Chapter no 3:

"Dynamics"

Q no 1

Differentiate between kinematics & dynamics?

Ans:

Kinematics	Dynamics
The branch of mechanics that deals with the study of motion of a body without discussing the cause of motion.	The branch of mechanics that deals with the study of motion of an object and the cause of its motion.

Q no 2

Define the following terms:-

(i) Force (ii) Inertia (iii) Momentum

(i) Force:-

A Force moves or tends to move, stop or tends to stop the motion of a body. The force can also change the direction of motion of body. It can also change the shape or size of the object.

(i) It is a vector quantity.
(ii) It is represented by F.
(iii) Its unit is Newton represented by N.
(iv) Its formula is F = ma

(iii) Inertia:-

Inertia is that characteristic of a body due to which it resists any change in its state of rest or rest of uniform motion.

Examples to understand inertia:-

Take a glass and cover it with a piece of cardboard. Place a coin on the cardboard. Now kick the card horizontally with a jerk of your finger. The coin does not move with the cardboard due to inertia and fell into the glass because it continue its state of rest.

Consider another example of inertia. Cut a strip of paper. Place it on the table. Stack a few coins at its one end. Pull out the paper strip under the coins with a jerk. The coin will remain at its position due to inertia.

(iii) **Momentum:-**

The quantity of motion of a body it posseses due to its mass and velocity is called momentum.

(i) It is a vector quantity.

(ii) It is represented by P.

(iii) Its SI unit is $kgms^{-1}$ or (Ns).

(iv) Its formula is as $P = mv$.

Momentum of system depends upon mass and velocity of a body.

Q No 3

State Newton's first law of motion. Why is it called law of inertia?

Ans:-

Newton's first Law:-

"Everybody continues its state of rest or of uniform motion in a straight line provided no net force acts on it."

According to newton's first law of motion, a body at rest provided no net force acts

on it. This part of the law is true as we observe that objects do not move by themselves unless someone move them. For example, a book lying on a table remains at rest as long as no net force acts on it.

Similarly, a moving object doesnot stop moving by itself. A ball sounds on a rough group stops earlier than that rolled on a smooth ground. It is because rough surfaces offer greater frictions. If there would be no force to oppose the motion of a body then then moving body would never stop.

Newton's first Law as law of inertia

Since newton's first law of motion deals with the inertial property of matter, therefore, Newton's first law of motion is known as law of inertia.

Q NO 4

State and Desive Newton's second Law of motion:

Ans:

Newton's Second law of motion:

"When a net force acts on a body an acceleration is produced in the direction of net force, the magnitude of acceleration is directly proportional to the applied force and is inversely proportional to mass of body.

If a body force F produces an acceleration (a) in a body of mass (m), then the body will be accelerated in the direction of force. If we double the applied force, the acceleration will be doubled. The magnitude of acceleration is directly proportional to applied force

$$a = P \quad \text{---} \quad (i)$$

It is easy to produce acceleration in a lighter body than that of heavier body. It means that acceleration produced by the force is inversely proportional to the mass of body.

$$a = \frac{1}{m} \quad \text{.....} \quad (ii)$$

combining (i) and (ii) ...

$$\Rightarrow a = \frac{F}{m} \quad , \quad a = \text{constant} = \frac{F}{m}$$

putting k as propositionally constant, we get

$$a = \frac{kF}{m}$$

Let F = 1N which produce acceleration $1ms^{-2}$ in a body of mass 1kg.

In SI units, the value of k comes out to be 1.

Those above equation becomes.

$$a = \frac{F}{m} \quad , \quad F = ma.$$

Q no 5

Define newton (unit of force).

Ans:

"One newton is that force which produces an acceleration of one metre per second square in a body of mass one kilogramme."

$$1N = 1kg \times 1ms^{-2}$$

$$1N = kgms^{-2}.$$

Q No 6

What is the difference between Mass & Weight?

Mass	Weight
Mass of a body is the quantity of matter possesed by the body.	Weight of a body is equal to the force with which Earth surface the body towards its centre
It is represented by m.	It is represented by W.
It does not change with change of place.	It varies from point to point depending upon the value of g.
It is measured by physical balance.	It is measured by spring balance.
Its unit is kg.	Its unit is Newton.
Formula of mass is $m = \frac{F}{a}$.	Formula of weight is $W = mg$.

Q No 7

Explain newton's third law of motion?

Ans:

Statement:

"To every action there is always an equal but opposite reaction.

Explanation:

Newton's third law of motion deals with reaction of a body when a force acts. Let a body A exerts a force on another body B, the body B reacts against this force and exerts a force on body A. The force exerted by body A on B is called action. Where as the force exerted by body on A is called the reaction force.

Note:

According to this law, action is always accompained by a reaction force and the two forces must always be equal and opposite. Action and reaction force act on two different bodies.

Example 1:

Consider a book on a table. The weight of the book is acting on the table in the downward direction This is called action. The reaction of the table acts on book in the upward direction. This is called reaction.

Example 2:

Take an air filled balloon. When the

balloon is set free, the air inside it rushes out and the balloon moves forward. In this example, the action is by the balloon that pushes the air out of it when set free. The reaction of the air which escapes out from the balloon acts on the balloon. It is due to this reaction of the escaping air that moves the balloon forward.

Example 3:-

A rocket moves on the same principle. When its fuel burns, hot gases escape out from its tail with a very high speed. The reaction of these gases on the rocket causes it to move opposite to the gases rushing out of its tail.

Q No 8

Define tension. Also write its conditions during the vertical motion of a block.

Ans:-

"The force exerted along a string when it is subjected to pull". Tension and weight are in opposite direction.

OR

The force acting along the string is called tension.

i.e. $T = W = mg$

It is a vector quantity. And its SI unit is Newton. It is represented by T.

Condition:

(i) If $T > W$ then body moves upward.

(ii) If $T < W$ then body moves downward.

(iii) If $T = W$ then body does not move.

Q No 9

Find the tension and acceleration during vertical motion of two bodies attached to the ends of a string that passes over a frictionless pulley?

Ans:

Consider two bodies 'A' and 'B' of masses m_2 respectively. Let m_1 is greater than m_2. The bodies are attached to the opposite ends of an inextensible string. The string passes over a frictional pulley. The body 'A' being heavier must be moving downwards with some acceleration. Let this acceleration be 'a'. At the same time the body B attached to the other end of the string moves up with the same acceleration 'a'. As the

pulley is fictionless, hence tension will be same throughout the string. Let the tension is the string be 'T'.

Since the body 'A' moves downward, hence its weight m_1g is greater than the tension T in the string.

Net force acting on body A = weight - T

$$F_1 = w_1 - T \Rightarrow F_1 = m_1g - T$$

From second law of motion:

$$F_1 = m_1a$$

Putting the values in above equation

$$m_1a = m_1g - T \quad \text{——(i)}$$

As body B moves upward, hence its weight m_1g is greater than the tension T in the string.

Net force acting on body B = T - weight.

$$F_1 = T - w_2 \Rightarrow F_2 = T - m_2g$$

And from second law

$$F_2 = m_2a$$

Putting the value in above equation

$$m_2a = T - m_2g$$

Adding eq (i) and eq (2), we get acceleration

$$m_1a + m_2a = m_1g - T + T - m_2g$$

$$(m_1 + m_2)a = (m_1 - m_2)g$$

$$a = \left[\frac{m_1 - m_2}{m_2 + m_2}\right] g \quad \text{---- (A)}$$

By using this formula we can find acceleration.

By dividing eq (1) and (2), we get tension.

$$\frac{m_1 a}{m_2 a} = \frac{m_2 g - T}{T - m_2 g}$$

$$\frac{m_1}{m_2} = \frac{m_2 g - T}{T - m_2 g}$$

$$\Rightarrow m_1 (T - m_2 g) = m_2 (m_2 g - T)$$

$$m_1 T - m_1 m_2 g = m_2 m_2 g - m_2 T$$

$$m_2 T + m_2 T = m_2 m_2 g + m_1 m_2 g$$

$$T (m_1 + m_2) = 2 m_1 m_2 g$$

$$T = \left[\frac{2 m_1 m_2}{m_1 + m_2}\right] g$$

The above arrangement is also known as Atwood machine. It can be used to find the acceleration g due to gravity by using relation given below:

$$g = \left[\frac{(m_1 + m_2)a}{m_1 - m_2}\right]$$

Q No 10

What is atwood machine?

Ans:-

"It is a machine which is used to find the acceleration due to gravity".

Construction:-

Atwood machine is an arrangement of two objects of unequal masses. Both the object are attached to the ends of a string. The string passes over a fictionless pulley.

$$g = \frac{(m_1 + m_2)a}{m_1 - m_2}$$

Q No 11

Find out a relation for acceleration and tension for motion of two bodies attached to the end of a string that passes over a frictionless pulley such that one body moves vertically and the other moves on a string that horizontal surface.

Ans:-

Consider two bodies A and B of masses m_1 and m_2 respectively attached to the ends of an inextensible string. Let the body 'A' moves downward with an

acceleration 'a', Body 'B' also moves over the horizontal surface with some acceleration (a). As the pulley is frictionless, hence tension T will be the same throughout the string.

Since body A moves downwards, therefore, its weight $m_1 g$ is greater than the tension T in the string.

Net force acting on body A.

Net force acting on body A

$$F_1 = m_1 g - T$$

And from second law $F_1 = m_1 a$

$$m_1 a = m_1 g - T$$

The force acting on body B

The forces acting on body B are:

(i) Weight $m_2 g$ of the body B acting downward.

(ii) Reaction R of the horizontal surface acting on body B in the upward direction.

(iii) Tension T in the string pulling the body B horizontally over the smooth surface.

As body B has vertical motion, hence resultant of vertical forces ($m_2 g$ and R) must be zero. Thus,

The net force acting on body B is T.

$$F_2 = T$$

According to Newton's second law of motion $F_2 = m_2 a$

$$m_2 a = T \quad ---(2)$$

According Eq (1) & (2)

$$m_1 a + m_2 a = m_1 g - T + T$$

$$m_1 a + m_2 a = m_1 g$$

$$a(m_1 + m_2) = m_1 g$$

$$a = \frac{m_1 g}{m_1 + m_2} \quad ------ (A)$$

Putting the value of 'a' in eq (2)

$$T = \frac{m_1 m_2 g}{m_1 + m_2} \quad --(B).$$

Q NO 12

Show that range of change of momentum is equal to applied force?

Ans:-

"When a force acts on a body, it produces an acceleration in the body and will be equal to the rate of change of momentum of the body."

Explanation:

Consider a body of mass (m) moving with initial velocity v_i

When a force acts upon a body an acceleration is produced in it, this change the velocity v_i of the body of final velocity v_f.

If P_i and P_f be the initial momentum and final momentum of the body related to initial and final velocity respectively then

$$P_i = mv_i$$

and $$P_f = mv_f$$

Change in Momentum = final momentum - initial momentum

$$\frac{P_f - P_i}{t} = \frac{mv_f - mv_i}{t}$$

$$\frac{P_f - P_i}{t} = m\frac{v_f - v_i}{t} \quad \text{------ (1)}$$

Since $\frac{v_f - v_i}{t} = a$ $\quad \therefore \frac{P_f - P_i}{t} = ma$ ------ (2)

According to newton's second law of motion,

$F = ma$ put in eq. no. (2)

$$\frac{P_f - P_i}{t} = F$$

OR

$F = \frac{P}{t}$ This equation shows that rate of change of momentum is equal to applied force.

Q No 13

Explain law of conservation of momentum? Also drive its formula.

Ans:

Law of conservation of Momentum:

Statement:

The momentum of an isolated system of two or more than two interacting bodies remains constant. Momentum of a system depends on its mass and velocity. "An isolated system is a group of interacting bodies on which no external force is acting." If no unbalanced or net force acts on a system, its momentum remains constant. Thus the momentum of an isolated system is always conserved. This is the law of conservation of momentum.

Explanation:

Consider an isolated system of two spheres

of masses m_1 and m_2. They are moving in a straight line with initial velocities u_1 and u_2 respectively, such that u_1 is greater than u_2. Sphere of mass m_1 approaches the sphere of mass m_2 as they move.

Initial momentum of mass $m_1 = m_1u_1$

Initial momentum of mass $m_2 = m_2u_2$

Total initial momentum of the system before collision

$= m_1u_1 + m_2u_2$

After sometime mass m_1 hits m_2 with some force. According to Newton's third law of motion, m_2 exerts an equal and opposite reaction force on m_1. Let their velocities become v_1 and v_2 respectively after collision. Then

Final momentum of mass $m_1 = m_1v_1$

Final momentum of mass $m_2 = m_2v_2$

Total final momentum of the system after collision $= m_1v_1 + m_2v_2$

According to the law of conservation of momentum

Total initial momentum of the system before collision = Total final momentum of the system after collision

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

This equation shows that the momentum of an isolated system before and after collision remains the same which

is the law of conservation of momentum.

Law of conservation of momentum is an important law and has vast applications.

Application of law of conservation of momentum:

Consider a system of gun and a bullet. Before fising the gun, both the gun and bullet are at rest, so the total momentum of the system is zero. As the gun is fired, bullet shoots out of the gun and acquires momentum. To conserve momentum of the system, the gun recoils. According to the law of conservation of momentum, the total momentum of the gun and the bullet will also be zero after the gun is fired. Let m be the mass of the bullet and v be its velocity on fising the gun; M be the mass of gun and V be the velocity with which it recoils. Thus the total momentum of the gun and the bullet after the gun is fired will be;

[Total momentum of the gun and the bullet after the gun is fired] = MV + mv

According to the law of conservation of momentum.

[Total momentum of the gun and the bullet after the gun is fired] = [Total momentum of the gun and the bullet before the gun is fired]

$\therefore MV + mv = 0$

$MV = -mv$

Hence $V = -\frac{mv}{M}$

Equation gives the velocity V of the gun.

Negative sign indicates that velocity of the gun is opposite to the the velocity of the bullet i.e. the gun recoils. Since mass of the gun is much larger than the bullet, therefore, the recoil is much smaller than the velocity of the bullet.

Examples

Rockets and jet engines also work on the same principal. In these machines, hot gases produced by burning of fuel rush out with large momentum. The machines gain an equal and opposite momentum. This enables them to move with very high velocities.

Q no 14

Define friction and how does it produce?

Ans:-

"The force that opposes the motion of moving objects is called friction."

Explanation

Friction is a force comes into action as soon as a body is pushed or pulled over a surface. In case of solids, the force of friction between two bodies depend upon many factors such as nature of the two surfaces in contact and the pressing force between them.

Production of friction:-

No surface is perfectly smooth. A surface that appears smooth has pits and bumps that can be seen under a microscope. Two wooden blocks with their polished surface in contact. A magnified view of two smooth surfaces in contact shows the gaps and contacts between them. The contact points between the two surfaces form a sort of cold welds. These cold welds resist the surfaces sliding over each other. Adding weight over the upper block increases

the force pressing the surfaces together and hence, increases the resistance. Thus, greater is the pressing force greater will be the friction between the slidding force.

Q No 15

Define Limiting friction.

Ans:

"The maximum value of friction is known as the force of limiting friction (F_s)".

It depends on the normal reaction (pressing force) between the two surfaces in contact.

Q No 16

What is meant by co-efficent of friction? Write its mathematical form.

Ans:

Co-efficent of friction:

"The ratio between the force of limiting friction F_s and the normal reaction R is constant. This constant is called the coefficent of friction and is represented by μ."

Thus $\mu = \frac{F_s}{R}$

$F_s = \mu R$

If m be the mass of the block, then for horizontal surface:

$R = W$

$R = mg$

Hence $F_s = \mu mg$.

Unit:

Co-efficent of friction has no unit.

Q No 17

Why is rolling friction less than slidding friction?

Ans:

When the axle of a wheel is pushed, the force of friction between the wheel and the ground at the point of contact provides the reaction force. The reaction force acts at the contact points of the wheel in a direction opposite to the applied force. The wheel rolls without rupturing the old wheel. Thats why the rolling friction is extremely small than sliding friction.

Q No 18

Write a few applications of rolling friction?

Ans:

Application of rolling friction:

i. The fact that rolling friction is less than sliding friction is applied in ball bearings or roller bearings to reduce losses due to friction.

ii. The wheel would not roll on pushing it if there would be no friction between the wheel and the ground. Thus, friction between the wheel and the ground is desireable for wheels to roll over a surface. It is dangerous to drive on a wet road because the friction between the road and the tyres is very small. This increases the chance of slipping the tyres from the road. The threading on tyres is designed to increase friction. Thus, threading improves road grip and make it safer to drive even on wet road.

iii. A cyclist applies brakes to stop bicycle, As soon as brakes are applied, the wheels stop rolling and begin to slide over the road. Since sliding friction is much greater than rolling friction. Therefore, the cycle stops very quickly.

Q NO 19

How does Braking and Skidding happen?

Ans:

The wheels of a moving vehicle have two velocity components:

i: Motion of wheels along the road.

ii: Rotation of wheels about their axis.

Braking:

"The force of friction (gripping force) between the tyres and the road must be enough that prevents them from slipping."

To move a vehicle on the road as well as to stop a moving vehicle requires friction between its tyres and the road. For example, if the road is slippery or the tyres are worn out then the tyres instead of rolling, slip over the road. Thus for the wheels to roll, the force of friction between the tyres and the road must be enough that prevent from slippery.

Skidding:

In order to reduce the chance of skidding it is advisable not to apply brakes too hard that

lock up their rolling motion especially at high speeds. Moreover, it is unsafe to drive a vehicle with worn out tyres."

To stop a car quickly, a large force of friction between the tyres and the road is needed. But there is a limit to this force of friction that tyres can provide. If the brakes are applied too strongly, the wheels of the car will lock up (stop turning) and the car will skid due to its large momentum. It will lose its directional control that may result in an accident.

Q no 20

Write advantages and disadvantages of friction?

Ans:

Disadvantages:

i: Friction is undesirable when moving at high speeds because it opposses the motion and thus limits the speed of moving object.

ii. Most of energy is lost as heat and sound due to the friction between various moving parts of machines.

iii. In machines, friction also causes wear and tear of their moving parts.

iv. Shoes and clothes also wear out due to friction.

Advantages:-

i: Friction is needed to walk on the ground.

ii: We cannot write with pencil if these is no friction between pencil and paper.

iii: Athletes use special shoes that have extraordinary ground grip. Such shoes prevent them from slipping while running fast.

iv: We can stop the fast moving vehicles when we apply brakes.

v: Birds cannot fly, if these is no air resistance. The reaction of pushed air enables the birds to fly.

vi: Nails remain fixed in the walls due to friction.

vii: Most of living bodies climb on trees only due to friction.

Q NO 21

Write down few methods of reducing friction?

Ans:-

The friction can be reduced by following proper methods:

i. Making the sliding surface smooth by polish.

ii. Making the fast moving objects a streamline

shape (fish shape) such as cars, aeroplanes, etc. This causes the smooth flow of air and thus minimize air resistance at high speeds.

iii. Lubricating the sliding surfaces e.g (oil or grease is used for this purpose).

iv. Using ball bearings or roll bearings. Because the rolling friction is lesser than the sliding friction.

Q No 22

Define circular motion. Also write its example.

Ans:

"The motion of an object in a circular path is known as circular motion."

Example:

Take a small stone. Tie it at one end of a string and keep the other end of the string in your hand. Now rotate the stone holding the string. The stone will move in a circular path. The motion of stone will be called as circular motion.

Q No 23

Define and explain centripetal force and write down its mathematical form?

Ans:

Centripetal force:

"Centripetal force is a force that keeps a body to move in a circle."

Example 1:

The moon revolves around the nucleus. The gravitational force of the Earth provides the necessary centripetal.

Example 2:

Electrons revolve around the nucleus. The electrostatic force between electrons and nucleus provide the necessary centripetal force.

Example 3:

A stone tied to one end of a string rotating in a circle. The tension in the string provides the necessary centripetal force. It keeps the stone to remain in a circle.

Factors:

Centripetal force depends on following factors:

(i) Mass of body (m).

(ii) Square of velocity of body (v^2).

(iii) Radius of circle. (r)

Explanation:

Let a body of mass (m) move with uniform speed (v) in a circle of radius (r). The acceleration a_c produced by the centripetal force F_c is given by

Centripetal acceleration $a_c = \frac{v^2}{r}$

The acceleration produced by the centripetal force is always directed towards the centre of circle is called centripetal acceleration.

According to Newton's second law of motion, the centripetal force F_c is given by

$$F_c = ma_c$$

$$F_c = \frac{mv^2}{r}$$

E

Above equation shows that the centripetal force needed by a moving in a circle depends on the

mass (m) of the body, square of its velocity (v) and reciprocal to the radius (r) of the circle.
Centripetal force always acts perpendicular to the motion of the body.

- If the mass of body is doubled then centripetal force will also become doubled.
- If velocity of body is doubled then centripetal force become four-time.
- If radius of circle is doubled then centripetal force is reduced to half.
- Centripetal force is always perpendicular to the motion of the body.
- Centripetal force and centripetal acceleration is directed towards the centre of circle.

Q no 24

Define centrifugal force.

Ans:-

"A force which plays the body outward during the circular motion is called centrifugal force."

Consider a stone, tied to a string moving

in a circle. The necessary centripetal force acts on the stone through the string that keeps it move in a circle. According to Newton's third law of motion, there exists a reaction to this centripetal force. Centripetal reaction that pulls the string outward is sometimes called the centripetal force.

Q no 25

From where does centripetal force Fc come during motion on circular track?

Ans:-

When a car takes a turn, centripetal force is needed to keep it in its curved track. The friction between the tyres and the road provides the necessary centripetal force.

Q no 26

Why is the outer edge of road kept higher than inner edge?

Ans:-

When a car takes a turn, centripetal force is needed to keep it in this curved track. The friction between the tyres and the road provides the necessary

centripetal force. The car would skid if the force of friction between the tyres and the road is not sufficent enough particularly when the roads are wet. This problem is solved by banking of curved roads. Banking of a road means that the outer edge of a wall is raised. Imagine a vehicle on a curved road.

Q No 27

Explain the working of washing machine?

Ans:

The dryer of a washing machine is basket spinner. They have a perforated wall having large number of fine holes in the cylindrical rotor.

The lid of the cylindrical container is closed after pulling wet clothes in it. When it spins at high speed, the water from wet clothes is forced out through these holes due to lack of centripetal force.

Q No 28

Explain cream seperator?

Ans:

Most modern plants use a seperator to control the

fat contents of various products. A seperator is a high-speed spinner. It acts on the same principle of centrifuge machine.

The bowl spins at very high speed causing the heavier contents of milk to move outward in the bowl pushing the lighter contents inward toward the spinning axis. Cream or butterfat is lighter than other components in milk. Therefore, skimmed milk, which is denser than cream is collected at the other wall of the bowl. The lighter part (cream) is pushed toward the centre from where it is collected through a pipe.