PHYSICS

BOOKS - ICSE

PRESSURE IN FLUIDS AND ATMOSPHERIC PRESSURE

Examples

1. A boy weighing 60 kgf is wearing shoes with heel of area of cross section $20cm^2$, while a

girl weighing 45 kgf is wearing sandals with heel of area of cross section $1.5cm^2$. Compare the pressure exerted on ground by their heels when they stand on the heel of one foot.

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2. Calculate the pressure due to a water column of height 100 m. (Take $g = 10ms^{-2}$ and density of water $= 10^3 kgm^{-3}$).

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3. At what depth below the surface of water will pressure be equal to twice the atmospheric pressure ? The atmospheric pressure is $10Ncm^{-2}$, density of water is 10^3kgm^{-3} and $g = 9.8ms^{-2}$.

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4. A cube of each side 5 cm is placed inside a liquid. The pressure at the centre of one face of cube is 10 Pa. Calculate the thrust exerted by the liquid on this face.

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5. A square plate of side 10 m is placed horizontally 1 m below the surface of water. The atmospheric pressure is $1.013 \times 10^5 Nm^{-2}$. Calculate the total thrust on the plate.

(Density of water $\rho = 10^3 kgm^{-3}, g = 9.8ms^{-2}$)

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6. A vessel of base area $100cm \times 60cm$ and height $200cm$ is completely filled with a liquid of density $1.1 \times 10^3 kgm^{-3}$.

(a) Ignoring the atmospheric pressure, find :

(i) the thrust at the bottom of the vessel,

(ii) the pressure at the bottom of the vessel,

(iii) The pressure at a depth of 5 cm from the free surface,

(iv) the net force experienced by a metal foil of area $10cm^2$ placed at a depth of 5 cm from the free surface,

(b) The thrust at the bottom of the vessel if the atmospheric pressure equal to

$1 \times 10^5 Nm^{-2}$ is taken into account.

Take $g = 9.8ms^{-2}$.

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7. In Fig. 4.10, a tube of length 200 cm filled with a liquid of density $0.90 \times 10^3 kgm^{-3}$ is placed inclined with the vertical such that the level A of liquid in the tube is at a vertical height 100 cm from its lowest point C. there is a point B in the tube below the point A at a vertical depth 60cm.

(a) Calculate the pressure at points

(i) A,

(ii) B and

(iii) C

(b) What will be the pressure at point C when the tube is made vertical ?

Take atmospheric pressure $= 1.013 \times 10^5 Nm^{-2}$

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8. A U tube is first partially filled with mercury. Then water is added in one arm and an oil is added in the other arm. Find the ratio of water and oil columns so that mercury level is same in both the arms of U tube. Given : Density of water $= 10^3 kgm^{-3}$, density of oil $= 900 kgm^{-3}$.

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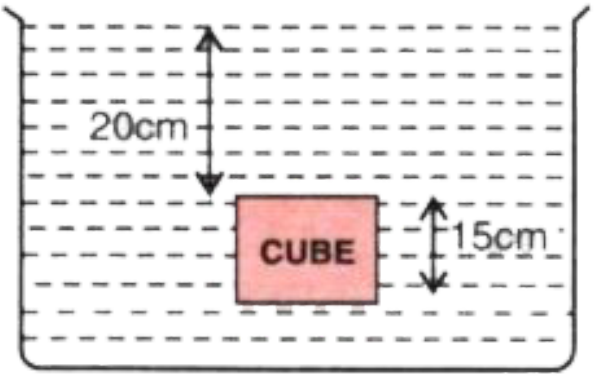
9. Fig. 4.11 shows a cube of each side 15 cm immersed in a tube containing water of density $10^3 kgm^{-3}$ such that its top surface is 20 cm below the free surface of water.



Calculate (i) the pressure at the top of cube,

(ii) the pressure at the bottom of cube,

(iii) the resultant pressure on cube.

(iv) the resultant thrust on cube.

Take atmospheric pressure = 10^5 Pa and $g = 9.8 N kg^{-1}$.

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10. An air bubble rises from the bottom of a lake of depth $10.34 m$ to its surface. Compare the pressure on bubble at the bottom to that on surface. (Atmospheric pressure $= 0.76 m of Hg$, density of $Hg = 13.6 \times 10^3 K g m^{-3}$ and density of water $= 10^3 k g m^{-3}$).

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11. In a hydraulic machine, the two pistons are of area of cross section in the ratio 1:10. What weight force in needed on the narrow piston to overcome a force of 100 N on the wide piston?

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12. The area of cross section of press plunger of a hydraulic press is $4m^2$. It is required to

overcome a resistiveload of 400 kg on it. Calculate the force required on the pump plunger if the area of cross section of the pump plunger is $0.01m^2$.

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13. What is meant by the statement “the atmospheric pressure at a place is 76 cm of Hg"? State its value in Pa.

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14. The upper blood pressure of a patient is 160 cm of Hg whereas the normal blood pressure should be 120 cm of Hg. Calculate the extra pressure generated by the heart in S.I. unit . Take density of $Hg = 13600 kgm^{-3}$ and $g = 9.8 ms^{-2}$.

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15. (a) What length of water column is equivalent to 0.76 m of mercury column ? State the assumption made in your

calculation.

(b) Can water be used as barometric liquid ? Give a reason.

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16. A mercury barometer reads 75cm. Now $3cm^3$ of atmospheric air is introduced into the tube. The mercury falls to a height of 65 cm and the length of air column above the mercury is found to be 15 cm Calculate the cross-sectional area of the barometer tube.

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Exercise 4 A

1. Define the term thrust. State its S.I. unit.

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2. What is meant by pressure ? State its S.I. unit.

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3. (a) What physical quantity is measured in bar ?

(b) How is the unit bar related to the S.I. unit pascal ?

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4. Define one pascal (Pa), the S.I. unit of pressure.

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5. State whether thrust is a scalar or vector ?

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6. State whether pressure is a scalar or vector ?

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7. Differentiate between thrust and pressure .

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8. How does the pressure exerted by a thrust depend on the area of surface on which it acts ? Explain with a suitable example.

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9. Why is the tip of an allpin made sharp ?

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10. Explain the following :

(a) It is easier to cut with a sharp knife than with a blunt one.

(b) Sleepers are laid below the rails.

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11. What is a fluid ?

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12. What do you mean by the term fluid pressure ?

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13. How does the pressure exerted by a solid and a fluid differ ?

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14. Describe a simple experiment to demonstrate that a liquid enclosed in a vessel exerts pressure in all directions.

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15. State three factors on which the pressure at a point in a liquid depends.

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16. Deduce an expression for the pressure at depth inside a liquid.

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17. Deduce an expression for the pressure at depth inside a liquid.

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18. How does the pressure at a certain depth in water differ from that of the same depth in river water. Explain year answer.

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19. Pressure at free surface of a water lake is P_1, while at a point at depth h below its free surface is P_2. (a) How are P_1 and P_2 related ? (b) which is more P_1 or P_2 ?

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20. Explain why a gas bubble released at the bottom of a lake grows in size as it rises to the surface of the lake.

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21. A dam has broader walls at the bottom than at the top. Explain.

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22. Why do the deep sea divers wear specially designed suits?

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23. State the laws of liquid pressure.

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24. How does the liquid pressure on a diver change if :

(i) the diver moves to the greater depth, and

(ii) the diver moves horizontally ?

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25. State Pascal's law for the transmission of pressure in enclosed liquids.

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26. Name two applications of Pascal.s law.

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27. Explain the principle of a hydraulic machine. Name two devices which work on this principle.

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28. Name and state the principle on which a hydraulic press works. Write one use of the hydraulic press.

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29. Draw a simple diagram of a hydraulic jack and explain its working.

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30. Explain the working of a hydraulic brake with a simple labelled diagram.

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31. Complete the following sentences:

(a) Pressure at a depth h in a liquid of density ρ is .....

(b) Pressure is ..... In all direction about a point in a liquid.

(c) Pressure at all points at the same depth is ....

(d) Pressure at a point inside a liquid is ..... to its depth.

(e) Pressure of a liquid at a given depth is ..... to the density of liquid.

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Exercise 4 A Multiple Choice

1. The S.I. unit of pressure is

A. Ncm^{-2}

B. Pa

C. N

D. Nm^2

Answer: A

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2. The pressure inside a liquid of density ρ at a depth h is :

A. $h\rho g$

B. $\frac{h}{\rho g}$

C. $\frac{h\rho}{g}$

D. $h\rho$

Answer:

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3. How does the pressure at a certain depth in water differ from that of the same depth in river water. Explain year answer.

A. $P_1 > P_2$

B. $P_1 = P_2$

C. $P_1 < P_2$

D. $P_1 - P_2 = \text{atmospheric pressure}$

Answer: A::B

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4. The pressure P_1 at the top of a dam and P_2 at a depth h from the top inside water (density ρ) are related as :

A. $P_1 > P_2$

B. $P_1 = P_2$

C. $P_1 - P_2 = h\rho g$

D. $P_2 - P_1 = h\rho g$

Answer: A::B

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Exercise 4 A Numericals

1. A human exerts a force of 1.5 N on each of the two nails A and B the area of cross secton of tip of nail A in $2\mathrm{mm}^2$ while that of B in $6\mathrm{mm}^2$ Calculate the pressure on each nail in pascal.

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2. A block of iron of mass 7.5 kg and of dimensions 12 cm x 8 cm x 10 cm is kept on a table top on its base of side 12 cm x 8 cm.

Calculate : Thrust

Take 1 kgf= 10 N

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3. A vessel contains water up to a height of 1.5 m. Taking the density of water $10^3 kgm^{-3}$, acceleration due to gravity $9.8ms^{-2}$ and area

of base of vessel $100cm^2$ calculate : (a) the pressure and (b) the thrust, at the base of vessel.

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4. The area of base of a cylindrical vessel is $300cm^2$. Water $\left(\text{density} = 1000kgm^{-3}\right)$ is poured into it up to a depth of 6 cm. Calculate : (a) the pressure and (b) the thrust of water on the base. $\left(g = 10ms^{-2}\right)$.

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5. (a) Calculate the height of a water column which will exert on its base the same pressure as the 70 cm column of mercury. Density of mercury is $13.6 g cm^{-3}$

(b) Will the height of the water column in part (a) change if the cross section of the water column is made wider ?

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6. The pressure of water on the ground floor is 40,000 Pa and on the first floor is 10,000 Pa. Find the height of the first floor. (Take : density of water = 1000kg m^{-3}, $g = 10\text{m s}^{-2}$)

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7. A simple U tube contains mercury to the same level in both of its arms. If water is poured to a height of 13.6 cm in one arm, how much will be the rise in mercury level in the

other arm ?

Given : density of mercury = $13.6 \times 10^3 \mathrm{kg\ m^{-3}}$

and density of water = $10^3 \mathrm{kg\ m^{-3}}$.

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8. In a hydraulic machine, a force of 2 N is applied on the piston of area of cross section $10 \mathrm{cm}^2$. What force is obtained on its piston of area of cross section $100 \mathrm{cm}^2$?

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9. What should be the ratio of area of cross section of the master cylinder and wheel cylinder of a hydraulic brake so that a force of 15 N can be obtained at each of its brake shoe by exerting a force of 0.5 N on the pedal ?

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10. The areas of pistons in a hydraulic machine are $5cm^2$ and $625cm^2$. What force on the smaller piston will support a load of 1250 N on

the larger piston ? State any assumption which you make in your calculation.

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Exercise 4 A Assumptions

1. (a) The diameter of neck and bottom of a bottle are 2 cm and 10 cm respectively. The bottle is completely filled with oil. If the cork in the neck is pressed in with a force of $1.2kgf$, what force is exerted on the bottom of the

bottle ?

(b) Name the law/ principle you have used to find the force in part (a)

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2. A force of 50 kgf is applied to the smaller piston of a hydraulic machine. Neglecting friction, find the force exerted on the large piston, if the diameters of the pistons are 5 cm and 25 cm respectively.

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3. Two cylindrical vessels fitted with pistons A and B of area of cross section $8cm^2$ and $320cm^2$ respectively. Are joined at their bottom by a tube and they are completely filled with water. When a mass of 4 kg is placed on piston A, find : (i) the pressure on piston A, (ii) the pressure on piston B and (iii) the thrust on piston B.

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4. What force is applied on a piston of area of cross section $2cm^2$ to obtain a force 150 N on the piston of area of cross section $12cm^2$ in a hydraulic machine ?

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Exercise 4 B

1. What do you understand by atmospheric pressure ?

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2. The value of atmospheric pressure on the Earth's surface is .....

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3. What physical quantity is measured in torr ? How is it related to the S.I. unit of the quantity ?

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4. Name the physical quantity which is expressed in the unit .atm.. State its value in pascal.

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5. We do not feel uneasy even under enormous pressure of the atmosphere above as well as around us. Give a reason.

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6. Describe an experiment to demonstrate that air exerts pressure.

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7. Explain the following :

(i) A balloon collapses when air is removed from it.

(ii) Water does not run out of a dropper unless its rubber bulb is pressed.

(iii) Two holes are made in a completely filled sealed tin can to take out oil from it.

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8. Why does the liquid rise in a syringe when its piston is pulled up?

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9. How is water drawn up from a well by a water pump ?

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10. A partially inflated balloon is placed inside a bell jar connected to a vacuum pump. On creating vacuum inside the bell jar, balloon gets more inflated. How does the pressure change : increase, decrease or remains same, inside the (a) bell jar and (b) balloon ?

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11. What is the purpose of a barometer ?

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12. What is a barometer ? How is a simple barometer constructed ?

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13. Explain how is the height of mercury column in the tube of a simple barometer, a measure of the atmospheric pressure.

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14. Illustrate with the help of a lebelled diagram of a simple barometer that the atmospheric pressure at a place is 76 cm of Hg.

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15. Why is the barometric height used as a unit to express the atmosphric pressure ?

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16. What is meant by the statement “the atmospheric pressure at a place is 76 cm of Hg"? State its value in Pa.

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17. How will you show that there is vacuum above the surface of mercury in a barometer ? What name is given to this vacuum ?

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18. How is the barometric height of a simple barometer affected if

(a) its tube is pushed down into the trough of mercury ?

(b) its tube is slightly tilted from vertical ?

(c) a drop of liquid is inserted inside the tube ?

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19. State two uses of a barometer.

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20. State two advantages of use of mercury as a barometric liquid.

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21. Water is not used as a barometeric liquid because :

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22. Mention two demerits of a simple barometer and state how they are removed in a Fortin barometer.

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23. Draw a simple labelled diagram of a Fortin barometer and state how it is used to measure the atmospheric pressure.

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24. State two advantages of an aneroid barometer over a simple barometer.

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25. How is the reading of a barometer affected when it is taken to (i) a mine, and (ii) a hill ?

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26. How does atmospheric pressure change with altitude ? Draw an approximate graph to show this variation .

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27. State two factors which affect the atmospheric pressure as we go up.

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28. Why do ink pens start leaking at high altitudes?

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29. Why does nose start bleeding on high mountains?

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30. What is an altimeter ? State its principle. How is its scale calibrated?

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31. What do the following indicate in a barometer regarding weather :

(a) gradual fall in the mercury level,

(b) sudden fall in the mercury level,

(c) gradual rise in the mercury level ?

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Exercise 4 B Multiple Choice

1. The unit torr is related to the barometric height as :

A. $1\text{torr} = 1\text{cm of Hg}$

B. $1\text{torr} = 0.76\text{m of Hg}$

C. $1\text{torr} = 1\text{mm of Hg}$

D. $1\text{torr} = 1\text{m of Hg}$

Answer: A

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2. The normal atmospheric pressure is :

A. 76 m og Hg

B. 76 cm of Hg

C. 76 Pa

D. $76Nm^{-2}$

Answer: C

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3. The atmospheric pressure at earth surface is P_1 and inside a mine is P_2. They are related as :

A. $P_1 = P_2$

B. $P_1 > P_2$

C. $P_1 < P_2$

D. $P_2 = 0$

Answer: A::B

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Exercise 4 B Numericals

1. Convert 1 mm of Hg into pascal. Take density of $Hg = 13.6 \times 10^3 kgm^{-3}$ and $g = 9.8ms^{-2}$.

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2. At a given place, a mercury barometer records a pressure of 0.70 m of Hg. What would be the height of water column if

mercury in barometer is replaced by water? Take R.D. of mercury = 13.6.

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3. At sea level, the atmospheric pressure is 76 cm of Hg. If air pressure falls by 10 mm of Hg per 120 m of ascent, what is the height of a hill where the barometer reads 70 cm Hg. State the assumption made by you. .

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4. At sea level, the atmospheric pressure is 1.04×10^5 Pa. Assuming $g = 10 \mathrm{m\,s^{-2}}$ and density of air to be uniform and equal to $1.3 \mathrm{kg\,m^{-3}}$, find the height of the atmosphere.

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5. Assuming the density of air to be $1.295 \mathrm{kg\,m^{-3}}$, find the fall in barometric height in mm of Hg at a height of 10^7m above the sea level. Take density of mercury = $13.6 \times 10^3 \mathrm{kg\,m^{-3}}$.

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