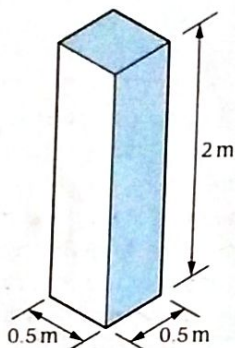


Questions

1 A stone pillar has a mass of 3.0 tonnes. If the area of its base is 0.3 m^2 , calculate the pressure under the pillar. Give your answer in pascals.

2 A block of metal of density 3000 kg m^{-3} is 2 m high and stands on a square base of side 0.5 m, as shown in fig. 5.8.

- What is the base area of the block?
- What is the volume of the block?
- What is the mass of the block?
- What is the weight of the block?
- What is the pressure exerted by the weight of the block on the surface on which it stands?



▲ Figure 5.8

- State two factors on which the pressure exerted by a liquid depends.
- The atmospheric pressure on a particular day was measured as 750 mm of mercury. What is this pressure when it is measured in pascals (Pa) (N m^{-2})? (Assume that the density of mercury is $13\,600 \text{ kg m}^{-3}$ and that the acceleration of free fall (due to gravity) is 10 m s^{-2} (N kg^{-1}).

4 The pressure at a point below the surface of the sea is caused by both the height of water above that point and the air pressure on the surface. If a diver reaches a depth of 20 m below the surface of the sea, calculate:

- the additional pressure on him due to the height of seawater alone
- the total pressure on him.
Density of seawater = 1150 kg m^{-3} .
Air pressure = $1.0 \times 10^5 \text{ Pa}$.
 $g = 9.8 \text{ m s}^{-2}$.

- Explain what is meant by pressure.
- Describe a simple experiment to show how the pressure exerted by a liquid varies with the depth below the liquid surface. State the result you would expect to obtain.

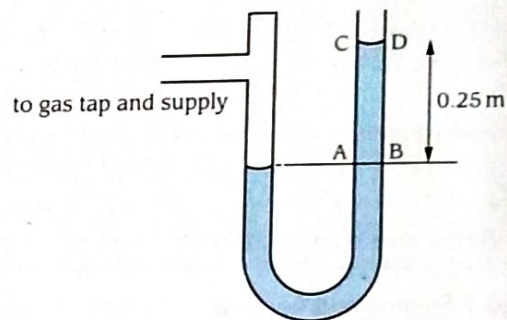
c) A rectangular block 0.01 m by 0.02 m by 0.04 m has a mass of 0.064 kg. Calculate:

- the density of the material of the block
- the weight of the block
- the pressure the block would exert when resting on its smallest side.

Acceleration of free fall is 10 m s^{-2} .

6 Fig. 5.9 shows a manometer with limbs of area of cross section 0.012 m^2 that contains liquid which weighs 8000 N m^{-3} . The manometer is connected to the laboratory gas supply and the tap turned on. As shown in the diagram, there is a difference in the liquid levels in the two limbs of 0.25 m. Calculate:

- the volume of liquid between the levels AB and CD in the right-hand tube
- the weight of this liquid
- the excess pressure, in N m^{-2} , of the gas supply above atmospheric.



▲ Figure 5.9

7 The level of water in a measuring cylinder is at the 50 cm^3 mark. A small solid object is put into the cylinder so that it is submerged. The water level is now at the 90 cm^3 mark.

Take $g = 10 \text{ N kg}^{-1}$.

- What is the volume of the object?
- If the density of the object is 2.5 g cm^{-3} , find:
 - its mass
 - its weight.

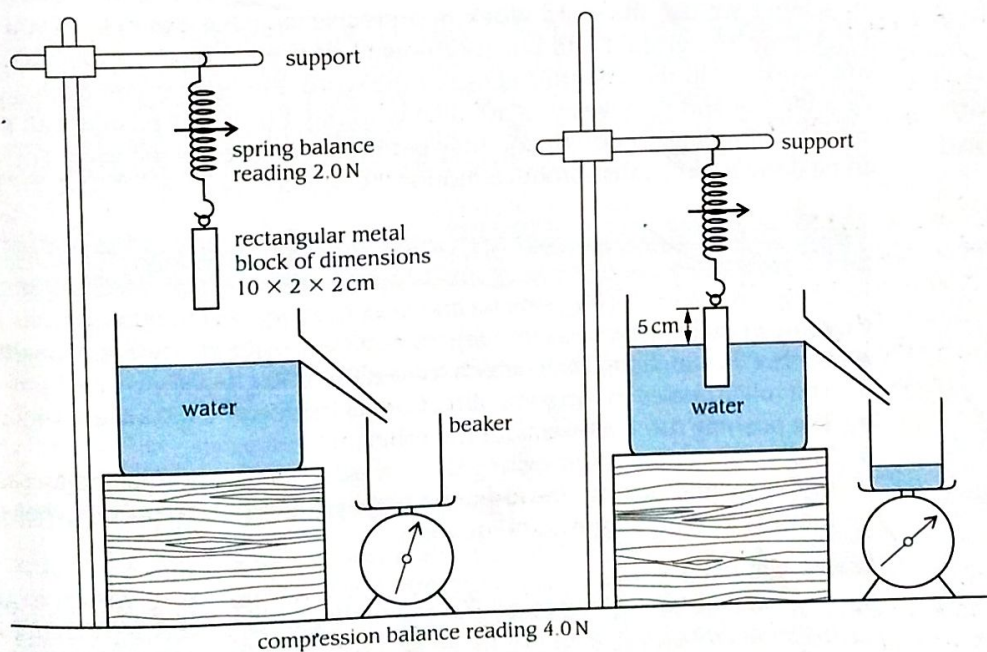
8 The pressure inside a gas cylinder is to be measured using a U-tube manometer similar to the one shown in fig. 5.9. The U-tube is half-filled with a coloured liquid of density $9.6 \times 10^2 \text{ kg m}^{-3}$. If the difference in height between the liquid levels in the two arms of the U-tube is 0.16 m, calculate the excess gas pressure (above air pressure) in the cylinder. ($g = 10 \text{ N kg}^{-1}$)

9 A diver reaches a depth in sea water where the pressure on him is five times greater than at the surface. If the air pressure at the surface of the sea is $1.0 \times 10^5 \text{ Pa}$, what depth has the diver reached in the sea? (density of sea water is $1.03 \times 10^3 \text{ kg m}^{-3}$, $g = 9.8 \text{ N kg}^{-1}$)

- 10 a) State Archimedes' principle.
 b) A solid cylinder of wood has a cross-sectional area of 20 cm^2 and height 90 cm . It floats upright in water. If two-thirds of the length of the cylinder is submerged, calculate:
- the weight of water displaced
 - the weight of the wooden cylinder
 - the density of the wood.
- Acceleration due to gravity, $g = 10 \text{ m s}^{-2}$
 Density of water = 1000 kg m^{-3} .

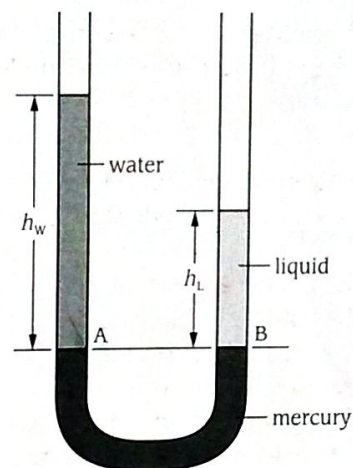
- 11 a) A rectangular block of wood measures $4 \text{ cm} \times 4 \text{ cm} \times 10 \text{ cm}$ and has a mass of 128 g .
- Calculate its volume in SI units.
 - Express this volume in standard form.
 - Express the mass in SI units and standard form.
 - Calculate the density of the wood.
- b) Using Archimedes' principle, explain why this block of wood will float in water of density 1000 kg m^{-3} .
 c) Do you think the same block of wood would float in a liquid of relative density 0.85 ? Explain.

- 12 Fig. 5.10 shows details of an experiment performed by a student and the results obtained. Calculate:
- the volume of the metal block below water
 - the mass of water displaced into the beaker
 - the new reading on the compression balance
 - the new reading on the spring balance
 - the reading you would expect to obtain on the spring balance if the metal block were completely immersed in water.



▲ Figure 5.10

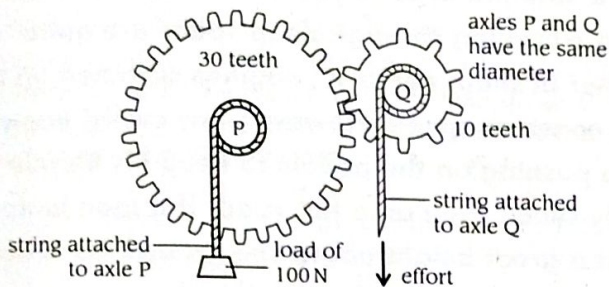
- 13 a) State the equation which gives the pressure at a depth, h , in a liquid of density ρ .



▲ Figure 5.11

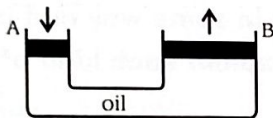
- b) The U-tube in fig. 5.11 can be used to find the density of a liquid by comparison with water. The liquids are level at points A and B where the pressures are also equal. Calculate the additional pressure at point A below the water column if the height of water, h_w is 0.20 m . The density of water is 1000 kg m^{-3} . Acceleration due to gravity, $g = 10 \text{ m s}^{-2}$.
 c) If the height of the liquid column, h_L , is 0.16 m , calculate the relative density of the liquid.

- 10 Fig. 6.11 shows a set of gears used to lift a load attached to the axle P by applying an effort to the axle Q.
- In order to lift the load through a distance of 2 m, the axle P must rotate five times. How many times must axle Q be rotated?
 - Through what distance must the effort be applied if the axles P and Q have the same diameter?
 - Assuming that the set of gears is 100% efficient, calculate the effort required to lift the load.



▲ Figure 6.11

- 11 Fig. 6.12 represents a hydraulic system in which two cylinders with closely fitting pistons A and B are linked by a tube filled with oil. The area of A is 5.0 cm^2 and the area of B is 50 cm^2 . A force of 10 newtons is exerted downwards on A.



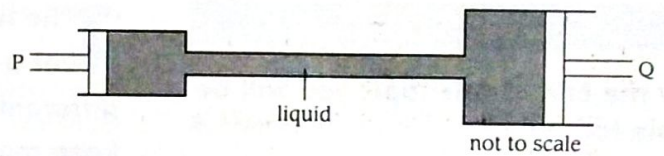
▲ Figure 6.12

- What is the pressure exerted on the oil by piston A?
- What is the pressure exerted by the oil on piston B?
- What force will B exert upwards if frictional forces between the pistons and cylinders can be neglected?
- Draw a labelled diagram showing how the same principle can be used to operate the braking system in a car.

- 12 A hydraulic car jack has a ram piston (the one that lifts the car) of cross-sectional area 30 cm^2 . It is used to lift one corner of a car so that a wheel can be removed. The operating lever compresses a pump piston of cross-sectional area 5 cm^2 and applies a compressing force of 600 N to the fluid in the hydraulic system. Calculate:
- the pressure applied to the fluid by the pump piston,
 - the fluid pressure acting on the ram piston,
 - the lift force applied to the ram piston.

- If the ram piston lifts the corner of the car by 50 cm:
- Calculate the work done by the ram piston.
 - Explain why the work done by the mechanic operating the lever would be greater than this.

- 13 Fig. 6.13 shows part of a hydraulic system which lies horizontally.

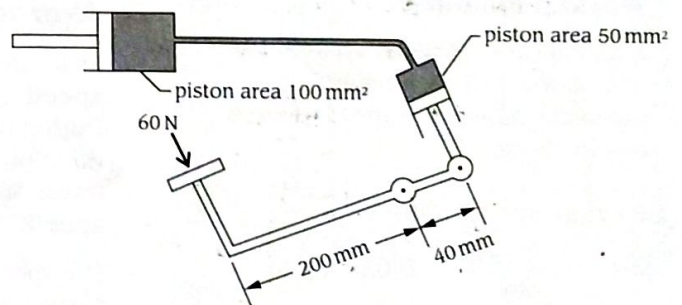


▲ Figure 6.13

Calculate the thrust which must be applied to piston P, which has an area of $1.25 \times 10^{-4} \text{ m}^2$, to enable piston Q which has an area of $6.25 \times 10^{-4} \text{ m}^2$, to exert a force of 2500 N.

- 14 Fig. 6.14 represents part of a hydraulic braking system in which the effort is applied to a pedal at the end of a lever arm, 200 mm from a pivot. On the other side of the pivot, 40 mm away, the lever connects to a piston of area 50 mm^2 . The piston transmits pressure through oil to another piston of area 100 mm^2 connected to the brake.

- When the effort applied is 60 N, what is:
 - the force applied to the first piston
 - the pressure on the oil?
- What force is applied to the brake at the end of the system if frictional forces can be ignored?
- What is the velocity ratio of this system, and what steps could be taken to increase it?
- With a small amount of air trapped in the oil, why would the system work badly, if at all?



▲ Figure 6.14