FORCE & PRESSURE

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CHAPTER

CONTENTS

➢ FORCE

The external agent which can changes :

the speed and direction of motion or
the shape of a body

is called **force**.

It is a vector quantity

◈ **Types of forces :**

(A) Contact forces :

The forces that act on bodies when they are in actual contact are known as contact forces.

Ex. Frictional force, normal reaction force, tension in string, force exerted during collision, force applied as a push or a pull etc.

(B) Non-contact forces :

The forces that act on bodies without being touched are called non-contact forces.

Ex. Gravitational force, electrostatic force, magnetic force etc.

➢ NEWTON'S LAWS OF MOTION

(A) Newton´s Ist law :

A body can not change its state of motion by itself. If the object is at rest it will remain at rest and if it is in uniform motion, it continues to be in motion unless some external force is applied on it.

This law is also known as *law of inertia.*

(B) Newton´s second law :

Newton's second law can be written as

$$\vec{F} = m\vec{a} = m\left[\frac{v-u}{t}\right]$$

Ex.1 Calculate the force required to produce an acceleration of 5 m/s^2 in a body of mass 2.4 kg.

Sol. We know that force = mass × acceleration

= 2.4 kg × 5 m/s^2 = 12.0N

Ex.2 A force acts for 0.2 s on a body of mass 2.5 kg initially at rest. The force then ceases to act and the body moves through 4m in the next one second. Calculate the magnitude of force.

Sol. When the force ceases to act, the body will move with a constant velocity. Since it moves a distance of 4 m in 1 s, therefore, its uniform velocity = 4m/s.

Now, initial velocity, $u = 0$

Final velocity, $v = 4$ m/s

Time interval $\Delta t = 0.2$ s

$\therefore$ Acceleration, $a = \frac{v-u}{\Delta t} = \frac{4-0}{0.2} = 20 m/s^2$

From the relation,

F = ma, we get

Force, $F = 2.5 \times 20 = 50$ N

Ex.3 A ball of mass 20 gm is initially moving with a velocity of 100 m/s. On applying a constant force on the ball for 0.5s, it acquires a velocity of 150 m/s. Calculate the following :

(i) Acceleration of the ball

(ii) Magnitude of the force applied

Sol. Given , m = 20 gm = kg = 0.02 kg

Initial velocity, u = 100 m/s

Time interval, t = 0.5 s

Final velocity, v = 150 m/s

(i) Acceleration, $a = \frac{v-u}{t} = \frac{150-100}{0.5} = 100 ms^{-2}$

(ii) Force, F = mass × acceleration

=0.02 × 100 = 2.0 N

Ex.4 A cricket ball of mass 200 gm moving with a speed of 40 m/s is brought to rest by a player in 0.04s. Calculate the average force applied by the player.

Sol. Mass, m = 200 gm = $\frac{200}{1000}$ kg = 0.2 kg

Initial velocity, u = 40 m/s

Final velocity, v = 0

Time, t = 0.04s

Average force =

$\frac{\text{Change in momentum}}{\text{Time}} = \frac{-8.0}{0.04} = -200$ N

(The negative sign shows that the force is applied in a direction opposite to the direction of motion of the ball).

Ex. 5 A motorcycle is moving with a velocity of 108 km/hr and it takes 5 s to stop it after the brakes are applied. Calculate the force exerted by the brakes on the motorcycle if its mass along with the rider is 250 kg.

Sol. Given that initial velocity of the motorcycle = 108 km/hr = 30 m/s

Final velocity = 0 m/s

Time taken to stop = 5s, the mass of the motorcycle with rider = 250 kg.

The change in the velocity of the motorcycle in 5s = 0 – 30 = –30 m/s

Therefore, the acceleration of the motorcycle,

$a = \frac{-30}{5} = -6 m/s^2$

The magnitude of the force applied by the brakes is given by the equation,

F = mass × acceleration

= 250 kg × (6)m/s^2 = 1500 N

(C) Newton's third law of motion

Newton's third law of motion states that *" if a body A exerts a force on the body B, the body B will also exert an equal and opposite force on A."*

Newton's third law is also stated as "to every action there is an equal and opposite reaction."

- The force exerted by A on B is called action while the force exerted by B on A is called the reaction.

Action and reaction always act on different bodies.

Forces always occur in pairs.

eg. by hitting a table with palm we apply a force. The table also exerts a force on palm on hitting it.

➢ THRUST AND PRESSURE

(A) Thrust :

- The force acting normally on surface is called 'thrust'.
- This is a vector quantity.
- It is measured in newton (N).

(B) Pressures :

- The thrust on an unit area of a surface is called 'pressure'.
- Pressure = $\frac{\text{Thrust}}{\text{Area}}$ or $P = \frac{F}{A}$
- Unit : The SI unit of pressure is newton per meter square or N/m^2, other units of pressure are *pascal* and *bar.*
- *One Pascal* : One pascal is defined as the pressure exerted on a surface area of 1m^2 by a thrust of 1 newton. i.e. 1 Pascal = 1 N/m^2

◈ **Some examples based on pressure**

- ◆ Inserting a pointed nail in a wooden block is an easier task than to insert a rod inside a wooden block with the same force because the nail has a smaller area and thus it will experience more pressure even with the same force.
- ◆ A sharp knife cuts better than a blunt knife.
- ◆ While walking, a man exerts more pressure on the ground in comparison to when he is standing.

◈ **Pressure in fluids**

- ◆ A substance that can flow is called a 'fluid'.
- ◆ liquids and gases are considered as fluids.

◈ **Laws of pressure**

- ◆ Pressure exerted by the liquid is the same in all directions about a point.
- ◆ Pressure exerted is the same at all points in a horizontal plane as well as in a stationary liquid.
- ◆ Pressure at a point inside a liquid increases with depth from the free surface.
- ◆ *The pressure exerted anywhere in a confined liquid is transmitted equally and undiminished in all directions throughout the liquid which is called 'Pascal's law'.*

(A) Hydrostatic Pressure : The normal force (or thrust) exerted by a liquid at rest per unit area of the surface in contact with it is called "pressure of liquid or hydrostatic pressure."

(B) Atmospheric Pressure : The pressure exerted by atmosphere is called atmospheric pressure.

- ◆ At sea level, atmospheric pressure is the pressure exerted by 0.76 m of mercury column i.e. h = 0.76 m.

Ex.6 A force of 150 N is applied on an area of 1.5 m^2. Calculate the pressure exerted.

Sol. Force, F = 150 N; area, A = 1.5 m^2

Now, Pressure = $\frac{\text{Force}}{\text{Area}}$

or $P = \frac{F}{A} = \frac{150\text{N}}{1.5\text{m}^2} = 100\ \text{N/m}^2$

Ex.7 A force of 500 dynes is applied on an area of 20 cm^2. Calculate the pressure exerted.

Sol. Force, F = 500 dynes = 500×10^{-5} Newton

Area, A = 20 cm^2 = 20×10^{-4} m^2

$$\text{Pressure, } P = \frac{F}{A} = \frac{500\times10^{-5}\text{N}}{20\times10^{-4}\text{m}^2} = 2.5\ \text{N/m}^2$$

➢ BUOYANCY

When a body is immersed in a liquid, the liquid exerts an upward force on the body called as the 'upthrust' or 'buoyant force.'

◈ **Factors affacting upthrust :**

- ◆ Larger the volume of the body submerged in the liquid, greater is the upthrust.
- ◆ Larger the density of the liquid, greater is the upthrust.

◈ **Archimedes principle :**

'Archimedes' principle states that when a body is immersed in liquid partially or completely, it experiences an upthrust equal to the weight of the liquid displaced." or the loss in weight of the block, (buoyant force) acting on the block is equal to the weight of the liquid displaced.

Ex. 8 A body weighs 300 N in air and 260 N when completely immersed in water. Calculate the following :

(i) loss in weight of the body

(ii) upthrust on the body.

Sol. Given : Weight of body in air = 300 N

Weight of the body in water = 260 N

∴ Loss in weight of the body

= 300 – 260 = 40 N

∴ Upthrust of the body = Loss in weight = 40 N

➢ DENSITY

- ◆ Density = $\frac{\text{Mass}}{\text{Volume}}$ or $d = \frac{M}{V}$

SI unit of density is kg/m^3 and CGS unit of density is g/cm^3

- ◆ Water has anomalous expansion. When water is cooled at 4ºC, its volume decreases but on further cooling its volume starts increasing.

⇒ the density of water is maximum at 4ºC.

EXERCISE # 1

A Very Short Answer Type Questions

FORCE

Q.1 Define force.

Q.2 An inflated balloon was pressed against a wall after it has been rubbed with a piece of synthetic cloth. It was found that the balloon sticks to the wall. What force might be responsible for the attraction between the balloon and the wall ?

Q.3 How many objects should be present for a force to come into play ?

Q.4 Two friends A and B are applying a force of 2 newton and 4 newton on a box in the same direction. What will be the total force applied by them ?

Q.5 In a tug of war, side A applies 10 newton force and side B applies 8 newton force. Which side will the rope move ?

Q.6 What happens to the speed of a body when a force is applied ?

Q.7 Can we change the direction of the moving object by applying a force ?

Q.8 Is it possible that a force changes the direction of motion but not the speed of an object ?

Q.9 Give an example to show that force can change the shape of an object.

Q.10 What is meant by contact force ?

PRESSURE

Q.11 Define the term atmospheric pressure.

Q.12 How would 'thrust' on the bottom of a liquid level change if 'area' is doubled keeping the 'pressure' same ?

Q.13 Two objects of masses M and 2M are lying on an equal area. Determine the ratio of pressure exerted by them on the ground.

Q.14 Define pressure.

Q.15 Do the gases and liquids exert pressure on the walls of the container ?

Q.16 Why is it comfortable to lift a school bag with broad straps than thin straps ?

Q.17 Why do mountaineers suffer from nose bleeding at high altitudes ?

Q.18 Why is easier to hammer a sharp nail into wood than a blunt one ?

Q.19 How would pressure change if area is doubled keeping force constant ?

Q.20 How would pressure change if force is doubled keeping area constant ?

B Short Answer Type Questions

FORCE

Q.21 Give two examples each of situations in which you push or pull to change the state of motion of objects.

Q.22 Give two examples each of situations in which applied force causes a change in the shape of an object.

Q.23 If the force is applied opposite to the motion, what will happen to the speed of the object?

Q.24 State the two factors which describe the state of motion of an object.

Q.25 How do the mud particles fly off the wheel of a vehicle moving on the wet road ?

PRESSURE

Q.26 Define Pressure. Write the relation between pressure force and area. Name the instrument used to measure atmospheric pressure.

Q.27 Why is it difficult to cut vegetables with a blunt knife ?

Q.28 Trucks intended to carry heavy loads have eight tyres instead of four tyres. Why ?

Q.29 Give reasons for the following :
(a) The skiers use flat and broad skis
(b) Deep sea divers wear special suits.

Q.30 How does the medicine enter a dropper ?

C Long Answer Type Questions

FORCE

Q.31 Name the forces acting on a plastic bucket containing water held above ground level in your hand. Discuss why the forces acting on the bucket do not bring a change in its state of motion.

Q.32 (a) What is weight ?
(b) What is the unit of weight ?
(c) Name the device used for measuring the weight of an object.
(d) Can weight be taken as a measure of force ?

Q.33 Name the type of force in the following cases.
(a) Raindrops falling on the earth.
(b) Holding a book on your hand.
(c) Running a comb through your dry hair.
(d) A bar magnet suspended freely.
(e) Bullocks ploughing the field.

PRESSURE

Q.34 (a) Define one atmosphere.
(b) Where is the pressure greater, 10 m below the surface of sea or 20 m below ?
(c) Where is pressure greatest and the least inside a bottle filled with water.

Q.35 What happens to the atmospheric pressure if,
(a) the temperature is high.
(b) the humidity in air increases
(c) metrological office predicts fair weather.
(d) there is a storm.
(e) the weather is dry

Q.36 Define force and pressure. What do you do to get maximum pressure with a minimum forces ? Name atleast one appliance based on this principle.

EXERCISE # 2

Single correct answer type questions

FORCE

Q.1 Which of the following is the action-at-distance force ?

(A) muscular force (B) frictional force
(C) magnetic force (D)mechanical force

Q.2 The force exerted by one object on another by virtue of their masses is
(A) magnetic force
(B) electrostatic force
(C) gravitational force
(D) frictional force

Q.3 The standard unit of force is
(A) metre/second (B) newton
(C) metre/second^2 (D) gram-weight

Q.4 A spring balance is used for measuring
(A) weight (B) speed
(C) acceleration (D) mass

Q.5 A force applied on a moving body may
(A) bring it to rest
(B) increase its speed
(C) decrease the speed
(D) all of the above

Q.6 Earth always pulls everything towards it due to
(A) muscular force
(B) mechanical force
(C) gravitational force
(D) electrostatic force

Q.7 A cart being carried by a horse is an example of
(A) muscular force
(B) mechanical force
(C) gravitational force
(D) electrostatic force

Q.8 If you press an inflated balloon, it deforms due to a type of
(A) contact force
(B) non-contact force
(C) gravitational force
(D) none of these

Q.9 Force exerted by the muscles is known as
(A) mechanical force
(B) gravitational force
(C) electrostatic force
(D) muscular force

Q.10 A hockey player uses his hockey stick –
(A) To push the ball
(B) To pull the ball
(C) To change its direction
(D) All of these

Q.11 A force when applied brings change in –
(A) Direction of motion of the body
(B) Speed of moving body
(C) Shape of the body
(D) Any of these

Q.12 The force responsible for the wearing out of the car tyres is –
(A) Frictional force
(B)Gravitational force
(C) Magnetic force (D) Muscular force

Q.13 The force you will use to collect the iron nails scattered on a sandy ground is –
(A) Frictional force
(B)Gravitational force
(C) Magnetic force (D) None of these

Q.14 The force you use to stretch a rubber band is –
(A) Frictional force
(B)Gravitational force
(C) Magnetic force (D) Muscular force

Q.15 The SI unit of force is
(A) metre (B) newton
(C) pascal (D) second

Q.16 A contact force cannot act through
(A) empty space
(B) touching
(C) touching with a metal rod
(D) touching with a wooden rod

Q.17 A force that opposes the motion of one surface sliding over another is called
(A) friction (B) newton
(C) lubrication (D) ball bearing

PRESSURE

Q.18 If a given force is applied on a smaller area of contact the pressure exerted by it
(A) decreases (B) increases
(C) does not change (D) none of these

Q.19 A camel can walk/run in deserts very easily as compared to horse, donkey etc., because is –
(A) feet are smaller (B) weight is lesser
(C) feet are broader (D) heavier body

Q.20 The SI unit of pressure is
(A) atmosphere (B) pascal
(C) cm of mercury (D) mm of mercury

Q.21 Pressure is defined as
(A) force
(B) force × distance
(C) force per unit area
(D) force × area

Q.22 Pressure can be measured in the units of .....
(A) Newton/m^2 (B) Pascal
(C) Both A & B (D) none of these

Q.23 Approximate value of pressure exerted by air is .....
(A) 1 kilo Pascal (B) 10 kilo Pascal
(C) 100 kilo Pascal (D) none of these

Q.24 With the depth of a liquid, exerted pressure.....
(A) decreases (B) ceases
(C) increases (D) no change

Q.25 At high altitudes the air pressure is ..... than at sea level
(A) less (B) more
(C) same (D) can't say

Q.26 The substances that do not have a fixed shape and can flow are commonly called....
(A) Gases
(B) Liquids
(C) both (A) and (B)
(D) none of these

Q.27 The pressure applied on a body depends on
(A) Force
(B) Mass
(C) Both force and mass
(D) Both force and area

Q.28 You have two nails, one with sharp end and other with blunt end. If you apply equal force on each, the nail that will be hammered first will be
(A) The nail with pointed
(B) The nail with blunt end
(C) Both will be hammered in same time
(D) None of these can be hammered

Q.29 The formula for pressure is
(A) force × area (B) force / area
(C) Area / force (D) none of these

Q.30 The pressure increases with
(A) Decreasing depth
(B) Increasing depth
(C) Depth has no effect on pressure
(D) None of these

Q.31 The instrument used to measure the pressure is
(A) Hydrometer (B) Manometer
(C) Galvanometer (D) Anemometer

Q.32 Which of the following is not a unit of pressure?
(A) bar (B) Newton
(C) atm (D) Pascal

Q.33 Deep-sea diving vessels have to withstand pressure from the crushing effect of sea water acting
(A) upwards (B) downwards
(C) sideways (D) in all directions

Q.34 Which among the following will exert maximum pressure when pushed with the same amount of force ?
(A) An eraser of area 2 cm^2
(B) A sharpened pencil tip
(C) The blunt end of a pencil
(D) The rear portion of closed safely pin

Q.35 How does pressure vary as we move from sea level to the mountain top ?
(A) Decreases
(B) Increases
(C) Increases upto a few kilometre and then decreases
(D) Decreases upto a few kilometres and then increases

Q.36 At sea level, atmospheric pressure is about

(A) 10^3 Pa (B) 10^4 Pa

(C) 10^5 Pa (D) none of these

Q.37 Pascal is used as a unit for

(A) thrust (B) weight

(C) pressure (D) work

Q.38 SI unit of thrust is

(A) N (B) Kgm^{-3}

(C) Nm^{-2} (D) Joule

Q.39 The force divided by area on which it acts is called

(A) pressure (B) weight

(C) thrust (D) work

Q.40 1 Pa equals

(A) 10 Nm^{-2} (B) 1 Nm^{-2}

(C) 1/10 Nm^{-2} (D) 10^5 Nm^{-2}

Q.41 The unit of pressure used for meterological purpose is called

(A) a bar (B) pascal

(C) kg wt. (D) atm

Q.42 A high altitudes the air pressure (as compared to pressure o the surface of the Earth) is

(A) less (B) more

(C) same (D) none of these

Q.43 The pressure in a liquid at greater depth is

(A) smaller (B) greater

(C) same (D) none of these

Q.44 The pressure at any point in a liquid at rest depends only on the depth and on the ..... of the liquid.

(A) density (B) weight

(C) colour (D) none of these

ANSWER KEY

EXERCISE-1

Sol.1 Force is a push or pull on an object.

Sol.2 Electrostatic force.

Sol.3 There should be atleast two objects for a force to come into play.

Sol.4 The total force will be 6 newton, i.e., the sum of their individual forces.

Sol.5 The rope will move towards side A as more force is applied by side A.

Sol.6 The speed of a body can be increased or decreased by applying force.

Sol.7 Yes, we can change the direction of the moving object by applying a force.

Sol.8 Yes, it is possible when a body is moving on a circular path.

Sol.9 Pressure a rubber ball with the hand.

Sol.10 A force which is applied only when it is in contact with an object is called a contact force.

Sol.11 The pressure exerted by air is known as atmospheric pressure.

Sol.12 Thrust will also be doubled.

Sol.13 $P_1 = \frac{M}{A}, P_2 \frac{2M}{A}; \frac{P_1}{P_2} = \frac{M \times A}{A \times 2M} = \frac{1}{2}$ $\therefore$ ratio of pressure is 1 : 2

Sol.14 Pressure is the force acting per unit area.

Sol.15 Yes, liquids and gases exert pressure on the walls of the container.

Sol.16 Pressure is inversely proportional to area since broader atreps have grater area, therefore, the pressure decreases.

Sol.17 The atmospheric pressure decreases with high altitude. Since the pressure of the blood inside the body is high, the nose starts bleeding.

Sol.18 Pressure = force/area.

Therefore, when we hammer a sharp nail, force acts on a smaller area, and it exerts more pressure on the nail.

Sol.19 If area is doubled keeping the force constant, then pressure becomes half.

Sol.20 If force is doubled keeping area constant, then pressure becomes double.

Sol.21 Push – moving a loaded cart, batsman hitting a ball.

Pull – opening a drawer, drawing a bucket of water from a well.

Sol.22 (a) Pressing a lump of dough with hand.

(b) Pressing an inflated balloon.

Sol.23 When the force is applied opposite to the motion of the object, then either the speed decreases or the direction changes.

Sol.24 The state of motion is described by its speed and direction of motion.

Sol.25 The direction of the mud particles change at every point as the wheel of the vehicle moves.

Sol.26 Pressure is force per unit area.

Sol.27 Pressure is inversely proportional to area. The area of the blunt knife is more and therefore, the effect of the force is less. Therefore, more force has to be applied.

Sol.28 Trucks intended to carry heavy loads have eight tyres, so as to increase the area of contact with the road. Since pressure is inversely proportional to area, less pressure is applied on the road.

Sol.29 (a) The skiers used flat and broad skis to ski on the snow. The larger surface of skis reduces pressure on snow and helps them to slide instead of sinking.

(b) Deep sea divers wear special suits, because the pressure of water increases with depth. The increased pressure may hurt the body of divers.

Sol.30 When the dropper is pressed, the air inside the dropper is driven out. The pressure inside the dropper decreases and the medicine rushes inside the dropper.

Sol.31 The forces acting on the bucket is its own weight acting downwards and the muscular force of the hand acting upwards. Since both the forces are equal and acting in opposite directions, they balance each other. So, they donot bring any change in the state of motion of bucket. The hand feels tired due to the weight of bucket.

Sol.32 (a) Weight of an object is the force of gravity acting on the object.

(b) Unit of weight is newton or kilogram weight.

(c) Spring balance is used for measuring the weight of an object.

(d) Yes, the weight can be taken as a measure of force.

Sol.33 (a) Force of gravity.

(b) Force of gravitation (weight)

(c) Electrostatic force.

(d) Magnetic force.

(e) Muscular force.

Sol.34 (a) The pressure which can support 76 cm of mercury in a mercury barometer, is called one atmosphere.

(b) 20 m below the surface of sea the pressure is greater.

(c) The pressure is greatest at the bottom and least on the surface of water filled in a bottle.

Sol.35 (a) Atmospheric pressure decreases.

(b) Atmospheric pressure decreases.

(c) Atmospheric pressure increases.

(d) Atmospheric pressure decreases.

(e) Atmospheric pressure increases.

Sol.36 – Force is a push or pull on an object.

– Pressure is force acting per unit area.

– As pressure is inversely proportional to area and directly proportional to force, so to get maximum pressure with a minimum force we can decrease the area.

– Sharp knife, pointed nails are based on this principle.

EXERCISE-2

Ques.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Ans.	C	C	B	D	D	C	A	A	D	D	D	A	C	D	B
Ques.	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Ans.	A	A	B	C	B	C	C	C	C	A	C	D	A	B	B
Ques.	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	
Ans.	B	B	D	B	A	C	C	A	A	B	A	A	B	A	