PRESSURE & BUOYANCY

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 pt.
- Pressure exerted is the same at all pts in a horizontal plane as well as in a stationary liquid.
- Pressure at a pt inside a liquid increases with depth from the free surface.
- Pressure at a particular depth is different for different liquids, i.e. P = hdg

  where, h = height of the column of liquid.

  d = density of the liquid

  g = acceleration due to gravity
- 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.
- The density of mercury, $d = 13.6 \times 10^3$ kg m^{-3} and $g = 9.8$ ms^{-2}.

  $\Rightarrow$ atm pressure = $P = hdg = 1.013 \times 10^5$ Nm^{-2} or Pa

Ex. What will be the pressure in N/m^2 at a depth of 15cm in brine of density 1.2 gm/cm^3 ?

Sol. $P = hdg$

$$= \frac{15}{100} \times \frac{1.2}{1000} \times 100 \times 100 \times 100 \times 10$$

$$= 1800 \text{ N/m}^2$$

Ex. Calculate the density of a liquid if the pressure at a pt 30 m below its surface is 32×10^4 N/m^2.

Sol. $P = hdg \Rightarrow d = \frac{P}{hg} = \frac{32 \times 10^4}{30 \times 10} = 1066.6 \text{ kg/m}^3$

Ex. 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

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

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

Ex. 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}neowton

Area, $A = 20 \text{ cm}^2 = 20 \times 10^{-4} \text{ m}^2$

$$\text{Pressure, } P = \frac{F}{A} = \frac{500 \times 10^{-5}\text{N}}{20 \times 10^{-4}\text{m}^2} = 2.5 \text{ N/m}^2$$

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."

i.e. $F = Vdg$

where V = volume of the body

d = density of the liquid

g = acceleration due to gravity

or the loss in weight of the block, i.e. buoyant force acting on the block is equal to the weight of the liquid displaced.

Ex. A body weighs 300 gmf in air and 260 gmf 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 gmf

Weight of the body in water = 260 gmf

$\therefore$ Loss in weight of the body = 300 – 260 = 40 gmf

$\therefore$ Upthrust of the body = Loss in weight = 40 gmf

Ex. A solid block of volume 2 litres has a weight of 80 N. What will be its weight when immersed completely in water ?

Sol. In order to calculate the weight of the block in water, first calculate the upthrust, i.e. the loss in weight of the body in water, then

Volume of the block = 2 litres = 2000 cc

$\therefore$ Volume of water displaced = 2000 cc

Weight of water displaced = 2000 gm = 2.0 kgf ($\because$ Density of water = 1 gm/cc)

$= 2.0 \times 9.8 \text{ N} = 19.6 \text{ N}$

$\therefore$ Upthrust of water = 19.6 N

Hence, weight of the body fully immersed in water = 80 N – 19.6 N = 60.4 N

Ex. A solid block of density D has a weight W in air is fully immersed in a liquid of density d. Calculate its apparent weight when fully immersed in liquid.

Sol. Weight of the block = W

Density of block = D

$\therefore$ Volume of the block = $\frac{W}{D}$

$\therefore$ Upthrust on the block = $\frac{W}{D}.d$

$\therefore$ Loss in weight of the block inside liquid = $\frac{W}{D}.d$

Hence, apparent weight of the block when fully immersed in water

$$= W - \frac{W}{D}.d = W\left(1-\frac{d}{D}\right)$$

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
- $1\ gm/cm^3 = 1000\ kg/m^3$
- Different substances have different densities which gets affected by temperature.
- Respective density of a substance decreases on heating due to the expansion of the substance.
- Water has anomalous expansion. When water is cooled at 4°C, its volume decreases but on further cooling its volume starts increasing.

  $\Rightarrow$ the density of water is maximum at 4°C.

Ex. A solid weighs 60 gmf in air and 52 gmf when completely immersed in water. Calculate the following:

(i) upthrust,

(ii) volume of the solid,

Sol. Given:

Weight of solid in air = 60 gmf

Weight of solid in water = 52 gmf

$\therefore$ Loss of weight in water = 60 – 52 = 8 gmf

(i) $\therefore$ Upthrust = loss of weight in water = 8 gmf

(ii) Since density of water is $1\ gm/cm^3$, and weight of equal volume of water = 8 gmf

$\therefore$ Volume of solid = $8\ cm^3$

EXERCISE- 1

VERY SHORT ANSWER TYPE QUESTION

Q.1 Define the term atmospheric pressure.

Q.2 How would 'thrust' on the bottom of a liquid level change if 'area' is doubled keeping the 'pressure' same ?

Q.3 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.4 Define pressure.

Q.5 Do the gases and liquids exert pressure on the walls of the container ?

Q.6 Why is it comfortable to lift a school bag with broad straps than thin straps ?

Q.7 Why do mountaineers suffer from nose bleeding at high altitudes ?

Q.8 Why is easier to hammer a sharp nail into wood than a blunt one ?

Q.9 How would pressure change if area is doubled keeping force constant ?

Q.10 How would pressure change if force is doubled keeping area constant ?

Short Answer Type Question

Q.11 Define Pressure. Write the relation between pressure force and area. Name the instrument used to measure atmospheric pressure.

Q.12 Why is it difficult to cut vegetables with a blunt knife ?

Q.13 Trucks intended to carry heavy loads have eight tyres instead of four tyres. Why ?

Q.14 Give reasons for the following :

(a) The skiers use flat and broad skis

(b) Deep sea divers wear special suits.

Q.15 How does the medicine enter a dropper ?

Long Answer Type Question

Q.16 (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.17 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.18 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

Q.1 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.2 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.3 The SI unit of pressure is
(A) atmosphere (B) pascal
(C) cm of mercury (D) mm of mercury

Q.4 Pressure is defined as
(A) force
(B) force × distance
(C) force per unit area
(D) force × area

Q.5 Pressure can be measured in the units of .....
(A) Newton/m^2 (B) Pascal
(C) Both A & B (D) none of these

Q.6 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.7 With the depth of a liquid, exerted pressure.....
(A) decreases (B) ceases
(C) increases (D) no change

Q.8 At high altitudes the air pressure is ..... than at sea level
(A) less (B) more
(C) same (D) can't say

Q.9 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.10 The pressure applied on a body depends on
(A) Force
(B) Mass
(C) Both force and mass
(D) Both force and area

Q.11 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.12 The formula for pressure is
(A) force × area (B) force / area
(C) Area / force (D) none of these

Q.13 The pressure increases with
(A) Decreasing depth
(B) Increasing depth
(C) Depth has no effect on pressure
(D) None of these

Q.14 The instrument used to measure the pressure is
(A) Hydrometer (B) Manometer
(C) Galvanometer (D) Anemometer

Q.15 Which of the following is not a unit of pressure?
(A) bar (B) Newton
(C) atm (D) Pascal

Q.16 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.17 Which among the following will exert maxiumum pressure when pushed with the same amount of force ?
(A) An eraser of area 2 cm^2
(B) A shrapened pencil tip
(C) The blunt end of a pencil
(D) The rear portion of closed safely pin

Q.18 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.19 At sea level, atmospheric pressure is about
(A) 10^3 Pa (B) 10^4 Pa
(C) 10^5 Pa (D) none of these

Q.20 Pascal is used as a unit for
(A) thrust (B) weight
(C) pressure (D) work

Q.21 SI unit of thrust is
(A) N (B) Kgm^{-3}
(C) Nm^{-2} (D) Joule

Q.22 The force divided by area on which it acts is called
(A) pressure (B) weight
(C) thrust (D) work

Q.23 1 Pa equals
(A) 10 Nm^{-2} (B) 1 Nm^{-2}
(C) 1/10 Nm^{-2} (D) 10^5 Nm^{-2}

Q.24 The unit of pressure used for meterological purpose is called
(A) a bar (B) pascal
(C) kg wt. (D) atm

Q.25 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.26 The pressure in a liquid at greater depth is
(A) smaller (B) greater
(C) same (D) none of these

Q.27 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

VERY SHORT ANSWER TYPE QUESTION

Sol.1 The pressure exerted by air is known as atmospheric pressure.

Sol.2 Thrust will also be doubled.

Sol.3 $P_1 = \frac{M}{A}$, $P_2 = \frac{2M}{A}$; $\frac{P_1}{P_2} = \frac{M \times A}{A \times 2M} = \frac{1}{2}$

\ ratio of pressure is 1 : 2

Sol.4 Pressure is the force acting per unit area.

Sol.5 Yes, liquids and gases exert pressure on the walls of the container.

Sol.6 Pressure is inversely proportional to area since broader atreps have grater area, therefore, the pressure decreases.

Sol.7 The atmospheric pressure decreases with high altitude. Since the pressure of the blood inside the body is high, the nose starts bleeding.

Sol.8 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.9 If area is doubled keeping the force constant, then pressure becomes half.

Sol.10 If force is doubled keeping area constant, then pressure becomes double.

Sol.11 Pressure is force per unit area.

Sol.12 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.13 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.14 (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 wtih depth. The increased pressure may hurt the body of divers.

Sol.15 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.16 (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.17 (a) Atmospheric pressure decreases.

(b) Atmospheric pressure decreases.

(c) Atmospheric pressure increases.

(d) Atmospheric pressure decreases.

(e) Atmospheric pressure increases.

Sol.18 – 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.	B	C	B	C	C	C	C	A	C	D	A	B	B	B	B
Ques.	16	17	18	19	20	21	22	23	24	25	26	27			
Ans.	D	B	A	C	C	A	A	B	A	A	B	A			