WAY TO SUCCESS

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10th

SCIENCE

Study material

Unit - 1

LAWS OF MOTION

Dear Teachers! & Students!

We publish this study material on the request of many teachers and students. This study material contains only Book back exercise questions. Way to success – 10th science guide will be published very shortly. Way to success is preparing 10th science guide based on Govt.New Pattern with the help of expert cum experienced teachers to give an assurance for you to score high marks in your public examination.

Best Wishes to All.....

Way to Success team

PHYSICS

1. LAWS OF MOTION

TEXTBOOK QUESTIONS

I. Choose the correct answer

1. Inertia of a body depends on

a) weight of the object b) acceleration due to gravity of the planet

c) mass of the object d) Both a & b

2. Impulse is equals to

a) rate of change of momentum b) rate of force and time

c) change of momentum d) rate of change of mass

3. Newton's III law is applicable

a) for a body is at rest b) for a body in motion

c) both a & b d) only for bodies with equal masses

4. Plotting a graph for momentum on the X-axis and time on Y-axis. slope of momentum-time graph gives

a) Impulsive force b) Acceleration

c) Force d) Rate of force

5. In which of the following sport the turning of effect of force used

a) swimming b) tennis **c) cycling** d) hockey

6. The unit of 'g' is m s^{-2}. It can be also expressed as

a) cm s^{-1} **b) N kg^{-1}** c) N m^2 kg^{-1} d) cm^2 s^{-2}

7. One kilogram force equals to

a) 9.8 dyne b) 9.8 × 10^4 N **c) 98 × 10^4 dyne** d) 980 dyne

8. The mass of a body is measured on planet Earth as M kg. When it is taken to a planet of radius half that of the Earth then its value will be ____ kg

a) 4 M b) 2M **c) M/4** d) M

[Hints: $M = \frac{gR^2}{G}$; $R = \frac{R}{2}$; $M = \frac{g\left(\frac{R}{2}\right)^2}{G} = \frac{1}{4}\frac{gR^2}{G} = \frac{M}{4}$]

9. If the Earth shrinks to 50% of its real radius its mass remaining the same, the weight of a body on the Earth will

a) decrease by 50% b) increase by 50%

c) decrease by 25% d) increase by 300%

10. To project the rockets which of the following principle(s) is /(are) required?

a) Newton's third law of motion

b) Newton's law of gravitation

c) law of conservation of linear momentum

d) both a and c

II. Fill in the blanks

1. To produce a displacement ***Force*** is required
2. Passengers lean forward when sudden brake is applied in a moving vehicle. This can be explained by ***Newton's first law.***
3. By convention, the clockwise moments are taken as ***negative*** and the anticlockwise moments are taken as ***positive.***
4. ***Accelerator pedal*** is used to change the speed of car.
5. A man of mass 100 kg has a weight of ***980 N*** at the surface of the Earth

III. State whether the following statements are true or false. Correct the statement if it is false:

1. The linear momentum of a system of particles is always conserved - ***True***
2. Apparent weight of a person is always equal to his actual weight - ***True***
3. Weight of a body is greater at the equator and less at the polar region - ***False***
   Corrected statement: Weight of a body is **less** at the equator and **greater** at the polar region
4. Turning a nut with a spanner having a short handle is so easy than one with a long handle - ***False***
   Corrected Statement: Turning a nut with a spanner having a **long** handle is so easy than one with a **short** handle
5. There is no gravity in the orbiting space station around the Earth. So the astronauts feel weightlessness - ***True***

IV. Match the following :

Column I	Column II	Answer
Newton's I law	propulsion of a rocket	Stable equilibrium of a body
Newton's II law	Stable equilibrium of a body	Law of force
Newton's III law	Law of force	Flying nature of bird
Law of conservation of Linear momentum	Flying nature of bird	propulsion of a rocket

V. Assertion & Reasoning :

Mark the correct choice as

(a) If both the assertion and the reason are true and the reason is the correct explanation of assertion.
(b) If both the assertion and the reason are true, but the reason is not the correct explanation of the assertion.
(c) Assertion is true, but the reason is false.
(d) Assertion is false, but the reason is true.

1. Assertion : The sum of the clockwise moments is equal to the sum of the anticlockwise moments.
Reason : The principle of conservation of momentum is valid if the external force on the system is zero.

Ans. (b) If both the assertion and the reason are true, but the reason is not the correct Explanation of the assertion.

2. Assertion : The value of 'g' decreases as height and depth increases from the surface of the Earth.
Reason : 'g' depends on the mass of the object and the Earth.

Ans. (a) If both the assertion and the reason are true and the reason is the correct explanation of assertion.

VI. Answer briefly:

1. Define inertia. Give its classification.

Any body would like to continue to be in its state of rest or the state of motion is known as Inertia.

Classification of Inertia

(i) Inertia of rest
(ii) Inertia of motion
(iii) Inertia of direction

2. Classify the types of force based on their application.

Types of Forces:

(i) Like parallel force
(ii) Unlike parallel force

3. If a 5 N and a 15 N forces are acting opposite to one another. Find the resultant force and the direction of action of the resultant force

Given , $F_1 = 5N$ $F_2 = 15\ N$

Two forces acting opposite one another. Therefore, Resultant force. $F_{net} = F_2 - F_1$

$F_{net} = 15 - 5 = 10\ N$. The direction of $F_{net}\ is\ F_2$.

4. Differentiate mass and weight.

Mass	Weight
1. Fundamental quantity	1. Derived quantity
2. Quantity of matter contained in the body	2. Gravitational force exerted on it due to the Earth's gravity
3. Its unit Kg	3. Its unit Newton
4. It is measured by physical Balance	4. It is measured by Spring Balance

5. Define moment of a couple.

The line of action of the two forces does not coincide. It does not produce any translatory motion since the resultant is zero. But a couple results in causes the rotation of the body. Rotating effect of a couple is known as moment of a couple.

6. State the principle of moments.

When a number of like or unlike parallel force act on a rigid body and the body is in equilibrium, then the algebraic sum of the moments in the clockwise direction is equal to the algebraic sum of the moments in the anticlockwise direction. **(or)**

At equilibrium, the algebraic sum of the moments of all the individual forces about any point is equal to zero.

7. State Newton's second law.

The force acting on a body is directly proportional to the rate of change of linear momentum of the body and the change in momentum takes place in the direction of the force.

$$F \propto \frac{mv - mu}{t}$$

8. Why a spanner with a long handle is preferred to tighten screws in heavy vehicles?

- When the handle of the spanner is long, the force required to turn the body is less.
- The turning effect of a body depends upon the perpendicular distance of the line of action of the applied force from the axis of rotation.

Moment of force = F× d

- Hence, the spanner has a long handle is preferred to tighten screws in heavy vehicles.

9. While catching a cricket ball the fielder lowers his hands backwards. Why?

- A fielder pulls back his hand while catching the ball.
- He experiences a smaller force for a longer interval of time to catch the ball, resulting in a lesser impulse on his hands.

10. How does an astronaut float in a space shuttle?

- Astronauts are not floating but falling freely around the earth due to their huge orbital velocity.
- Since space station and astronauts have equal acceleration , they are under free fall condition.
- Hence, both the astronauts and the space station are in the state of weightlessness.

VII. Solve the given problems

1. Two bodies have a mass ratio of 3:4 The force applied on the bigger mass produces an acceleration of 12 ms^{-2}.What could be the acceleration of the other body, if the same force acts on it.

mass ratio $m_1 : m_2 = 3 : 4$

The force applied on the bigger mass (m_2 = 4kg) produces an acceleration $a_2 = 12\ ms^{-2}$

$Therefore, m_1 = 3\ kg\ ,\ a_1 = ?$

$F_2 = m_2 a_2 = 4 \times 12 = 48\ N$

The acceleration of the 3 kg body mass $F_1 = m_1 a_1$

Same force $F_2 = F_1 = 48\ N$; $a_1 = \frac{F_1}{m_1} = \frac{48}{3} = 16\ ms^{-1}$;

$a_1 = 16\ ms^{-1}$

2. A ball of mass 1 kg moving with a speed of 10 ms^{-1} rebounds after a perfect elastic collision with the floor. Calculate the change in linear momentum of the ball.

Mass of the ball m = 1 kg , Velocity v = 10 ms^{-1}

Change in linear momentum ,

Before collision = After collision

$mu = mv$

$1 \times 0 = 1 \times 10$

Change in linear momentum = 10 ms^{-1}

3. A mechanic unscrew a nut by applying a force of 140 N with a spanner of length 40 cm. What should be the length of the spanner if a force of 40 N is applied to unscrew the same nut?

Force $F_1 = 140\ N$, Length $L_1 = 40\ cm$

Force $F_2 = 40\ N$, Length L_2 =?

$F_1 L_1 = F_2 L_2$

$$L_2 = \frac{F_1 L_1}{F_2} = \frac{40 \times 140}{40} = 140\ cm$$

The length of the spanner if a force 40 N is applied = 140 cm

4. The ratio of masses of two planets is 2:3 and the ratio of their radii is 4:7 Find the ratio of their accelerations due to gravity.

Given data:

Ratio of mass $m_1 : m_2 = 2 : 3$: Ratio of radius $R_1 : R_2 = 4 : 7$

Ratio of acceleration due to the gravity = $g_1 : g_2$ = ?

Answer:

$g_1 = \frac{GM_1}{R_1^2}$ ---- (1) $\qquad g_2 = \frac{GM_2}{R_2^2}$ ------ (2)

(1) / (2), $\qquad \frac{g_1}{g_2} = \frac{\frac{GM_1}{R_1^2}}{\frac{GM_2}{R_2^2}}$

$$\frac{g_1}{g_2} = \frac{GM_1}{R_1^2} \times \frac{R_2^2}{GM_2}$$

$$\frac{g_1}{g_2} = \frac{M_1}{M_2} \times \frac{R_2^2}{R_1^2}$$

$$\frac{g_1}{g_2} = \frac{2}{3} \times \frac{7^2}{4^2} = \frac{2}{3} \times \frac{49}{16} = \frac{49}{24}$$

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The ratio of acceleration due to gravity $g_1 : g_2$ = 49 : 24

VIII. Answer in detail :

1. What are the types of inertia? Give an example for each type.

(i) Inertia of rest

(ii) Inertia of motion

(iii) Inertia of direction

Explanation with Example:

a) Inertia of rest:

- The resistance of a body to change its state of rest is called Inertia of rest.
- **Example:** When you vigorously shake the branches of a tree, some of the leaves and fruits are detached and they fall down.

b) Inertia of motion

- The resistance of a body to change its state of motion is called inertia of motion.
- **Example:** An athlete runs some distance before jumping . Because, this will help him jump longer and highter.

c) Inertia of direction

- The resistance of a body to change its direction of motion is called Inertia of direction.
- **Example:** When you make a sharp turn while driving a car, you tend to lean side ways.

2. State Newton's laws of motion?

a) Newton's First law

Every body continues to be in its state of rest or the state of uniform motion along a straight line unless it is acted upon by some external force.

b) Newton's second law

The force acting on a body is directly proportional to the rate of change of linear momentum of the body and the change in momentum takes place in the direction of the force.

$$F \propto \frac{mv - mu}{t}$$

c) Newton's third law

For every action, there is an equal and opposite reaction. They always act on two different bodies.

3. Deduce the equation of a force using Newton's second law of motion.

Newton's second law of motion

The force acting on a body is directly proportional to the rate of change of linear momentum of the body and the change in momentum takes place in the direction of the force.

Equation of force

Let 'm' be the mass of a moving body, moving along a straight line with an initial speed 'u'.

After a time interval of 't' , velocity of the body changes to 'v' due to the impact of an unbalanced external forc e 'F'

Initial momentum of the body $P_i = mu$, Final momentum of the body $P_f = mv$

Change in momentum $\Delta P = P_f - P_i$

$\Delta P = mv - mu$

$F \propto \frac{Change\ in\ momentum}{time}$

$F \propto \frac{mv-mu}{t}$, $F = k\ \frac{mv-mu}{t}$

K is proportionality constant , k = 1

$F = \frac{mv - mu}{t}$

$F = m\left[\frac{v-u}{t}\right]$; We know that, Acceleration a = $\frac{v-u}{t}$

$$\boxed{F = ma}$$

Force = mass × acceleration

SI unit of force is Newton.

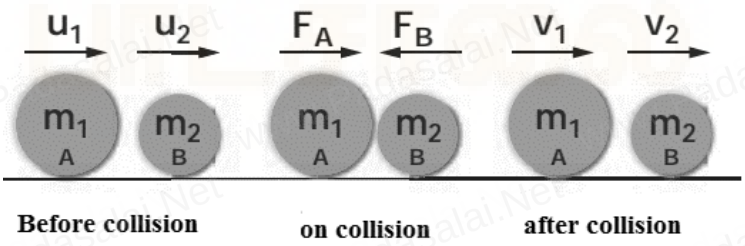
The amount of force required for a body of mass 1 kg produces an acceleration of $1ms^{-2}$.

4. State and prove the law of conservation of linear momentum.

Law of Conservation of momentum:

In the absence of in the absence of an external force, the algebraic sum of the momentum after collision is numerically equal to the algebraic sum of the momentum before collision.

There is no change in the linear momentum of a system of bodies as long as no net external force acts on them.



- Let two bodies A and B having masses m_1 and m_2 move with initial velocity u_1 and u_2 in a straight line. Let the velocity of the first body be higher than that of the second body. i.e., $u_1 > u_2$.
- During an interval of time t second, they tend to have a collision.
- After the impact, both of them move along the same straight line with a velocity v_1 and v_2 respectively.

Force on body B due to A, Force on body A due to B

$F_B = \frac{m_2(v_2 - u_2)}{t}$ -------- (1) $F_A = \frac{m_1(v_1 - u_1)}{t}$ -------- (2)

By Newton's third law, Action Force = Reaction force : $F_A = -F_B$

$$\frac{m_1(v_1 - u_1)}{t} = -\frac{m_2(v_2 - u_2)}{t}$$

$$m_1(v_1 - u_1) = -m_2(v_2 - u_2)$$

$$m_1v_1 - m_1u_1 = -m_2v_2 + m_2u_2$$

$$\boxed{m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2}$$

In the absence of in the absence of an external force, the algebraic sum of the momentum after collision is numerically equal to the algebraic sum of the momentum before collision.

5. Describe rocket propulsion.

- Propulsion of rockets is based on the law of conservation of linear momentum as well as Newton's III law of motion.
- Rockets are filled with a fuel (either liquid or solid) in the propellant tank.
- When the rocket is fired, this fuel is burnt and a hot gas is ejected with a high speed from the nozzle of the rocket, producing a huge momentum.
- To balance this momentum, an equal and opposite reaction force is produced in the combustion chamber, which makes the rocket project forward.
- While in motion, the mass of the rocket gradually decreases, until the fuel is completely burnt out.
- Since, there is no net external force acting on it, the linear momentum of the system is conserved.
- The mass of the rocket decreases with altitude, which results in the gradual increase in velocity of the rocket.
- At one stage, it reaches a velocity, which is sufficient to just escape from the gravitational pull of the Earth. This velocity is called escape velocity.

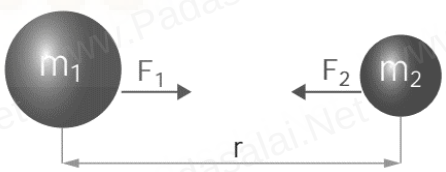
6. State the universal law of gravitation and derive its mathematical expression

Newton's Universal gravitational law

Every particle of matter in this universe attracts every other particle with a force. This force is directly proportional to the product of their masses and inversely proportional to the square of the distance between the centers of these masses. The direction of the force acts along the line joining the masses.

Mathematical Expression of Universal gravitational law:

Let, m_1 and m_2 be the masses of two bodies A and B placed r metre apart in space.



$F \propto m_1m_2$ --------- (1) $F \propto \frac{1}{r^2}$ --------- (2)

To combain the two equations

$$F \propto \frac{m_1m_2}{r^2}$$

$$\boxed{\mathbf{F = G\frac{m_1m_2}{r^2}}}$$

Where G - Universal gravitational constant $G = 6.674 \times 10^{-11} Nm^2kg^{-2}$

7. Give the applications of universal law gravitation.

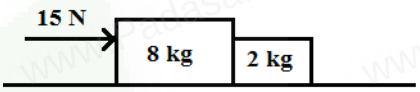
1) Dimensions of the heavenly bodies can be measured using the gravitation law.
2) Mass of the Earth, radius of the Earth, acceleration due to gravity, etc. can be calculated with a higher accuracy.
3) Helps in discovering new stars and planets.
4) One of the irregularities in the motion of stars is called 'Wobble' lead to the disturbance in the motion of a planet nearby. In this condition the mass of the star can be calculated using the law of gravitation.
5) Helps to explain germination of roots is due to the property of geotropism which is the property of a root responding to the gravity.
6) Helps to predict the path of the astronomical bodies.

IX. HOT Questions :

1. Two blocks of masses 8 kg and 2 kg respectively lie on a smooth horizontal surface in contact with one other. They are pushed by a horizontally applied force of 15 N. Calculate the force exerted on the 2 kg mass.

Given Data:

$m_1 = 8\ kg\ ,\ m_2 = 2\ kg$



Horizontal applied force F = 15 N

According to Newton's Second law, F = ma

$F = (m_1 + m_2)\ a$

$a = \frac{F}{m_1+m_2} = \frac{15}{8+2} = \frac{15}{10} = 1.5\ ms^{-2}$

Force exerted on the 2kg mass

$m = 2\ kg \quad a = 1.5\ ms^{-2}$

F = ma

F = 2× 1.5 = 3N

The force exerted on the 2kg mass is F = 3N.

2. A heavy truck and bike are moving with the same kinetic energy. If the mass of the truck is four times that of the bike, then calculate the ratio of their momenta.

Mass of the truck = m_1

Mass of the bike = m_2

If the mass of the truck is four times that of the bike $4m_1 = m_2$

Kinetic energy for truck

$$K_1 = \frac{1}{2} m_1 v_1^2$$

Kinetic energy for bike

$$K_2 = \frac{1}{2} m_2 v_2^2$$

Same kinetic energy ; $K_1 = K_2 = K$

$$v_1^2 = \frac{2K}{m_1}$$

$$v_2^2 = \frac{2K}{m_2}$$

$$v_1 = \sqrt{\frac{2K}{m_1}}$$

$$v_2 = \sqrt{\frac{2K}{m_2}}$$

Momentum P = mv

$$P_1 = m_1 v_1$$

$$P_1 = m_1 \sqrt{\frac{2K}{m_1}}$$

$$P_1 = \sqrt{2m_1 K}$$

$$P_2 = m_2 v_2$$

$$P_2 = m_2 \sqrt{\frac{2K}{m_2}}$$

$$P_2 = \sqrt{2m_2 K}$$

$$m_2 = 4m_1$$

$$P_2 = \sqrt{2 \times 4m_1 K}$$

$$P_2 = 2\sqrt{2m_1 K}$$

$$\frac{P_1}{P_2} = \frac{\sqrt{2m_1 K}}{2\sqrt{2m_1 K}} = \frac{1}{2}$$

The ratio of momenta = $P_1 : P_2 = 1 : 2$

3. "Wearing helmet and fastening the seat belt is highly recommended for safe journey" Justify your answer using Newton's laws of motion.

Wearing helmet is highly recommended for safe journey:

- According to newton's second law, when you fall from a bike on the ground with a force equal to your mass and acceleration of the bike
- According to newton's third law, an equal and opposite reaching force on the ground is exerted on you.
- When you do not wear helmet, this reacting force can cause fatal head injuries. So it is important to wear helmet for the safe journey.

Fastening the seat belt is highly recommended for safe journey:

- Newtons First law of motion has to do with seat belts because when we don't wear a seat belt and our vehicle comes to a quick stop.
- You move forward and stay in motion until an unbalanced force acts upon you.
- An unbalanced force is one that is not opposed by an equal and opposite force operating directly against the force intended to cause a change in the object's state of motion or rest.
- So, when you come to a stop, you wouldn't stop motion unless a force is caused to change your motion and put you at rest.
- If you were wearing a seat belt, the seat belt would act as the unbalanced force, it would stop you from being in motion.