre.

**OR**

Weight of a body in a certain frame of reference is equal and opposite to the force required to prevent it from accelerating from rest in that frame of reference.

**EXPLANATION: -**

1. A coordinate system with respect to which measurements are taken is known as frame of reference.
2. When a body of mass ‘m’ is allowed to fall freely its acceleration is equal to ‘g’.

i.e.

The only force is acting on this body is its weight acting vertically downward.

Applying Second law of motion

Here,

1. In M.K.S system the unit of weight is Newton ‘N’
2. Expression for weight shows that it depends upon the mass and acceleration due to gravity. Mass of an object is a constant provided that velocity of the object is negligible as compare to the velocity of light. Acceleration due to gravity changes place to place and hence the weight of an object changes with respect to value of g.

**WEIGHTLESSNESS: -**

1. **IN ELEVATOR:**

Consider an object of mass ‘m’ suspended by the string of a spring balance and an observer in an elevator. There are two forces acting on this object.

1. Gravitational pull of the earth acting vertically downward which is given by

This is known a true weight of an object.

1. Tension ‘T’ in the thread (string) acting vertically upward. This the force which prevents the object from accelerating from rest in an elevator. Hence tension in the thread is equal to the weight of the object in the elevator. This is called apparent weight denoted by . (which is equal to T)
2. **WHEN ELEVATOR IS AT REST**

When the elevator is at rest. The force along the thread is equal and opposite to the force of gravity experienced by an object i.e. the true and apparent weight of the object are balanced by each other.

1. **WHEN ELEVATOR MOVES UP WITH AN ACCELERATION ‘a’**

When an elevator moves up with an acceleration ‘a’ unbalanced force acting on the object is given by

from the above expression it is clear that Apparent weight and hence the object appears heavier to the observer in the elevator.

1. **WHEN ELEVATOR MOVES DOWN WITH AN ACCELERATION “A”**

When an elevator moves down with acceleration ‘a’ unbalanced force acting on the object is given by

from the above expression it is clear that apparent weight and hence the object appears lighter to the observer in the elevator.

1. **WHEN THE CABLE SUPPORTING THE ELEVATOR BREAKS**

When the cable supporting the elevator break, elevator moves down with an weight of the object is given as

That is the apparent weight of the object becomes zero. Thus according to the observes in the elevator the body appears to be weight less and this state is known as weight lessness.

**WEIGHT LESSNESS IN STAELLITE**

Consider an object of mass ‘m’ suspended by the thread of a spring balance and an observer in a satellite orbiting around the earth. Apparent weight of this object is given as,

where,

But a space ship (satellite) in orbit has an acceleration towards the earth’s centre equal to the value of the acceleration due to gravity at its orbit radius i.e.

shows that the object becomes weightless to the observer in satellite. This does not mean that gravitational force of earth is not acting on it, it acts on both the satellite and the bodies in it giving each the same acceleration. Thus a body released inside the space craft does not fall relative to it and it appears to be weight less. So in this way all the objects in satellite are in a state of weight lessness.

**ARTIFICAL GRAVITY**

**DEFINITION: -**

When a spaceship is caused to spin about its own axis, apparent weights of the objects in it becomes equal to their true weights. In this way an artificial gravity is provided to these weightless object in space ship.

**EXPLANATION: -**

1. Weightlessness in satellite (space ship) is highly inconvenient to the passenger. To overcome this problem of weightlessness, an artificial gravity is created in the satellite to permit the passengers (astronauts) to perform their experiments efficiently. This artificial gravity is achieved by causing the satellite to rotate about its own axis.
2. **Expression for the frequency of space craft: -**

Consider a space craft consisting of two chambers connected by a tunnel of length ‘L’. when the space craft is caused to spin about its own axis it describes a circle of radius as shown below.

Centripetal acceleration of spin motion is given as

where,

‘T’ is the time taken by the satellite to complete one rotation about its own axis.

no. of rotation per second (i.e. frequency of rotation) necessary to provide artificial gravity is calculated as

But,

frequency of rotation is given by

**SPECIAL CASE:**

If

and in order to provide artificial gravity

∴ frequency of rotation is given as

**CHAPTER # 7**

**WORK, POWER & ENERGY**

**WORK: -**

When a force Acts upon a body and displaces it through a certain distance ‘d’, the work is said to be done by the force on the body. If the force is constant and the displacement takes place along the direction of the force then work can be defined as the product of the magnitude of the force and that of the displacement.

**MATHEMATICAL EXPRESSION: -**

where,

‘F’ is the magnitude of force.

and ‘d’ is the magnitude of displacement

**“WORK”** when the force makes an angle with the direction of displacement .

When the force makes an angle with the direction of the displacement , then the magnitude of force which displace the body through a distance ‘d’ is .

In this case work done is equal to the product of the displacement and the component of the force along the direction of the displacement.

i.e.

**ANOTHER DEFINATION OF WORK: -**

From equation no (i) we can also define the work as the scalar product or dot product of force and displacement.

**SCALAR QUANTITY: -**

As the work is a scalar product of force and displacement therefore it is a scalar quantity.

**SPECIAL CASES: -**

1. **POSITIVE WORK: - (MAXIMUM WORK)**

Work done is maximum when the force acts along the direction of displacement .

i.e.

According to equation of work

1. **ZERO WORK: -**

Work done is zero when the force and displacement are at right angle to each other.

i.e. .

According to equation of work

1. **NEGATIVE WORK: -**

Work done will be negative when the displacement is in the opposite direction to that of force.

i.e.

According to equation

**For example:**

1. Work done by frictional force on application of brakes is negative.
2. If a body is lifted against gravity very slowly the angle b/w gravity and displacement is and corresponding. In this case work will be negative.

**EXAMPLE OF ZERO WORK: -**

When a body moves in a circular path the work done by the centripetal force on the body is zero because the centripetal force is always acts at right angles to the direction in which the body is moving.

**EXAMPLE OF POSITIVE WORK: -**

When a spring is stretched the work done by the stretching force is positive.

**UNITS OF WORK: -**

S.I unit of work is Joule

**JOULE: -**

The amount of work done which is required to move a body through a distance of 1m by a force of “1N” is called one Joule.

According to equation of work done.

**ELECTRON VOLT: -**

multiple of electron volt

**GRAVITATIONAL FIELD: -**

**DEFINATION:**

The space of region around the earth with in which a body can experience a force of attraction due to earth is called gravitational field.

**GRAVITATIONAL FORCE: -**

The force with which earth attracts a body towards its centre is called gravitational force.

**WORK DONE AGAINST GRAVITATIONAL FORCE: -**

In the gravitational field every massive body experiences a force towards the center of the earth called weight of the body, which is the product of its mass and acceleration due to gravity.

When the body moves along the direction of gravitational force, the work done by this force is positive and when the body moves against the gravitational force the work done is negative.

Consider a body of mass ‘m’ initially at height . Suppose that this body is lifted very slowly from initial height to a final height against the gravitational force of earth.

During its upward motion, the only force acting on the body is which is equal to

The net displacement of the body is

Hence the work done is given by

This is the work done against gravitational force. Negative sign show that the force and displacement are opposite to each other.

This work done is stored in the body in the form of its potential energy.

here ‘h’ is the difference of the heights between two positions. Hence it is not necessary to measure the height from the surface of earth.

**CONSERVATIVE FIELD: -**

“It is the region in which work done by the force of filed is independent of the path and does depend only on intial and final points”.

**OR**

In conservative field work done by the force of field along a close path is zero.

**CLOSED PATH: -**

A path in which a body after passing through several point reaches the starting point is called a closed path or loop.

* WORK DONE IN A GRAVITATIONAL FIELD AROUND A CLOSED PATH

**OR**

* TO PROVE THAT WORK DONE IN THE GRAVITATIONAL FIELD IS INDEPENDENT OF THE PATH

**GRAVITATIONAL FIELD:-**

The space or region around the earth in which a body can experience a force of attraction due to earth is called Gravitational Field.

**CLOSED PATH: -**

A path in which a body after passing through several points reaches the starting point is called a closed or loop.

**EXPLANATION: -**

Consider a closed path ABCA. The amount of work done to displace the body from A to B, B to C and from C to A are as follows.

1. **Work done from point A to B is calculated as:**

According to equation of work

In right angle triangle BDA

1. **Work done from B to C is calculated as:**
2. **Work done from point C to A is calculated as:**

Consider triangle CDA

Thus the work done along a closed path ABCA

This shows that the work done along the close path in gravitational field is zero. Therefore it is a conservation field.

1. **Also work done along the path is found as:**

In triangle ADC

1. **If we consider A to B, B to C and A to C two separate paths, then:**

i.e from eq no (2), (3) and (5)

i.e,

this show that

This shows that in conservation field work done is independent of the path followed and it only depends intial and final point.

**ENERGY: -**

The ability of a body to do work is called energy. There are many forms of energy.

For example:

1. Electrical energy
2. Heat energy
3. Solar energy etc

**KINETIC ENERGY: -**

The energy possessed by a body by virtue of its motion is called Kinetic energy.

**DERIVATION: -**

Consider a body of mass ‘m’ projected up in the gravitational field with velocity ‘V’ intial Kinetic energy of the body is used up in doing work against the force of gravity. At the maximum height the K.E of the body becomes zero. This means that the total work done is a measure of its intial kinetic energy.

Thus work done by the body in the gravitational field is

Using equation of motion

here,

thus,

Substituting the value of ‘h’ in the expression of work done.

So,

Hence, K.E of a body of mass ‘m’ moving with velocity ‘V’ is

**POWER: -**

The work done by an agency per unit time is called power.

**OR**

The rate of doing work is called power.

**EXPRESSION: -**

If the work is done at constant rate then the expression of power ‘P’ can be obtained as

i.e.

From the above expression power may also be defined as the dot product of force and velocity.

**UNITS OF POWER: -**

1. In S.I system of units, the unit of power is watt and it is that much power of an agency which does work at the rate of joule per second. i.e.
2. In British Engineering system the unit of power is horse power it is that much power of an agency which does work at the rate of 550 ft-lb per second.

**UNIT OF WORK IN TERMS OF POWER UNIT:**

Power is the work per unit time thus

Thus the unit of work (or energy) is kilo watt hour which is defined as it is the amount of work done when a power of one kilo watt is maintained for one hour. i.e.

**INSTANTANEOUS POWER: -**

It is defined as the work done in an extremely small interval of time (tending to zero) i.e.

**INTERCONVERSION OF P.E & K.E:**

**DERIVE WORK, ENERGY EQUATION: -**

Let a body of mass ‘m’ be raised through a certain height ‘h’. As the body is at rest at point ‘P’ so it possesses a P.E; mgh w.r.t point 0.

If the body is now allowed to fall down under the action of gravity, it will be accelerated downward and its velocity will go an increasing. The body will have main velocity at 0. As the body falls down its height from the ground decreases & so it’s P.E goes a decreasing. At the same time the K.E of that body goes an increasing due to its accelerated motion during the fall. When the body strikes the ground its P.E is converted into its K.E & ‘m’ is the mass of the body “V” its velocity that its K.E will be;

When is the velocity with which the body reaches the point 0. Using equation of motion we obtain velocity as,

Where,

Hence,

then,

Therefore kinetic energy at 0 = potential energy at p

Then we see that the P.E lost by the body in falling from p to 0 is equal to the K.E gained by it when reaches A. the simply means that when P.E of the body decreases, there is an equal increases in K.E.

Thus, loss of P.E = Gain in K.E

The above relation holds, good, when the force of air friction is negligible. Now suppose the force of air frictions ‘ f ’. When it falls down. As the weight of the body acts downward and the force of friction upward. So the net acceleration force on the body will be and the work done by it when the body falls through a certain height ‘h’ will be and this work should be equal to the Kinetic energy acquired by the body i.e.

i.e. loss of P.E = Gain in K.E + work done against friction

this equation is called work energy equation

**LAW OF CONSERVATION OF ENERGY: -**

“Energy can neither be created nor be destroyed but it may change from one form to another.”

**OR**

“The total energy of the system remains constant.”

**PROOF:**

Consider a body of mass lying at a height above the ground as the body is at rest therefore it’s at point ‘A’ is zero but the at this point is Thus,

If this body is allowed to fall from this point ‘A’. it’s increases due to increase in its velocity.

In order to calculated at point ‘B’. we find velocity at this point by using equation of motion.

Now we have,

Initial velocity of the body at point

Distance covered

Acceleration

The velocity at ‘B’ after covering distance

Now,

The Potential energy at point ‘B’ can be given as,

Thus total energy at point ‘B’ is given as

This shows that sum of Kinetic energy and the potential energy (total energy) is always constant provided that there is no force of friction during the motion of the body.

**ABSOLUTE GRAVITATIONAL POTENTIAL ENERGY**

**DEFINITION: -**

Absolute potential energy is defined as the work done in morning a body from earth’s surface to a point at infinite distance where the value of ‘g’ is negligible.

**DETERMINATION OF ABSOLUTE POTENTIAL ENERGY: -**

Consider a body of mass ‘m’ which is to be lifted from point ‘1’ to point ‘N’ in the gravitational field. Since the gravitational force b/w the body and the earth being inversely proportional to the square of the distance b/w them therefore it does not remain constant. To over come, this difficulty we divided the distance b/w the point 1, N into small steps each of length . This interval is so small that the gravitational force remain constant during this interval has the value equal to the average of the forces acting at two ends of an interval.

The force acting at the point 1 is given by,

Here,

Similarly the force acting at point 2 is given by

The average force acting throughout the first interval

i.e.

As is so small so its higher powers can be neglected.

Thus the work done by this force in lifting the body from point 1 to 2 is given as,

Since the force and displacement are in the same direction.

i.e.

Similarly the work done in lifting the body from 2 to 3, 3 to 4 ……………….. and so on

Hence the total work done to lift the body from point 1 to N will be.

i.e.

This is the P.E represented by of the body at point with respect to the point 1.

Hence the P.E of the body at point 1 with respect to point N is

If the point ‘N’ is situated at infinite distance then and this point ‘N’ becomes a reference point and at this point P.E is zero

If the body of mass ‘m’ lies at the surface of earth then

thus, at the surface of earth is

where is the radius of the earth.

The absolute gravitational P.E at height above the earth surface is given by

Using Binomial expansion formula and by neglecting the higher of

we get,

**CHAPTER # 5**

**TORQUE,EQUILIBRIUM & ANGULAR MOMENT**

**MECHANICS: -**

It is the study of effects of force.

**STATICS: -**

It is the branch of Mechanics which deals with stationary bodies.

**DYNAMICS: -**

It is the branch of Mechanics which deals with moving bodies.

**EQUILIBRIUM: -**

A body at rest or moving with uniform velocity along a straight line is said to be in Equilibrium.

In both the cases the body do not posses any acceleration. Hence all bodies in equilibrium do not posses any acceleration.

**TYPES: -**

1. **STATIC EQUILIBRIUM: -**

A body at rest is said to be in static equilibrium.

**EXAMPLES:**

Bridges, building, a box lying on a table.

1. **DYNAMICS EQUILIBRIUM: -**

A body moving with uniform velocity along a straight line is said to be in dynamic equilibrium.

**EXAMPLES:**

1. Suppose that a steel ball dropped into a viscous liquid contained in a vertical tube. Soon after the ball is dropped, its weight acting vertically downward is balanced by friction force of liquid. Hence the net force on the ball is zero. Therefore it has no acceleration i.e. the ball falls down with uniform velocity.
2. Consider a paratrooper who jumps from a helicopter. Soon after the jumps, his downward weight is balanced by the upward reaction of air. Hence the net force on the paratrooper is zero. There force it has no acceleration. i.e. the paratrooper falls down uniform velocity.

**CONDITION OF EQUILIBRIUM**

**FIRST CONDITION: -**

1. **STATEMENT**

If the algebraic sum of all the forces acting on a body is zero then the body is said to be in state of Equilibrium.

1. **MATHEMATICAL EXPRESSION**

Revolving each force in n, x and y components

This is true only If

The above equations are written in simplified forms as:

**CONCLUSION:**

Since the sum of x-directed force and y-directed force is zero, so the net force acting on the body is zero i.e.

It shows that. There is no acceleration in the body.

**TORQUE: -**

It is the ability of a force to rotate a body about its axis of rotation.

**OR**

It is the vector product of

**EXPLANATION: -**

1. Torque of a force applied at point ‘p’ of a body, about point o is given by,

Where is the angle b/w following figure illustrates the idea.

1. **DIRECTION: -**

Torque is a vector quantity. The direction of is along the normal to the plain containing and and is obtained by using the right hand rule.

As a convention, a torque producing clock wise rotation is taken as –ve and a torque producing anti clock wise rotation is taken as +ve.

1. If

and

Then we can represent the Torque vector in the determinant form as

Here,

are the units vectors pointing in the positive direction of the axes of x, y and z respectively.

1. Consider a force acting at a point ‘P’ on a body as shown in the figure

Torque if force about point 0 is calculated as

Consider

Here, ‘d’ is the perpendicular distance b/w axis of rotation and line of action of force and it is known as “MOMENT ARM OF FORCE”

The above expression shows that

1. **(a)** **MINIMUN TORQUE**

If the applied force passes through the axis of rotation i.e.

then

Following figure illustrates the idea.

**(b)** **MAXIMUM TORQUE**

If the applied force is at right angle to vector i.e.

Following figure illustrates the idea.

**UNIT: -**

The S.I unit of Torque is

**SECOND CONDITION OF EQUILIBRIUM: -**

**STATEMENT: -**

“If the algebraic sum of all the torque acting acting on a body is zero then the body is said to be in a state of Equilibrium”

It means that the sum of anti-clock wise and clock wise torque is zero.

**MATHEMATICAL EXPRESSION:-**

**SIGN CONVENTION:-**

As a sign convention a torque producing clock wise rotation is taken as –ve and a torque producing anti-clock wise rotation is taken as +ve.

Following figure illustrates the idea.

* A body is in complete equilibrium when

According to first condition

According to first condition

According to second condition

**COUPLE:-**

When two forces of equal magnitudes, but opposite in direction act upon a body such that lines of action do not pass through the same point then these forces are called couple.

Following figure illustrates the idea.

**EXPLANATION:-**

Consider a couple composed of two forces and acting at point ‘A’ and ‘B’ respectively as shown in the figure

The torque (moment) of force about point 0 is which is calculated as

The Torque and moment of the force about the same point ‘0’ is

where,

= is the position vector of point A with respect 0 and is the position.

Vector of the point B from axis of rotation ‘0’

Total torque (moment) of the two forces is given as.

where is the displacement vector from point B to A. the is the called the moment of couple

The magnitude of vector by definition.

where, is the angle b/w and

is the perpendicular distance b/w the lines of action of the forces and . This distance is denoted by d.

where,

d is the perpendicular called the arm of the couple.

Since is the displacement vector from and , it is independent of the location of origion therefore the moment of a given couple is independent of the location of origin.

**LOCATION OF AXIS: -**

Consider a uniform beam of length ‘l’ and weight ‘w’ Supported horizontally at its two ends as shown.

Applying 1st condition on the beam

\_\_\_\_\_\_\_\_\_\_\_(1)

Applying Second condition of Equilibrium taking Torque around point ‘0’

Consider again:

Now applying second condition of Equilibrium taken torque around point ‘P’

**CONCLUSION: -**

From eq no (2) and (3) we conclude that we are independent in choosing axis about which torques are calculated for the application of second condition of equilibrium.

**ANGULAR MOMENTUM: -**

1. The angular momentum of the particle about the origion ‘o’ is defined as the vector product of and

i.e.

where is the position vector

and is the linear momentum

Since linear momentum is given as

∴ the above equation becomes

where represent of velocity of the particle following figure illustrates the idea,

1. The magnitude of angular momentum is given by,

where and P represents magnitude of and respectively and is the angle b/w and

1. In circular motion and are perpendicular to each other so the measure of is and

So thus for circular motion we have

1. Since Angular momentum is a vector product therefore it may be written as follows
2. **UNIT: -**

The unit of angular momentum in the S.I system is

1. The dimensions of angular momentum are given as

Also,

1. We know that

The above expression shows that torque acting on a particle is the time rate of change of its angular momentum.

* **Law of conservation of angular momentum:**

If the net external (applied) torque acting on the system is zero then the total angular momentum of a system of particles is conserved (constant).

**TRANSLATORY MOTION: -**

It is that type of motion in which axes of frame of reference of the moving body remains parallel to the corresponding axes of frame of reference of the observer.

In translator motion every particle on the moving object under goes equal displacement.

**EXAMPLE:**

Motion of car, motion of train

**ROTATOR MOTION: -**

It is that type of motion in which every particle on the rotating body moves in a circle. A line passing perpendicular through the centre of circle is called axis of rotation. There are two types of rotatory motion.

1. **SPIN MOTION:**

It is the rotatory motion in which axis of rotation passes through the rotating body. For example: rotation of fan, rotation of top

1. **ORBITAL MOTION:**

It is the rotatory motion in which axis of rotation does not passes through the rotating body. For example: orbital motion of planets around the sun, orbital motion of election around the nucleus.

Using the definition of vector product prove the Law of Sins for the plane triangles of sides a, b and

Proof:

Consider a triangle as shown.

According to figure,

As we know that

from the defination of vector product,

from eq no (1)

As we know that,

Using the property we have

As we know that,

From Eq (A) & (B) we consider that

of

then,

Or

Proved!

**SHORT QUESTIONS / ANSWERS**

**CHAPTER # 2**

Q.1: Should a quantity having magnitude & direction be necessarily a vector?

A: No The necessary condition is that the quantity should obey the law of vector addition for example, electric current has magnitude as well as direction but is a scalar quantity. It is because electric current does not obey the law of vector additions.

Q.2: What is a null vector & what is its importance?

A: A vector has zero magnitude is called null vector or zero vector. It is denoted by “”. There is no need to specify the direction of a zero vector as its length is zero. The need of zero vector arisen because if we multiply a vector by zero, the result must be a vector i.e.,

Similarly,

Q.3: What is the necessary condition for adding vector?

A: The necessary condition for adding vectors is that the vectors must be of same kind. We cannot add displacement vector to velocity vector.

Q.4: Are these vectors & perpendicular to each other?

A: If they are perpendicular to each other than,

Hence, are perpendicular to each other.

Q.5: Is commutative law is applicable to vectors subtraction?

A: Commutative law is not applicable to vector subtraction because

Q.6: The sum & difference of two vectors are equal in magnitude i.e Prove that vectors are perpendicular?

A: Since, &

It is given,

Squaring both the sides.

Hence,

Q.7: The sum and difference of two vectors are Perpendicular to each other. Prove that the vectors are equal in magnitude?

.

Q.8: What is the condition for zero result and vector for three vectors acting simultaneously on a particle?

A: If three vectors acting simultaneously on a particle can be represented in magnitude & direction by the three sides of a triangle taken in same order, their resultant is zero. Under such a situation the particle is in equilibrium.

i.e,

Q.9: Can the resultant of two vectors of the same magnitude be equal to the magnitude of either of the vectors? How?

A: It is given that

also,

If R be the magnitude of resultant of than according to given statement

then,

Squaring on both sides.

Q.10: The net force of 20N acting on a body in vertical direction and there is no unbalance force in horizontal direction. Will the body move horizontally?

A: No body will not move in a horizontal direction because according to second law of motion, acceleration in a body depends, upon net force in a particular direction since there is no unbalanced force in horizontal direction there will be no motion.

Q.11: At what angle b/w

Q.12: Can a vector have a component greater the vectors magnitude?

A: No, a vector cannot have component greater than the vector magnitude. It can only have component equal in magnitude of the vector when its components in any other direction are zero.

Q.13: If What can you say about the components of the two vectors

A: If then the sum of their respective components will be zero i.e.

&

Q.14: Two vectors of unequal magnitudes can their sum be zero. Explain

A: No, the sum of two unequal vectors cannot be equal to zero whatever be the directions.

Q.15: Under what condition will the x and y components of the vectors be equal?

A: A vector will have equal components when vector makes angle of i.e.

&

Therefore, will yield same answer.

**CHAPTER # 3**

Q.1: Is it possible for a body to have an acceleration when moving with a (a) Constant velocity (b) Constant speed

A: **CONSTANT VELOCITY:** The rate of change of velocity is known as acceleration. Since these is no change of velocity if a body is moving with constant velocity so there will be no acceleration.

i.e.

**CONSTANT SPEED:** The body moving with constant speed can have acceleration because body moving with constant speed can have change in velocity and thus acceleration. Uniform circular motion is an example of body moving with constant speed but having centripetal acceleration.

Q.2: A body thrown vertically upward reaches its maximum height in 105. How much time will it take to fall?

A: Since in motion under growth the body takes equal time to raise & fall therefore the body will fall in 105.

Q.3: Two different masses dropped from same height which one will reach the ground earlier?

A: Both will reach at the same time in absence of air friction.

Q.4: Why is it difficult to stop loaded vehicle than unloaded vehicle?

A: She momentum depends upon mass and velocity. Since loaded vehicle has greater mass hence greater momentum or greater quantity of motion so it will be difficult to stop the loaded vehicle.

Q.5: The average velocity of a particle is zero but not its average speed. Is it possible?

A: Yes, if the particle starts from one point and comes back to the same point. In this case displacement is zero but not the distance travelled. Therefore, the average velocity is zero but not the average speed.

Q.6: If a body is thrown vertically upward with certain velocity, it reaches its maximum height in 105. How much time will it take to fall?

A: Since an object takes equal time to raise and fall, therefore object will take 105 to fall.

Q.7: Why it is difficult to stop can than motorcycle if both are moving with same velocity?

A: The more the momentum of the body the more difficult to stop it. Since momentum depends upon both mass & velocity therefore it will be difficult to stop the car, since it has more mass than motorcycle.

Q.8: Prove that bodies move with the same acceleration on frictionless plane?

A: Body is moving down the plane.

Which shows acceleration is independent of mass.

Therefore every body moves with the same acceleration irrespective of masses.

Q.9: Is it possible for the body that its displacement is zero but not the distance?

A: Yes, A ball thrown vertically upward return to the starting point after sometime Therefore, displacement is zero. However, the distance travelled is 2h where h is the maximum height to which the ball rises.

Q.10: Is it possible that the velocity of the object is zero but acceleration is non-zero?

A: The example of an object thrown vertically upward. At the highest point, velocity is zero but acceleration due to gravity is “g”.

**CHAPTER # 4**

Q.1: Why does bomber does not drop the bomb when he is above the target?

A: When bomb is dropped from moving plane. It follows a projectile path and therefore it will not hit the target which lies just below it.

Q.2: which keeps the object to follow a parabolic trajectory?

A: Gravitational forced of the earth lets the object to follow a parabolic path. In the absence of such force the object will continue its straight-line motions once fired.

Q.3: Is it possible in circular motion that

A: No, centripetal acceleration can’t be equal to zero as centripetal acceleration is due to the change in direction of velocity (linear), since in circular motion the direction of velocity is kept on changing from point to point.

Q.4: Is there any tangential acceleration if a body performs uniform circular motion?

A: No, since in uniform motion the magnitude of tangential velocity does not change, so there will be no tangential acceleration when body moves with in uniform circular motion.

Q.5: Is it possible that direction of angular acceleration is opposite to that of angular velocity?

A: If the angular velocity is decreasing than the direction of angular acceleration is opposite to that of angular velocity.

Q.6: Is it possible for a body to move in a circular path if there is no friction force on road?

A: No, body cannot move in a circular path as there will be no friction force, hence no centripetal force which keeps the object to move in a circular path. The body will follow straight line motion in the observe of friction or centripetal force.

Q.7: Can a body rotate about its center of gravity under the action of its weight?

A: No, a body cannot rotate about its center of gravity under the action of its weight since the moment arm will be zero and hence turning effect or torque will be zero.

**Chapter # 5**

Q.1: If a body satisfy 1st condition of equilibrium, can we say body is in complete equilibrium?

A: No, body will be in complete equilibrium when it satisfies first as well as second condition of equilibrium. i.e.

&

Q.2: Is it possible to produce torque in a body by applying force on axis of rotation of the body?

A: The body will not have any turning effect what’s over be the magnitude of the force. Since torque depends upon force as well as distance from axis of rotation. i.e.

Q.3: What do you say about angular momentum, if the net torque acting on body is zero?

A: If the net torque acting on the body is zero, then body will have a constant angular acceleration.

Which shows angular momentum remains conserve.

**CHAPTER # 6**

Q.1: Prove that acceleration due to gravity at the centre of earth is zero?

A: Acceleration due to gravity ‘g’ becomes zero to centre of earth. Since

At centre of earth d = Re

Q.2: Why passenger in satellite experience weight lessness though the force of earth is acting on it?

A: The passenger will experience weight lessness if they are in frame of reference which fall freely toward earth centre i.e.

Q.3: Why there is variation in value of ‘g’?

A: Variation in ‘g’ is due to the following reasons;

1. Earth is not a perfect sphere.
2. The earth is continuously in motion.

**CHAPTER # 7**

Q.1: Work done by the Centripetal force on the body is zero why?

A: Work done in by the centripetal force is zero because work done is the product of Force, displacement and , where is the angle b/w force and displacement. Since forces remains always Perpendicular to the displacement. Therefore , hence the work done will be zero.

Q.2: Show that work done against gravitational force is negative?

A: Work done is given by

**Chapter # 8**

Q.1: Why sound travels faster in warm all than cold air?

A: Since the speed of sound is given by

Which shows velocity is directly proportional to i.e.

In warm air temperature is greater than the cold air. Therefore sound towards faster in warm air.

Q.2: Why the amplitude of simple pendulum kept constant?

A: Since in simple pendulum is directly proportional to amplitude and while driving the formula for the time period we assume that is small which gives .

Q.3: Can two waves travelling in same direction in same medium produces standing waves?

A: No, Standing waves are produced when two waves travel in a same medium in opposite direction.

Q.4: Will the period of vibrating spring increases by adding more weight>

A: As the time period is given by,

Hence time period will increase if we increase the mass attached.

Q.5: Why does sound waves travel faster in solid than gases?

A: The speed of Sound is given by

Since the modulus of elasticity (E) is higher than that of gases, hence the Speed of sound waves is greater in solid than in gases since .

Q.6: Change of Pressure do not effect the velocity of Sound. Explain

A: The velocity of Sound is given by

When there is change in Pressure of medium there take place corresponding change in density of the medium So that the ratio remain constant. Therefore velocity remains constant during changes in Pressure.

Q.7: What would be the effect on velocity of waves in Stretched String if the tension in string is increased 4 times?

A: Since the velocity of transverse wave is related to tension according to the formula,

It shows that if is increased 4 times than velocity is increased by i.e. twice.

Q.8: Two Persons are talking with each other on surface of moon, will they hear each other?

A: No, Sound waves are mechanical waves & therefore need a material medium for their Propagation. There is no atmosphere at the moon so that sound waves cannot propagate

Q.9: Does acceleration of Simple harmonic oscillator remains constant during its motion? Is the acceleration is ever zero? Explain

A: The acceleration of Simple harmonic oscillator is given by,

Where ‘x’ is the displacement from mean position. As the ‘x’ changes acceleration will also change and it becomes zero as ‘x’ becomes zero. Acceleration is maximum at extreme position.

Q.10: A wave is produced along a stretched string but some of its, Particles Permanently show zero displacement? What type of wave is it?

A: This is stationary waves as some of the points of the medium remains Permanently Stationary. These particles are called as nodes.

Q.11: If the mass attached to the elastic spring is doubled, what would its effect on time period of oscillation?

A: Time period of spring mass attachment is given by,

Which shows, if the mass is doubled, so the time period will be increased by times or 1.42 times.

**CHAPTER 9 & 10**

Q.1: Why is these dark spot in the centre in Newton’s ring?

A: When monochromatic light falls, on Plano-convex lens, interference occurs between light waves reflected from top & bottom of air film. Since the thickness of air film is zero at the point of contact of lens glass plate the reflected rays from the centre do not have path difference and according to interference in thin film if the path difference is zero or a dark fringe will appear. Hence the center spot is dark.

Q.2: Why center fringe is bright in young double slit experiment?

A: Since both the light rays are coherent and hence initially in phase. When reach at the center of screen the path difference b/w them is zero and according to condition for constructive interference if path difference is zero or , a bright region will appear.

Q.3: Why x-rays do not diffract from ordinary slit?

A: Since the x-rays are of very short wavelength , since the opening is not comparable to the wavelength of light therefore X-rays do not diffract from ordinary slip.

Q.4: An oil film spreading over a road shows colours. Explain how does it happen?

A: An oil film on the surface of earth behave as a thin film, sunlight is reflected from the lower and upper portion of film and hence interfere with each other. Since we know white light consist of seven colours, we see only those colours which interferes constructively when reaches are eyes.

Q.5: Can there be diffraction without interference and interference without diffraction?

A: Interference can take place without diffraction, Interference infect is the resultant effect of the Superposition of waves coming from two coherent sources.

Diffraction cannot take place without interference. It is due to interference of waves, diffracted from the obstacle.

Q.6: Why a convex lens of small focal length preferred for a magnifying glass?

A: The magnifying power of magnifying glass is given by,

Since thus the smaller focal length the higher the magnification produced.

Q.7: At what position does a converging lens acts as a diverging lens?

A: When an object is placed within focal length of a convex lens, than a virtual erect and magnified image is formed by the lens on the same side which is the properties of image formed by concave lens.

Q.8: Although we can hear around corners, we cannot see around corners. Explain.

A: Sound & light both are waves. But the wavelength of sound waves is very large as compared to wavelength of light. Hence sound waves are bent around. Corners (of windows, door etc) so they are heard. However, light waves are diffracted by extremely small amount around corners of ordinary objects. So light cannot be observed around corners as they require very thin object comparable to wavelength of light to diffract.

Q.9: How does Thomas Young obtain the condition of phase coherence in his double slit experiment?

A: Phase Coherence means waves should be of the same phase or of constant difference in phase. Young obtain coherent light rays by illuminating Screen with monochromatic light having two narrow slits. Thus original beam of light is splitted into two parts, which are coherent. So interference effect can be observed.

Q.10: Why is it not possible to use identical lamps to obtain interference fringes?

A: Two waves from two different lamps of identical nature differ in phase and their phase difference is not constant. The condition of phase coherence is not satisfied.

**MISCALLANEOUS QUESTIONS**

Q.1: If the velocity of Projectile is doubled what will be its effect on range and max height of Projectile?

A: Since the relation between range, height and velocity is,

&

which shows

If the velocity is doubled than the Range and maximum height will increase 4 times.

Q.2: Wether Person do some work if he lifts the suitcase & starts his motion?

A: No, Since the work depends upon the angle between force and displacement. Since the force is perpendicular to the direction of displacement. Therefore no work will be done i.e.