GRADE –9

LESSON – 10B, [CRAVITAION (FLOATATION)]

THRUST
Force Acting on an object perpendicular to the surface is called thrust.
The SI unit of thrust is same as force, i.e. newton

Pressure
Thrust acting per unit area is called pressure (P)
SI unit: pascal (Pa) or newton/ $meter^2$ (N/mr^2)

Pressure = 1 pascal (Pa)
= Thrust of 1 N is exerted on unit area

Pressure on solids

Pressure on liquids / gases

Pressure is inversely proportional to the area on which thrust

Upthrust is independent of the shape of the container
Upthrust is independent of the volume of a fluid in the Container
Volume of fluid displaced = volume of body immersed

Properties of up thrust

When a body is partially or fully immersed in a fluid (i.e. liquid or a gas) it experiences an upward force due to fluid displaced by it. This is called buoyancy or upthrust.

Archimedes' Principle

I t states that if a body is partially or fully immersed in a fluid at rest, it experiences an upthrust (U) which is equal to weight of the fluid (W) displaced by it.

i.e.   U = W

            W = mg

If   V = Volume of fluid displaced

            ρ = Density of fluid

Then   m = V ρ

Or   W = V ρg

$\Rightarrow$ U = V ρg

Principe of floatation

If a body of weight 'W' is immersed in a fluid and an upthrust 'U' acts on it, then

a.
The body sinks in fluid

b.
The body floats on the surface of fluid

c.
The body floats while being completely immersed in fluid.

Applications of Archimedes'

Ship designing and making sub machine

Making hydrometer to measure density

Making lactometer to measure purity of milk

Relative density of a substance is the ratio of density of a substance to the density of water
It has no unit as it is a ratio

If relative density > 1, the body sinks in water
If relative density < 1, the body floats in water
If relative density = 1, the body floats while completely immersed in water

Relative density $= \dfrac{Density\ of\ a\ substance}{Density\ of\ water} = \dfrac{Mass\ of\ substance}{Mass\ of\ equal\ volume\ of\ water}$

$= \dfrac{Weight\ of\ substance}{Weight\ of\ equal\ volume\ of\ water} = \dfrac{Weight\ of\ substance\ in\ air}{loss\ of\ weight\ of\ substance\ in\ water}$

[Density of water = 1 g/cm^3 = 1000 kg/cm^3]

Activity/Project 1 :

Aim : To study the impact of density of immersing fluid on the upthrust exerted by it.

Materials required : A solid metal cube (1cm x 1cm x1cm), spring balance, inelastic thread, distilled water, saturated salt solution and two beakers.

Method :

1. Take 100 ml each of distilled water and saturated salt solution in the beakers provided.

2. Check the zero error and least count of spring balance

3. Tie the inelastic thread to the metal cube and suspend it with the spring balance

4. Measure the weight of the solid when suspended freely in air. Record it as W_a

5. Now immerse the solid completely (so that it does not touch walls or base) in the beaker containing distilled water. Record the weight read on spring balance as W_r

6. Again immerse the solid completely in salt solution and find its weight (W_s)

7. Find loss in weight of solid in both cases, i.e. (W_a - W_r) and (W_a - W_s)

Conclusion : The density of salty water is more than distilled water. The solid experiences a greater loss in weight when immersed in salty water. This means an upthrust exerted by a fluid
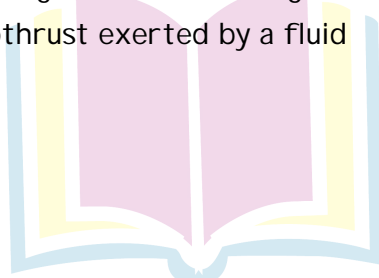
Activity / Project 2 :

Aim : To verify that an upthrust exerted by a fluid depends on the volume of an object immersed.

Materials required : Two balls of the same size – one hollow and one solid, a stopwatch, feather and a sheet of paper

Method :
1. One person stands with all the materials, in the balcony of second / third floor of the building.

2. The other person readies the stopwatch and stands on the ground Floor

3. The first object say solid ball is released. Instantly, the stopwatch is started and stopped as soon as the object reaches the ground and the time of the fall of the object is recorded.

4. The same process is repeated for all the given objects and the time of the fall of all objects is compared.

Observation : The solid ball falls the fastest to ground through air. Feather and a sheet of paper fall very slowly.

Conclusion : Feather and a sheet of paper have large surface area, so they fall slowly as a greater air resistance acts on them during the course of the ball Hollow ball has air filled with it, so its overall density is less than the solid ball. As a result, the difference between its weight and v upthrust due to air is less than that of solid ball. Thus, solid ball falls the fastest

Objective Type Questions

I. Multiple choice questions

1. Upthrust on a body depends on

    a) Density of the liquid

    b) volume of the body

    c) density of the body

    d) both (b) and (c)

2. School bags have a broader base to reduce

    a) pressure   b) weight   c) air resistance   d) normal reaction

3. If upthrust U is equal to $\frac{1}{4}th$ the weight of the object in air, then the weight felt in the liquid   is

    a) $\frac{1}{4}W$ b) $\frac{3}{4}W$ c) $\frac{1}{2}W$ d) $2W$

4. A mass weighing W can float if the upthrust U is related as

    a) U > W   b) U = W   c) U < W   d) U ≥ W

5. In a tank having 'h' height of liquid, two points at a depth $\frac{3h}{4}$ from free surface have pressures P_A and P_B When the point A is more closer to the wall than B. Then

    a) $P_A > P_B$ b) $P_A < P_B$ c) $P_A = P_B$ d) Depends on density

6. The least value of apparent weight of a body in a fluid is

    a) > 0   b) = 0

    c) < 0   d) Depends on the density of solid and fluid

7. A heavy cylinder of length 1 is slowly taken out of a dense liquid. The weight felt as it is taken out of the liquid

    a) will remain the same   b) increases as it comes out

    c) decreases as it comes out   d) increases till it attains the weight in air

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8. An empty closed drum and a filled drum of same dimension will bring

    a) same upthrust   b) same volume   c) both (a) and (b)   d) neither (a) nor (b)

9. An object weighs 10 N in air. When immersed fully in water, It weighs only 8 N. The weight of the liquid displaced by the object will be [NCERT Exemplar Problem]

    a) 2 N   b) 8 N   c) 10 N   d) 12 N

10. A girl stands on a box having 60 cm length, 40 cm breadth and 20 cm width in three ways. In which of the following cases pressure exerted by the brick will be [NCERT Exemplar Problem]

    a) maximum when length and breadth form the base

    b) maximum when breath and width form the base

    c) maximum when width and length form the base

    d) the same in all the above three cases.

1. a	2. a	3. b	4. a	5. c	6. b	7. d	8. c	9. a	10. b

I. Match the columns

11.

Column I	Column II
1. Relative density	A). Mass per unit volume
2. S.I. unit of upthrust	B). Newton
3. Density	C). Density of object / density of water
4. Pressure	D). Inversely proportional to area
5. Archimedes' Principle	E). Lactometer

1. (C)	2. (B)	3. (A)	4. (D)	5. (E)

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12. As contact area between surfaces increases, pressure _____

13. Thrust is the _____ force on a surface.

14. If a heavy and light object have same momentum than heavier one will have _____ kinetic   energy than lighter one.

12. Decreases	13. Perpendicular	14. Lesser

I. True or false

15. Upthrust decreases when a body comes out of liquid.

16. When upthrust is greater than weight, the body floats in inside the liquid

17. Upthrust depends on density of liquid, volume of body immersed and acceleration due to gravity

15. True	16. False	17. True

Direction (Q.18 and Q.19) : In the following Questions, the Assertion and Reason have been put forward. Read the statements carefully and choose the correct alternative from the following.

   a. Both the Assertion and the Reason are correct and the Reason is the correct explanation of the Assertion.

   b. The Assertion and the Reason are correct but the Reason is not the correct explanation of the Assertion.

   c. Assertion is true but the Reason is false.

   d. The statement of the Assertion is false but the Reason is true.

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18. **Assertion:** It is easier for a camel to run on desert and than a horse.

   Reason: Both camel and horse exert less pressure on the sand as pressure does not depend upon the feet area of both animals.

   (c) Assertion is true but the Reason is false.

19. **Assertion:** A piece of cork pressed into water comes back to surface once released.

   Reason : When a solid is immersed in a fluid, it experiences a buoyant force due to the fluid.

   (a) Both the Assertion and the Reason are correct and the Reason is the correct explanation of the Assertion

20. Define thrust   [CBSE 2010]

   The force acting on an object perpendicular to the surface is called thrust. Its SI unit is newton.

21. Differentiate between force and thrust.

   Force can act on a surface in any direction. But thrust is a force which acts on the surface in perpendicular direction.

22. Define pressure.

   Pressure is defined as thrust per unit area of a surface.

23. State and define SI unit of pressure

   The SI unit of pressure is pascal (Pa)

   Pressure acting on a surface is 1 Pa if a thrust of 1 N acts on its unit area.

24. How is pressure related to the thrust exerted on a surface?

   Pressure is directly proportional to the thrust exerted on a surface,

   since pressure $= \dfrac{Thrust}{Area}$

25. How is pressure related to the area of a surface on which thrust acts?

   Pressure is inversely proportional to area on which thrust is exerted, i.e. if area is more, pressure reduces and if area is less, pressure increases.

26. Dams have broad foundation. Why is it so?

   The broad base of a dam reduces downward pressure of hug amount of water, as greater is the area, lesser is the pressure.

27. It is easier to cut an apple with the sharp edge of a knife. Give reason.

The sharp edge of a knife has a smaller area and the pressure is inversely proportional to area of contact. So it exerts a greater pressure on the apple and cuts it easily.

28. A solid exerts pressure of 20 Pa on a surface of $2m^2$. Find its weight.

Given Pressure = 20 Pa, Area = $2m^2$

Weight = Thrust

Now, Pressure $= \frac{Thrust}{Area}$

$\Rightarrow$ Thrust = Pressure x Area

= 20 Pa x = $2m^2$ = 40 N

29. Do fluids also exert pressure? If yes, in which direction do they exert pressure?

Yes, the fluid molecules exert an equal pressure in all directions and transmit it undiminished in all directions on the walls and base of the containers.

30. Why does a needle have a sharp tip?

The sharp tip of a needle has a smaller area and the pressure is inversely proportional to area of contact. So it increases the pressure exerted by needle for a given force and easily penetrates into the surface.

31. What is atmospheric pressure?

The pressure exerted on us by atmosphere of the earth is called atmospheric pressure [1 atmosphere = 1.013 x 10^5 Pa

32. Is pressure a scalar or a vector quantity? explain

Pressure is a scalar quantity since at a level inside a liquid, the pressure due to the liquid is exerted uniformly in all directions. Hence a definite direction is not associated with the pressure due to the liquid.

33. How does the density of fluid affect the magnitude of buoyancy acting on an object immersed in it?

The greater the density of fluid, more is the upthrust acting on the object immersed in it

34. Mark the direction of weight of the body and upthrust acting on it, in the following diagram
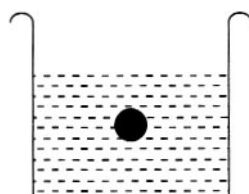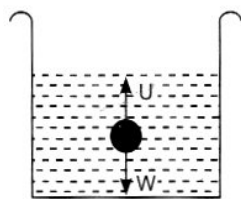
W = Weight of the body

U = Upthrust

35. State a condition for an object to float when placed on the surface of water.

An object floats on the surface of water if n upthrust exerted on it is greater than its weight, i.e. U > W

36. A coin sinks when placed on the surface of water. Give reason.
The coin sinks when placed on the surface of water because on it.

37. A body is immersed once in each of the following media:

a. mustard oil   b. water   c. glycerine   d. petrol

In which case will there be maximum apparent loss of weight and why?

c. The body experiences a maximum apparent loss in weight in glycerine because it has the highest density among the rest of the media.

38. A crumpled sheet of paper falls down faster through air than a plane sheet, why?

A crumpled sheet of paper falls faster as it experiences lesser air resistance due to its small area than a plane sheet during the fall

39. State Archimedes principle.

Archimedes' principle states that when an object is partially or fully immersed in a fluid, it experiences an upthrust or upward force that is equal to the weight of the fluid displaced by it.

40. Give two applications of Archimedes' principle.

Archimedes' principle is used in designing ships and submarines and in making lactometers.

41. Name two forces which act on an object immersed in a fluid.

Weight [Downward] and buoyancy [upward]

42. Why does a cork not sink in water?

A cork does not sink in water because its weight is less than the upthrust exerted by water.

43. What is the use of a hydrometer?

Hydrometer is used to find the density of water.

44. What is the use of a lactometer?

A lactometer is used to measure the purity of a given sample of milk

45. On what principle are lactometer and hydrometer based?

Archimedes principle

46. Why is it easier to swim in sea water than freshwater?

It is easier to swim in sea water as it exerts a greater buoyant force on the body of the swimmer. This is because sea water is denser than freshwater due to its salt content. Greater the density more is the upthrust exerted by fluid on the body.

47. Define density

Density is defined as mass per unit volume of a substances.

Density $= \frac{Mass}{Volume}$

48. State the SI unit of density

The SI unit of density is kilogram per cubic metre [kg/m^3]

49. Relate the SI unit of density with its egs unit.

$1 \, kg/m^3 = 1000 \, kg/m^3$

$\left[\because \ 1 \, kg/m^3 = \frac{10^{-3}\text{kg}}{10^{-6}\text{m}^3} = 10^3\text{kg/m}^3 \right]$

This is equal to the density of water

50. Define relative density

The ratio of density of a substance to density of water is called relative density.

51. State the SI unit of relative density

Ans. relative density has no unit as it is a ratio.

52. Relate relative density of a substance to its density

Relative Density $= \frac{Density \ of \ a \ substance}{Density \ of \ water}$

53. Density of a solid is 7.5 g/cm^3 . when is its relative density?

Given : Density of water, $p_w = 1g/cm^3$: density of solid, $p_s = 7.5 \ g/cm^3$

Relative density $= \frac{p_w}{p_s} = \frac{7.5}{1} = 7.5$

54. Relative density of an object is 1.35, will it float or sink in water?

Since the given relative density 1.35 > 1, the object will sink in water.

55. A body of mass 20kg is placed on an area $2m^2$. Find the pressure exerted.

Given. Mass, m = 20kg: g = 9.8 ms^{-2} : Area A = $2m^2$

Pressure = $\frac{Thrust}{Area} = \frac{mg}{A} = \frac{20 \times 9.8}{2} = 98\ Pa$

56. Thrust of 'F' N is exerted on an area 24 and thrust of "3F" N is exerted on an area A/2. Find the ratio of pressure exerted.

Pressure, $P_1 = = \frac{Thrust\ 1}{Area\ 1} = \frac{F}{2A}$

Pressure, $P_2 = = \frac{Thrust\ 2}{Area\ 2} = \frac{3F}{A/2} = \frac{6F}{A}$

∴ $\frac{P_1}{P_2} = \frac{F}{2A} / \frac{6F}{A} = 1 : 12$

57. An iron ball weighs 11 kg in air and 8 kg when immersed in water. Find its relative density.

Relative density $= \frac{Weight\ of\ a\ substance\ in\ air}{Loss\ in\ weight\ of\ a\ substance\ in\ water}$

$= \frac{11\ kg\ wt}{11\ kg\ wt - 8\ kg\ wt} = \frac{11}{3} = 3.6$

58. An army tank weighing more than a thousand tone rests upon a continuous chain. Why?

The chain at the base of the tank increases its area of contact with the ground. Since pressure is inversely proportional to the area of contact, it reduces the pressure exerted by the tank on the ground despite its large weight

59. Cutting tools have sharp edges. Why?

The sharp edges of cutting tools have small areas, so for a given amount of applied force, they exert greater pressure upon the surface to be cut. This makes the cutting of the surface easier as pressure increases.

60. Why is it easier for a camel to run on desert sand than a horse?

The feet of camel have large area, so the pressure exerted by camel on the sand is less since pressure is inversely proportional to area of contact. On the other hand, dig deep into the sand making it difficult for the horse to run.

61. What happens when buoyant force exerted by the fluid is equal to the weight of the body?

 [CBSE 2012]

When a buoyant force exerted by the fluid is equal to weight of the body, then the body floats while being completely immersed in the fluid.

62. Two blocks, one of iron and other of wood are immersed in water at the same depth. Which one will come upward? Why?   [CBSE 2011]

OR

A wooden block floats and an iron block sinks when both are placed on the surface of water. State reason.   [CBSE 2014]

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The block of wood will come upward as the weight of wooden block is less than the upthrust exerted by water. On the other hand, the iron block has more density so its weight is greater than the upthrust exerted by water and it sinks.

63. An object of weight 40N when immersed in water, loses 10 N weight, will the object float or sink? Why? [CBSE 2011]

Relative density of object

$$= \frac{Weight\ in\ air}{Loss\ in\ weight\ in\ water} = = \frac{40\ N}{10\ N} = 4$$

Since relative density, $4 > 1$, the object will sink in water.

64. A sharp knife is more effective than a blunt knife. Why? [CBSE 2012]

A sharp knife has a very thin edge of smaller area than that of a blunt knife. So it exerts a greater pressure for a given amount of force. Thus it is more effective as this large pressure cuts the object easily.

65. On what factors does the magnitude of an buoyant force experienced by a body in a fluid depend?

The magnitude of buoyant force experienced by a body in a fluid [according to Archimedes' principle] depends on

(i) volume of fluid displaced

(ii) density of fluid, and

(iii) acceleration due to gravity

66. Relative of density of gold is 19.5. the density of water is $1000 kg/m^3$. what will be the density of gold is SI unit and is g/cc? [CBSE 2015]

Density of gold = Density of water x Relative density of gold

= $1000\ kg/m^3 \times 19.5$

= $1.95 \times 10^4\ kg/m^3$

In g/cc, Density = $\left(\frac{1.95 \times 10^4}{10^3}\right) g/cm^3$

= $19.5\ g/cm^3$
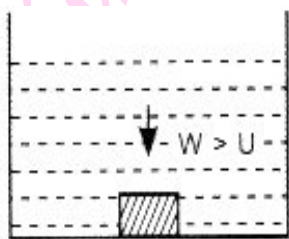
1. **State the principle of floatation for an object of weight W immersed in a fluid.**

   Principle of floatation: It states that if a body of weight "W" is immersed in fluid, such that an upthrust 'U' acts on it due to the fluid, then
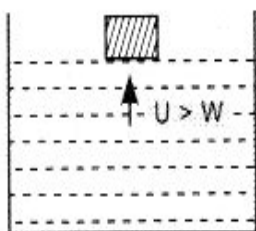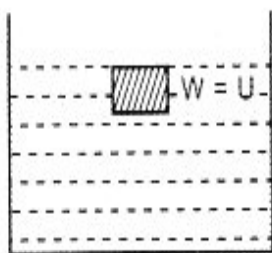
   (i) the body sinks

   $W > U$

   (ii) the body floats

   When $W < U$

   (iii) The body floats with its top when surface completely immersed in fluid

   When $W = U$

2. What are fluids? How does an upthrust exerted by a fluid on an object immersed in it vary with density of fluid?

Gases and liquids are fluids as they can flow. When the density of fluid is more, it exerts a greater buoyant force on the object immersed in it. This is according to Archimedes' principle that upthrust varies directly as density of fluid that upthrust varies directly as density of fluid [U = Vpg, where p = Density of fluid]. For example, sea water exerts a greater buoyant force on a swimming person than in freshwater, as the density of sea water is greater that the freshwater, like lake or river.

3. Define relative density of a substance. Relative density of silver is 10.8. The density of water is $1000 kgm^{-3}$. What is the density of silver in SI units?

Relative density of a substance is defined as the ratio of its density to the density of water.

Given: relative density, R.D = 10.8; density of water, $P_w = 10^3 \ kg/m^3$, density of silver, P_{Ag} = ?

$\because$ R.D = $\frac{p_{Ag}}{p_w}$

$\therefore$ $P_{Ag} = R.D \ x \ p_w$ = 10.8 $\times$ 10^3

$\qquad$ = 1.08 x $10^4 \ kg/m^3$

4. Define pressure and state its SI unit. The dimensions of a metallic cuboid are 30 cm x 20 cm x 15 cm and its mass is 30 kg. If the acceleration due to gravity be $10 \ m/s^2$, calculate the pressure exerted by the cubhoid when it is resting on the face having sides 20cm x 15cm on a table $\hspace{2em}$ **[CBSE 2012]**

Pressure is defined as thrust per unit area of a surface. Its SI unit is pascal (Pa).

Given: M = 30kg, g = $10 \ m/s^2$

A = 20 cm x 15 cm

Thrust = Mass x Acceleration due to gravity

$\qquad$ = 30kg x $10 \ ms^{-2}$ = 300 N

Area = 20 cm x 15 cm = 0.2 m x 0.15 m

$\qquad$ = 0.03m^2

Pressure = $\frac{Thrust}{Area}$ = $\frac{300 \ N}{0.03}$ = $10^4 \ Pa$

5. a). **State the SI units of Thrust and Pressure,**

b). **In which situation we exert more pressure on the ground – when we stand on one foot or on both the feet? Justify your answer.**

a). Thrust : newton

Pressure : pascal

b). We exert more pressure on the ground when we stand on one foot as all the weights of the body is exerted on the area of one foot only. The pressure is inversely proportional to area of contact. So it increases.

6. **A box has dimensions 15cm x 20cm x 25cm. Calculate pressure exerted by box if it is rested on a surface at (a) 15cm x 20cm face (b) 20 cm x 25cm face (c) 15cm x 25cm face, given mass of box = 20kg. Arrange the pressure in ascending order of their magnitude.**

Given: Mass of the box m = 20kg

$\therefore Weight\ of\ box = mg = 20 \times 10$

[if g = $10\ m/s^2$] = $200\ N$

(a) Area = 15cm x 20cm = 300 cm^2

= $0.03\ m^2$ [$\because 1\ m^2 = 10^4\ cm^2$]

Pressure, P_1 = 200/0.03 = 6666.67 P_a

(b) Area = 20cm x 25cm = 500 cm^2

= $0.05\ m^2$ [$\because 1\ m^2 = 10^4\ cm^2$]

Pressure, P_2 = 200/0.05 = 4000 P_a

(c) Area = 15cm x 25cm = 375 cm^2

= $0.0375\ m^2$

[$\because 1\ m^2 = 10^4\ cm^2$]

Pressure, P_3 = 200/0.0375 = 5333.33 P_a

4000 < 5333.33< 6666.67

$P_2 < P_3 < P_1$

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7. **A force of 100 N acts on a surface of area 25 square cm. Calculate thrust and pressure. Calculate the changed pressure if the force now is reduced to 25N**

   Given : Force, F = 100 N; Area,

   A = 25 cm^2 = 25 x $10^{-4} m^2$

   Thrust = Force = 100 N

   Pressure = $\frac{Trust}{Area}$ = $\frac{100}{25 \times 10^{-4}}$ = 40000 Pa

   If force becomes 25N, i.e., $\frac{1}{4}$th then pressure

   Also becomes one fourth, i.e. $\frac{40000}{4}$ = 10000 Pa

8. **Find the ratio of the pressure exerted by a block of 400 N when placed on a table top along its two different sides with dimensions 20cm x 10cm and 10cm x 15cm**

   Thrust = Weight = 400 N

   Base Area 1 = 20cm x 10cm

   Or A_1 = 0.2m x 0.1m = 0.02m^2

   Pressure, P_1 = $\frac{W}{A1}$ = $\frac{400}{0.02}$ = 2 × 10^4 Pa

   Base Area 2 = 10cm x 15cm

   Or A_2 = 0.1m x 0.15m = 0.015m^2

   Pressure, P_2 = $\frac{W}{A_2}$ = $\frac{400}{0.015}$ = 2.6 × 10^4 Pa

   ∴ $\frac{P_1}{P_2}$ = $\frac{2 \times 10^4}{2.6 \times 10^4}$ = $\frac{10}{13}$

   ∴ $P_1 : P_2$ = 10 : 13

9. **(a) Which will exert more pressure : a 100kg mass on 10m^3? Give reason**

   **(b) When we stand on loose sand, our feet go deep into the sand, but when we lie down on the sand our body does not go that deep in the sand. Why? **

   (a) Given: Weight of 100kg mass = 100 x 9.8 = 980 N = W_1

   Weight of 50kg mass = 50 x 9.8 = 490 N = W_2

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$A_1 = 10m^2$, $A_2 = 4m^2$,

$P_1 = \frac{W_1}{A_1} = \frac{980}{10} = 98\ P_a$

$P_2 = \frac{W_2}{A_2} = \frac{490}{4} = 122.5\ P_a$

i.e., $P_2 > P_1$ so 50kg mass on 4m^2 exerts a greater pressure.

(b) When we lie down, the area of contact of our body with surface is more, so we exert less pressure on the sand as pressure $\propto \frac{1}{Area}$. Hence we do not sink into the sand.

10. What is meant by buoyancy? Why does an object float or sink when placed on the surface of a liquid?   [CBSE 2012]

Buoyancy is defined as the upward force exerted by a fluid on an object immersed in it.

When the buoyancy of a liquid is greater than the weight of the object, it floats. However, when the buoyancy of liquid is less than the weight of the object, it sinks.

11. **A sealed empty plastic bottle is pushed in water in a bucket.**

(a) Explain the following observations in doing so:

(i)   It becomes more difficult to push it deeper and deeper.

(ii)   The bottle comes back to surface on being released.

(b) What should be done to keep the bottle completely immersed in water?

(a) (i) An upthrust exerted by water keeps on increasing as the empty bottle is pushed deeper till it is completely immersed.

   (ii) An upthrust of water is more than the weight of the empty bottle. So it bounces back to surface when released.

(b) To keep the bottle completely immersed, an upward force acting on it due to water must be balanced by an externally applied downward force. Thus force must atleast be equal to the difference between upward force and weight of the empty bottle.

12. (a) **Name the forces acting on a body when it is fully or partially immersed in a liquid.**

    (b) **Briefly explain. Why some objects float and some sink in the liquid.** [CBSE2015]

    (a) Upthrust or buoyant force

    (b) The object whose weight is greater than an upthrust exerted by the liquid, sinks in it and the object whose weight is less than an upthrust, floats on it.

13. **Describe a simple activity to prove that the objects of density less than that of the liquid float on it.**

    Activity:

    (i) Take a beaker and fill it with water.

    (ii) Put an iron nail and a cork in the beaker. It is observed that an iron nil sinks in water, whereas a cork floats on it. This is because the density of the iron nail is more than that of water, whereas that of the cork is less than water.

14. **The volume of a bag of mass 1250g is 150cm^3 . If this bag is put on water will it float of sink? Justify your answer. Lso, find the volume of water displaced by this bag.**

    Given : Mass of bag = 1250g

    Volume of bag = 150cm^3

    Density = 1250 g/150cm^3 = 8.33 g/cm^3

    Density of water = 1g/cm^3

    Since the density of bag is greater than that of water, i.e.8.33 > 1 it will sink.

    Volume of water displaced = Volume of bag = 150cm^3

15. **State any two daily life phenomena which are based on Archimedes' principle. Discuss the role of Archimedes' principle in industry and defence.**

    (i) When clothes are immersed in a bucket of water, the water level rises up.

    (ii) An empty mug floats on water. But when water is filled in the mug. It sinks.

    Archimedes' principle is used in indstry for ship designing and making lactometers to test purity of milk etc.,

    In country's defence, it plays an important role as it is used in making submarines.

16. **What is the condition for an object to sink in water? What is the physical meaning of relative density? float in air?** **[CBSE 2015]**

An object sinks in water if its density is greater than water.

Relative density is the ratio of density of a substance to density of water.

The hydrogen-filled ballooms have lesser density than air, so they float in air due upthrust exerted by air.

17. **A solid weighs 75g in air and 55.6g in water. Find the relative density of the solid. Also state if the object will float or sink when immersed in water [CBSE 2014]**

Relative density of solid

$$= \frac{Weight\ of\ solid\ in\ air}{Loss\ of\ weight\ of\ solid\ in\ water} = \frac{75\ gwt}{(75-55.6)gwt} = \frac{75}{19.4} = 3.8$$

Since relative density, 3.8 > 1, the object would sink when immersed in water.

I. Long Answer Type Question

1. **What is upthrust? What are the quantities that can vary upthrust? How does it account for the floating of a body? When a partially immersed body is pressed down a little, what will happen to the upthrust?**

Upthrust or Buoyant force: When a body is partially or fully immersed in a fluid, it experiences an upward force due to fluid displaced by it. This is called upthrust.

i.e. U = Volume immersed x Density of fluid x Acceleration due to Gravity

$= V_{pg}$

The volume of the fluid displaced is equal to the volume of the immersed portion of the body. Due to the presence of the upthrust, there is an apparent loss in the body's weight. When the upthrust is more that the weight of body, the body floats and when the upthrust is less than the weight of body, the body sinks,

Apparent weight = Weight – Upthrust

$= V_{P_b}g - V_{iP_l}g$

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Where P_b and P_l are the densities of the body and liquid respectively, and V and V$_i$ are the volumes of the body and volume immersed. When a body is pressed, the more immersion will lead to move upthrust for a moment.

2. **State Archimedes' principle. How will you verify it experimentally?**

Archimedes' Principle : Archimedes' principle states that when an object is partially or fully immersed in a fluid, it experiences an upthrust or upward force that is equal to the weight of the fluid displaced by it.

Experimental verification :
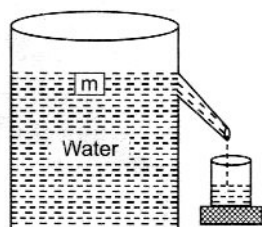
Take an overflow can and fill it with water. Put a block of mass m into it. Collect the overflowing water in another small beaker and measure the volume of water collected and the volume of the block. You will be able to see that the two volumes come to be one and   the same.

3. **(a)State two factors on which the magnitude of buoyant force acting on a body immersed in a fluid depends.**

(b) Will buoyant force exerted by a liquid increase if its volume is increased?

(c) Name the devices based on Archimedes' principle.

a) Buoyant force   = Weight of liquid displaced

= (Volume immersed)

x (Density of liquid)

x (Acceleration due to gravity)

So the density of the liquid and volume immersed affect the buoyant force

b) Buoyant force exerted by a liquid does not depend on its volume

c) Hydrometer and lactometer are based on Archimedes' principle. Submarines are also designed according to Archimedes principle.

4. (a) Define density, Give its mathematical form

b) Define relative density. Give its unit.

c) A solid weighs 80g in air, 68 g in water and 60g in oil. Calculate the relative density of solid and oil.

a) Density is defined as the mass per unit volume of a body.

Density = $\frac{\text{mass}}{\text{volume}}$

b) Relative density is the ratio of the density of a body to density of water. It has no unit as it is a ratio.

c) Relative density of solid = $\frac{Loss\ in\ Weight\ of\ solid\ in\ oil}{\text{Loss in weight of solid in water}}$

$= \frac{80g}{(80-68)gwt}$ $= \frac{80g}{12}$ = 6.6

Relative density of oil

$= \frac{Loss\ in\ Weight\ of\ solid\ in\ oil}{\text{Loss in weight of solid in water}}$

$= \frac{80-60}{80-68}$ $= \frac{20}{12}$ = 1.6

5. a) Radius of an iron sphere is 0.21 cm. If density of iron is 7.8 g / cm^3, calculate its mass.

b) A pressure of 1000 Pa, acts on a surface of area 15 cm^2 by a block of mass 'm'. Calculate 'm' Calculate the new pressure exerted by the same block if the area of contact with the surface becomes 10 cm^2

a) Given : Radius, r = 0.21cm.

Density = 7.8 g / cm^3

Volume of sphere $= \frac{4}{3}\pi r^3$

$= \frac{4}{3}$ x $\frac{22}{7}$ x 0.21 x 0.21 x 0.21 = 0.04 cm^3

Mass = Density x volume

= 7.8 g / cm^3 x 0.04 cm^3 = 0.312 g

b) Pressure, P = 1000 Pa; Area, A = $15 cm^2$

$= 15$ x $= 10^{-4} m^2$

Thrust = Pressure x Area

Or Mass $= \frac{PA}{g} = \frac{1000 \times 15 \times 10^{-4}}{10}$

$= 0.15$ kg $= 150$ g   [Taking g $= 10\ ms^{-2}$

If A $= 10\ cm^2 = 10 \times 10^{-4} m^2$

Then Pressure $= \frac{Thrust}{Area} = \frac{0.15 \times 10}{10 \times 10^{-4}}$

$= 1500$ Pa

Thus if area reduces, pressure increases.

6. Differentiate between thrust and pressure (Give two points)

What do you understand by 1 pascal and 1 newton? How will the pressure change if area of contact is doubled?

Thrust	Pressure
i) The perpendicular force acting on surface is thrust	i) Thrust per unit area of a surface is pressure
ii) The SI unit of thrust is newton	ii) The SI unit of pressure is pascal of N/m^2

1 Pascal : Pressure acting on a surface is one pascal, if a thrust of one newton acts on unit area.

1 Pa = 1 N/ 1 m^2 = 1 N/m^2

 1 newton : Thrust exerted on a surface is one newton if it accelerates a body of unit mass by m/s^2 while acting perpendicular to it.

If area of contact is doubled, pressure becomes half as pressure is inversely proportional to area.

I. Multiple choice Question

1. An object weight 10 N in air. When immersed fully in water. It weighs 8 N. The weight of the liquid displaced by the object will be.

    a) 2 N   b) 8 N   c) 10 N   d) 12 N

    (a) Weight in water = 8 N

    Weight in air = 10 N

   Weight of liquid displaced = Loss in weight

    = 10 N – 8 N = 2 N

2. An object is put one by one in three liquids having different densities. The object floats with 1/9, 2/11 and 3/7 parts of their volumes outside the liquid surface in liquids of densities d_1, d_2 and d_3 respectively. Which of the following statement is correct?

    a) $d_1 > d_2 > d_3$ b) $d_1 > d_2 < d_3$ a) $d_1 < d_2 > d_3$ a) $d_1 < d_2 < d_3$

    Sol: (d) Volume of solids above water surface = $1/9$, $2/11$ and $3/7$ respectively.

    Volume of solids immersed = $1 - (1/9)$, $1 - (2/11)$, and $1 - (3/7)$ respectively.

    As $v_1 > v_2 > v_3$ the densities of liquids are in magnitude $d_1 < d_2 < d_3$. This is because lesser the volume of solid immersed, more is the upthrust action on it and hence, greater is the density of fluid.
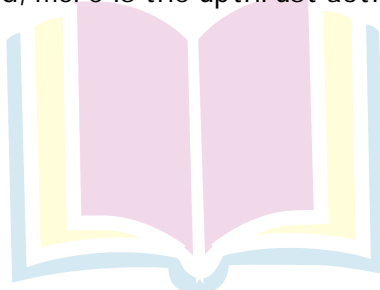
3. (a) A cube of side 5 cm is immersed in water and then in saturated salt solution. In which case will it experience a greater buoyant force? If each side of the cube is reduced to 4 cm and then immersed in water, what will be the effect on the buoyant force experienced by the cube as compared to the first case? Give reason for each case.

b)   A ball weighing 4 kg of density 4000 kgm^{-3} is completely immersed in water of density 10^3 kgm^{-3}. Find the force of buoyancy on it (Given g = 10 ms^{-2})

a) The cube experiences a greater buoyant force when immersed in salty water because salty water has greater density than water.

When the side of cube is reduce, then the buoyant force acting on it due to water, will reduce. This is according to Archimedes' principle as when the volume of a body is less, an upthrust exerted by the fluid on it, is also less.

b) Given : Mass of ball = 4 kg.

Density of ball = 4000 kg/m^{-3}

Diversity of water kgm^{-3}, g = 10 ms^{-2}

Volume of ball, V = $\frac{Mass}{Density}$ = $\frac{4}{4000}$

= $10^{-3}\ m^{-3}$

Upthrust U = Vρg = 10^{-3} x 10^3 x 10 = 10N