S. Chand's IIT Foundation Series

A Compact & Comprehensive Book of

IIT Foundation Science

(Physics and Chemistry)

Class – VIII

S.K. GUPTA
ANUBHUTI GANGAL

EPH
Eurasia Publishing House

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First Edition 2012, Reprint 2012

Reprint with Corrections 2013

ISBN : 81-219-4073-7 **Code :** 16 390

PRINTED IN INDIA
By Rajendra Ravindra Printers Pvt. Ltd., 7361, Ram Nagar, New Delhi-110 055
and published by S. Chand & Company Pvt. Ltd., 7361, Ram Nagar, New Delhi -110 055.

PREFACE AND A NOTE FOR THE STUDENTS

ARE YOU ASPIRING TO BECOME AN ENGINEER AND BECOME AN IIT SCHOLAR ?

Here is the book especially designed to motivate you, to sharpen your intellect and develop the right attitude and aptitude and lay solid foundation for your success in various entrance examinations like **IIT, AIEEE, EAMCET, WBJEE, MPPET, SCRA, Kerala PET, OJEE, Raj PET, AMU,** etc.

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2. Full and comprehensive coverage of all the topics.
3. Detailed synopsis of each chapter at the beginning in the form of ***'Key Concepts'***. This will not only facilitate thorough *'**Revision**'* and *'**Recall**'* of every topic but also greatly help the students in understanding and mastering the concepts besides providing a ***back-up*** to classroom teaching.
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We hope the series will be able to fulfil its aims and objectives and will be found immensely useful by the students aspiring to become top class engineers.

Suggestions for improvement and also the feedback from various sources would be most welcome and gratefully acknowledged.

AUTHORS

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Topics in Chemistry

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TOPICS IN PHYSICS

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Chapter 1

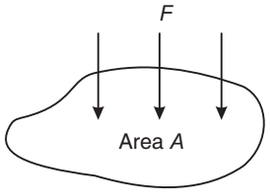
PRESSURE

Section-A

DEFINING PRESSURE, PRESSURE IN FLUIDS AND ATMOSPHERIC PRESSURE

KEY FACTS

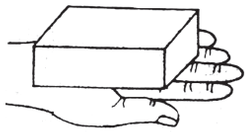
1. **Force.** A push or pull on an object is called *force*.
2. **Thrust.** When a force acts normal to a surface it is called *thrust*.



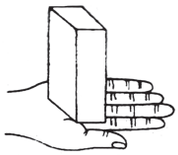
3. Pressure is produced when a force acts on an object.
4. Pressure can be increased by increasing the force or by decreasing the area.

   Thus, (a) more pressure is exerted when we press a wall harder with our thumbs (*increasing* the force).

   (b) Also, more pressure is felt if we hold a brick vertically in our hand than when we hold it in horizontal position. In the first case, the area over which the force acts is lesser than in the second case and so the pressure exerted when the brick is vertically is more than when it is held horizontally.



More surface lesser pressure



Lesser surface more pressure

5. Pressure depends on force and area. It is directly proportional to amount of force applied and inversely proportional to the area over which it is exerted.

The greater the force	⟶	More is the pressure
Greater the area	⟶	Lesser is the pressure

6. Pressure is defined as the thrust per unit area. If a thrust F acts on a surface of surface area A, then

$$\text{Pressure } (P) = \frac{\text{Normal force } (F)}{\text{Surface area } (A)} = \frac{\text{Thrust } (F)}{\text{Surface area } (A)}$$

$$\Rightarrow \quad \boxed{P = \frac{F}{A}}$$

If $A = 1$, then $P = F$. Thus, pressure is numerically equal to thrust (normal force) acting on unit area of a surface.

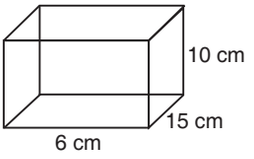
7. Unit of pressure. The thrust is a vector quantity and its SI unit is newton (N). But, pressure is a scalar quantity and its SI unit is **newton per metre^2 (N/m^2 or Nm^{-2})**. It is also called **pascal** (Pa).

One pascal is defined as the pressure on a surface due to a thrust of 1 N acting on 1m^2 surface area. The other units of pressure are kgfm^{-2} and one **bar**.

$$\boxed{\textbf{1bar} = 10^5 \textbf{ Pa.}}$$

Ex. 1. ***If a block of 5 kg is lying on the ground, then the thrust on the surface of the ground due to the weight of the block = weight of the block = mg = 5 kg × 9.8 ms^{-2} = 49 N.***

Ex. 2. ***A block of wood of dimensions 5 cm × 20 cm × 10 cm is kept on a table top. The mass of the block is 2 kg. Acceleration due to gravity is 9.8 ms^{-2}. Find the pressure exerted by the wooden block on the table top.***



Sol. Thrust (F) = Weight of the block = mg

$= 2 \text{ kg} \times 9.8 = 19.6 \text{ N}$

Area of the table top (A) = length × breadth

$= 20 \text{ cm} \times 10 \text{ cm}$

$= \frac{20}{100}\text{m} \times \frac{10}{100}\text{m} = 0.02 \text{ m}^2$

$\therefore \quad P = \frac{F}{A} = \frac{19.6\text{ N}}{0.02\text{ m}^2} = \frac{1960}{2}\text{ N/m}^2 = 980 \text{ N/m}^2.$

$= 980$ Pa (since 1 Pa = 1N/m ^{2}).

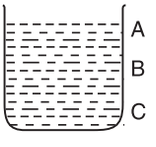
8. Pressure in fluids : All flowing substances such as liquids or gases are called fluids. Like solids, the fluids also have weight and therefore exert pressure. When filled in a container the pressure of the fluid is exerted in all directions and at all points of the fluid.

9. Solids have a definite shape but liquids do not have a definite shape. They acquire the shape of the vessel in which they are kept. Accordingly, their area of contact changes with the shape of the vessel.

10. Since the molecules of a fluid are in constant, rapid motion and the motion is random, which means particles are equally likely to move in any direction. Therefore, the pressure exerted by the fluid acts on an object from all directions.

11. **The pressure that a fluid exerts depends on the density $\left(\textbf{density} = \frac{\textbf{mass}}{\textbf{volume}}\right)$ and the depth of the fluid.**

(i) The pressure exerted by a liquid increases with increasing depth inside the liquid. Thus, in the figure given below,



Pressure at C > Pressure at B > Pressure at A. Pressure is most at C and least at A.

(ii) Liquid pressure remains the same in all directions at a given depth.

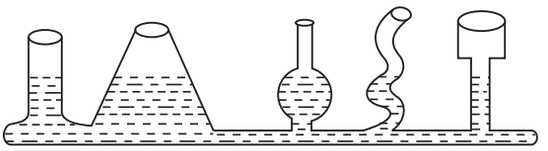
(iii) A liquid of higher density exerts more pressure than a liquid of low density.

Thus, while you are able to carry milk in a pouch of polythene, you won't be able to carry liquids like mercury in it. Because of the high density of mercury, the polythene pouch won't be able to withstand its pressure.

12. Liquid pressure does not depend on the surface area of the liquid as well as the shape and size of the container.

13. Liquid exerts pressure on the walls of the container also. This is called **lateral pressure.** Lateral pressure is exerted by the liquids and gases but not by solids.

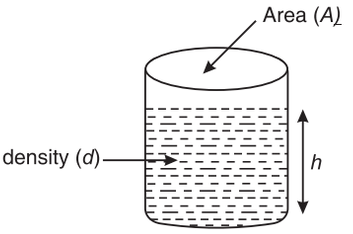
14. A liquid seeks its own level.



Thus, if you connect five vessels of different shapes to a horizontal pipe, the water will flow from the horizontal pipe to these vessels and stand at the same height in all of them irrespective of the shape of the vessel.

15. Pascal's law : According to Pascal's law, the pressure exerted at any point on an enclosed liquid is transmitted equally and undiminished in all directions.

16. The formula $P = hdg$.



Consider a container of cross-section area A. Suppose a liquid of density d is filled in the container up to height h.

The weight of the liquid (W) = mg and acts vertically downwards.

i.e., W = mass of the liquid × acceleration due to gravity

= (volume of the liquid × density) × acceleration due to gravity $\quad [d = \frac{m}{v} \Rightarrow m = d \times v]$

= area of cross-section × height of the liquid × density × acceleration due to gravity

$= A \times h \times d \times g = Ahdg$

The weight or thrust (W) of the liquid acts on area A. Hence,

$$\text{Pressure} = \frac{\text{Thrust } (W)}{\text{Area } (A)} = \frac{Ahdg}{A} = hdg$$

Pressure of liquid at depth h is given by $\boldsymbol{P = hdg}$
i.e., **P = depth × density × acceleration due to gravity.**

Ex. 1. ***Find the pressure at a depth of 20 cm in brine of density 1.2 g/cm^3. Take g = 10 ms^{-2}.***

Sol. Pressure (P) = hdg

Here, $h = 20 \text{ cm} = \frac{20}{100} \text{m} = \frac{1}{5} \text{m} = 0.2 \text{m}$,

$d = 1.2 \text{ g/cm}^3 = 1.2 \times 10^3 \text{ kg/m}^3$, $g = 10 \text{ ms}^{-2}$

$\therefore \quad P = [0.2 \times (1.2 \times 10^3) \times 10] \text{ Nm}^{-2} = \mathbf{2400 \text{ Nm}^{-2}}$.

Ex. 2. ***Calculate the water pressure and the thrust at the bottom of a tank whose length, width and the depth are 2m, 1.5 m and 1m respectively. Density of water is 1000 kg m^{-3}.***

Sol. Given : $h = 1\text{m}$, $d = 1000 \text{ kg m}^{-3}$, $g = 9.8 \text{ ms}^{-2}$

Since pressure depends only on the depth of the liquid, therefore,

$P = hdg = 1 \text{ m} \times 1000 \text{ kg m}^{-3} \times 9.8 \text{ ms}^{-2} = 9800 \text{ Nm}^{-2}$

17. Atmospheric pressure. The earth is surrounded by a layer of air up to a certain height (nearly 300 km) and this layer of air around the earth is called **atmosphere** of the earth.

Since air occupies space and has weight, therefore, it also exerts pressure. The pressure exerted by air is called ***atmospheric pressure.***

18. At sea level, air exerts pressure on us equal to about 1,00,000 pascals or 1,00,000 N/m^2. This amount of pressure is referred to as **one atmosphere**. This is a huge amount of pressure equivalent to two elephants sitting on our head but we are able to sustain it because materials in our body provide an outward pressure that balances the air pressure.

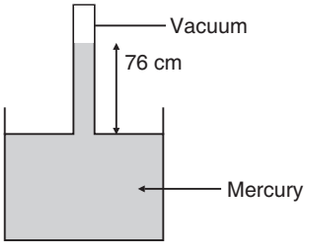
19. Variations in atmospheric pressure.

(1) Air has weight. The more air there is above us, the greater the weight of the air. As we climb up a mountain the air becomes thinner and thinner and so its weight reduces. Consequently, the atmospheric pressure also becomes lesser and lesser.

The atmospheric pressure at higher elevations is less than at lower elevations. It is less than 1 atmosphere.

(2) Air at lower elevations is more compressed, and therefore, denser, than air at higher elevations. Pressure is exerted by individual molecules - and therefore more collisions. An increase in the number of collisions results in an increase in the force, and therefore pressure exerted by the air.

20. The instrument with which atmospheric pressure is measured is called **barometer**. A simple barometer can be made in the laboratory by taking a glass tube about 1 m long, open at one end. It is filled with, and placing the thumb over the open end, it is inverted into a container containing mercury. The mercury in the tube drops and then it is found to stand steady at a height of **76 cm**. The space above the mercury in the tube is a vacuum (*i.e.*, without air or anything). This suggests that the air exerts as much pressure at sea level as is exerted by 76 cm high mercury column at the same place. The mercury column in the tube remains 76 cm whatever might be the shape and size of the container and even the tilting of the tube does not change this height.



Since h (height of mercury column at sea-level) = 76 cm = $\frac{76}{100}$ m = 0.76 m

density of mercury = 13600 kg m^{-3} and g = 9.8 ms^{-2}

$\therefore$ **Atmospheric pressure at sea-level** = hdg.

= 0.76 m × 13600 kgm^{-3} × 9.8 ms^{-2}

= 101292.8 Nm^{-2} (Pa)

which is approximately 1,00,000 Newtons per sq m

= **100 kPa** (kilo pascal)

Question Bank – 1 (a)

1. Fill in the blanks by suitable words to make them true statements.

(1) Force acting on a unit area is called _____.

(2) Pressure = Force ÷

(3) The instrument used to measure atmospheric pressure is _____.

(4) The SI unit of pressure which is equal to 1 newton per square metre is _____.

(5) The *bar* is another unit of _____ which is equal to _____ pascal.

(6) A force acting normal to a surface is called _____.

(7) The pressure exerted by a liquid _____ with depth.

(8) Fluid pressure acts on an object from _____ directions.

(9) Fluid pressure does not depend on the total volume of the fluid, it only depends on the _____ and _____.

(10) The layer of air above the earth is called _____.

(11) The atmospheric pressure at sea-level is equivalent to the pressure exerted by _____ cm mercury column at that place.

(12) Higher is the altitude, _____ is the atmospheric pressure.

(13) The pressure at a depth h in a liquid of density d is given by pressure = _____; where g is the acceleration due to gravity.

(14) A liquid seeks its own _____.

(15) _____ law states that pressure exerted at any point on an enclosed liquid is transmitted equally and undiminished in all directions.

(16) A drinking straw works on the existence of _____ pressure.

(17) Soap bubbles are spherical because air exerts equal _____ in all directions.

2. Write true or false for each statement.

(1) The pressure in a liquid is the same at all depths.

(2) A liquid in a container exerts pressure in all directions on the bottom of the container on its walls and even upwards.

(3) On the surface of earth, the atmospheric pressure is minimum at the sea-level.

(4) The atmospheric pressure on the top of a high mountain is much greater than at its base.

(5) A drinking straw works on the pressure exerted by the liquid filled in a soft drink bottle in which it is placed.

(6) Pressure is directly proportional to the area of contact.

(7) All states of matter exert pressure.

(8) The cutting instruments are made sharp because it decreases the area of contact thereby increasing the pressure.

(9) The foundations of high-rise buildings are kept wide so that they may exert more pressure on the ground.

(10) To increase pressure, either force has to be increased or area of contact has to be decreased.

(11) Liquids and gases exert pressure in all directions. They exert pressure on the walls of the container also.

(12) The unit used by meteorologists to measure atmosphere is bar (millibar).

(13) Inside a bottle filled with water, pressure is least at the bottom and greatest at the surface of water.

3. Answer the following questions.

(1) A balloon is floating in the air. In which direction is pressure acting on the balloon ?

(2) Why does water exert more pressure on you than air ?

(3) What height cause a balloon blown up at a low altitude to burst if it is taken to a higher altitude ?

(4) Will a diver experience greater pressure 10 cm below the surface of the water or 20 cm below the surface ?

(5) How does depth affect pressure ? How does volume affect pressure ?

(6) Dams store water for irrigation, home use, and hydroelectric power. Why should the dams be constructed so that they are much thicker at the bottom than at the top ?

(7) If a person dives to the bottom of a swimming pool to pick up a coin, how would he feel as he swims toward the bottom ?

(8) During cold winters, ice can form on small lakes and ponds. Many people skate on the ice. Sometimes, a person skates on thin ice and breaks through it. Why do rescue workers lie flat on the ice instead of walking upright when reaching out to help rescue a skater.

(9) You might have felt that your ears have 'popped' when you were in a plane taking off or in a car travelling down a steep mountain road. Why did it happen?

(10) Why do airplanes need to be pressurized for passenger safety when flying high in the atmosphere.

4. Give explanations for the following.

(1) A sharp knife cuts objects more effectively than a blunt knife.

(2) Why are school bags provided with wide straps to carry them.

(3) Why do the porters place a thick round piece of cloth on their heads while carrying heavy loads?

(4) Why are wooden (or concrete) sleepers kept below the railway line ?

(5) Why is a wide steel belt provided over the wheels of an army tank.

(6) How do snow shoes stop a person from sinking into snow ?

(7) Why is depression much more on a cushion when a person stands on it than when he lies down on it?

(8) Animals like camel, walk more easily in a desert than horses.

(9) Skiers use long flat skis to slide over the snow.

(10) The blood pressure in humans is greater at the feet than at the brain.

(11) We hammer the broader side of a nail and not its sharp end to put it in wood. Why ?

(12) A rubber sucker with a hook is used for hanging articles. Explain how it is able to do so.

5. Answer the following questions.

(1) It is correct to say that :

(a) Solids exerts downward pressure only ?

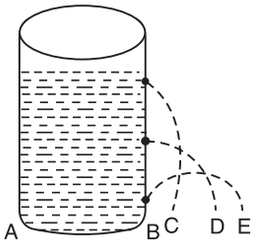
(b) Fluids exert pressure in all directions ?

(2) When asked by teacher that where does the water filled in a bucket exert pressure, one student answered '*at bottom of the bucket*' but another student said '*on the sides of the bucket*'. Give your comment.

(3) If you dip your open palm in a bucket full of water, you feel your hand being pushed up. Why?

(4) Water comes out more slowly from an upstairs tap than from a similar tap downstairs.

(5) Three tiny holes are made in an empty can at different levels, one over the other.



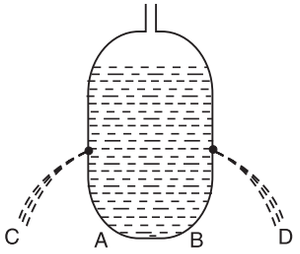
They are temporarily closed with an adhesive tap and then the can is filled with water. As the tapes are pulled out, water starts flowing out from the holes.

It is observed that water flowing out from the lowest hole goes farthest and that from the uppermost hole nearest to the can (BE > BD > BC). Why ? What does this experiment show ?

(6) The divers have to wear specially designed air filled suits for their protection while diving deep under the sea.

(7) Sometimes you see a fountain of water rushing out of the leaking joints (or holes) in the pipes of main water supply line in the city. Why does it happen ?

(8) What will happen if you make two tiny holes of the same size at equal heights from the bottom in a plastic bottle filled with water ? What does this experiment prove ?



6. Tick (✓) the correct statements.

(1) Air exerts pressure because it occupies space and has weight.

(2) Air is more dense near the earth. It goes on thinning out as we go up.

(3) Oxygen content of the air goes on decreasing as we go up.

(4) Air is uniformly dense right from the earth to the sky.

(5) Air pressure is very high near the earth and it goes on decreasing as we go up.

(6) 99% of air exists up to a height of nearly 30 km.

7. Answer the following questions.

(1) What is the cause of air pressure (or of other gases) inside their containers.

(2) What makes a balloon get inflated when air is filled in it ?

(3) Why do the tyres of a bicycle feel hard when air is filled in the tubes inside them.

(4) Why does the atmospheric pressure go on decreasing as we go higher up above the earths' surface?

(5) Why are our bodies not crushed by the large pressure exerted by the atmosphere.

(6) Why do mountaineers usually suffer from nose-bleeding at high altitudes?

(7) Answer true or false. 'Faster the movement of the air greater is the drop in pressure'.

(8) Why do the window panes break and fall outwards and the curtains over the open windows move out of the room and not into the room when strong winds blow along the sides of a building ?

(9) How would pressure change if

(a) area is doubled keeping force constant

(b) force is doubled keeping area constant.

(10) Why does blood ooze out when there is a slight cut on your body.

(11) Define force and pressure. What do you do to get maximum pressure with a minimum force ? Name at least one appliance based on this principle.

8. A 600 N girl on stilts says to two 600 N boys sitting on the ground, "I am exerting over twice as much pressure as the two of you are exerting together". Could this statement be true ? Explain your reasoning.

9. A glass is filled with water up to its brim and a thick hand card placed on top of it. Now keeping the card tightly closed and pressed with palm, the glass full of water is inverted and placed upside down. The

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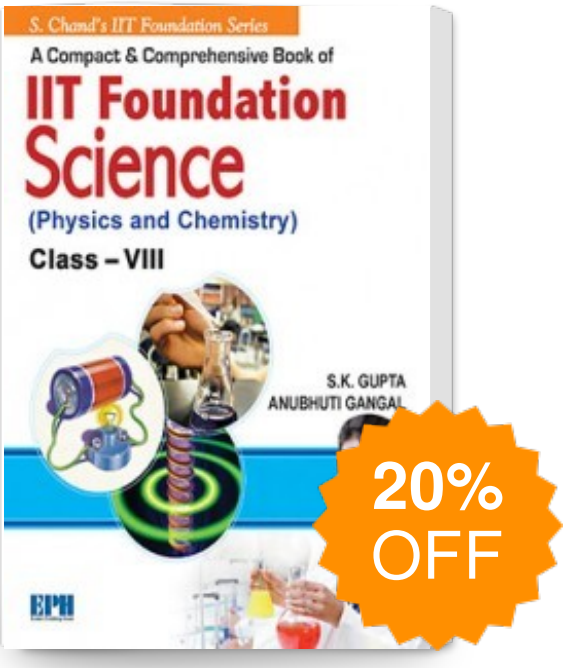

Publisher : SChand Publications ISBN : 9788121940733

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