Volume, Mass and Density

Mass refers to the weight of an object and is measured in Kilogram's(kg)

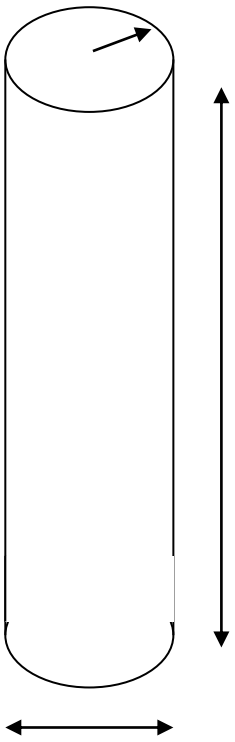
Density is mass per unit volume and is measured in Kg/m^3

If the volume and density of a material is known, the mass(weight) can be calculated:

Mass = Density x Volume

(This formula can also be expressed for Mass or Volume through transposition)

Example: Calculate the volume of concrete required for the cylindrical column shown, and from this, calculate the weight of the column if the density of concrete is 2400 kg/m^3
(Vol. of cylinder = $\pi r^2 h$)
Diameter = 500mm, Height = 4m



Answer:

Volume = $\pi r^2 h$
= $\pi \times 0.25^2 \times 4$
= $0.785m^3$

Mass = Density x Volume
= 2400 x 0.785
= **1884kg**

Volume, Mass and Density - (Questions)

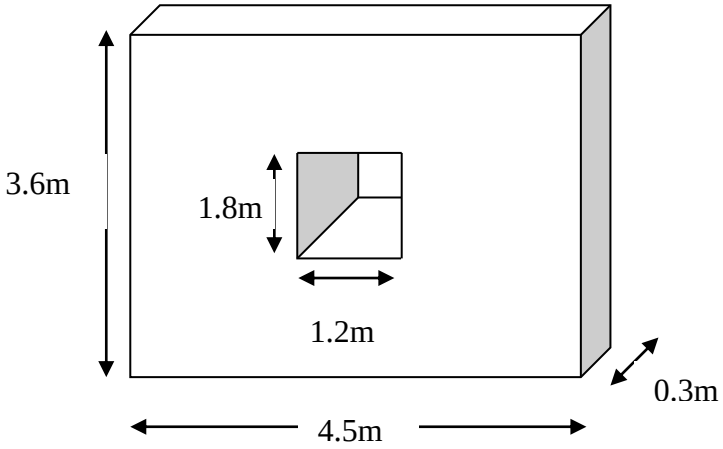
Q.1 Calculate the mass (weight) of the timbers listed below:

Norway Spruce (white deal)	Density = 470 kg/m³
European Redwood (red deal)	Density = 515 kg/m³
American Red Oak	Density = 790 kg/m³
Greenheart	Density = 1040kg/m³

(assume a plank size in each case of 2m x 300mm x 75mm)

Q.2 An ornamental stone sphere has a diameter of 0.5m. If the density of the stone is 2640 kg/m³, find the mass of the sphere.
(volume of sphere = $\frac{4}{3}\pi r^3$)

Q.3 A large concrete pre-cast cladding panel is to be lifted into place by a crane. The maximum lifting capacity of the crane is 10 tonnes (1,000kg = 1 tonne). Find out if the crane will be able to lift the pre-cast panel? (Density of Concrete is 2400 kg/m³)



Q.4 When deciding on whether to use a timber or steel beam, a contractor wants to know how much heavier one is than the other. The timber beam (3.5m x 225mm x 75mm) has a density of 720kg/m³.
Compare the mass (weight) of the timber beam with that of a steel beam of the same length which has a mass of 30kg per meter run.

Q.5 A builder incorrectly estimates that he needs 172m³ of concrete for the pour in an apartment block being built, and is charged € 11,180. When the pour is finished he has enough left over to form a wall (10m x 2 m x 200mm), and also to pour a section of footpath (20m x 3.5 m x 150mm).

- (a) How much concrete did he originally require?
- (b) How much did it cost him for (i) the wall?
  and (ii) the path?

Volume, Mass and Density - (Answers)

Q.1 Volume of plank = 2m x 0.3mm x 0.075mm = 0.045m³

(Mass = Density x Volume)

Norway Spruce = 0.045 x 470 = 21.15 kg
European Redwood = 0.045 x 515 = 23.175kg
American Red Oak = 0.045 x 790 = 35.55 kg
Greenheart = 0.045 x 1040 = 46.80 kg

Q.2 Volume of sphere = $\frac{4}{3} \pi r^3 = \frac{4}{3} \times \pi \times 0.25^3$

$= 1.333 \times \pi \times 0.015625$

$= 0.0654 m^3$

(Mass = Density x Volume)

= 2640 x 0.0654
= 172.656 kg

Q.3 Volume = (4.5 x 3.6 x 0.3) – (1.8 x 1.2 x 0.3)
= 4.86 – 0.648
= 4.212m³

(Mass = Density x Volume)

= 2400 x 4.212
= 10108.8 kg *(1,000 kg = 1 tonne)*
= 10.109 tonnes (**so crane can't lift it)**

Q.4 Volume of timber beam = 3.5m x 0.225mm x 0.075mm = 0.059m³

(Mass = Density x Volume)

= 720 x 0.059 = 42.48kg
= 42 kg

Steel beam mass = 3.5 x 30 (30kg for every meter run)
= 105 kg

Answer: Steel beam is 2.5 times heavier than wooden beam

Q.5 (a) Wall = 10 x 2 x 0.2 = 4m³
Path = 20 x 3.5 x 0.15 = 10.5m³
(wall + path) = 14.5m³

Total concrete – (wall + path) = Originally needed
172m³ - 14.5m³ = **157.5m³**

(b) 1m³ concrete costs € 65 *(11,180 / 172 = 65)*

(i) Wall = 10 x 2 x 0.2 = 4m³ x € 65 = **€ 260**
(ii) Path = 20 x 3.5 x 0.15 = 10.5m³ x € 65 = **€ 682.50**

QUESTIONS ON VOLUME AND AREA

Q. 1 Calculate the volume of concrete required to fill a column 400mm x 400mm at the base and 2.75m high.

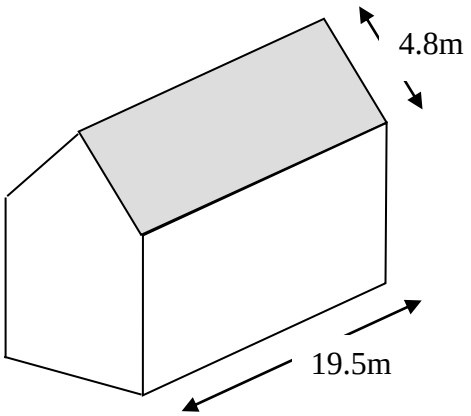
Q. 2 Calculate the volume of concrete required to fill a beam 400mm deep x 300mm wide x 4.1m long

Q. 3 Calculate the volume of a length of timber measuring 112mm x 44mm x 4.8m

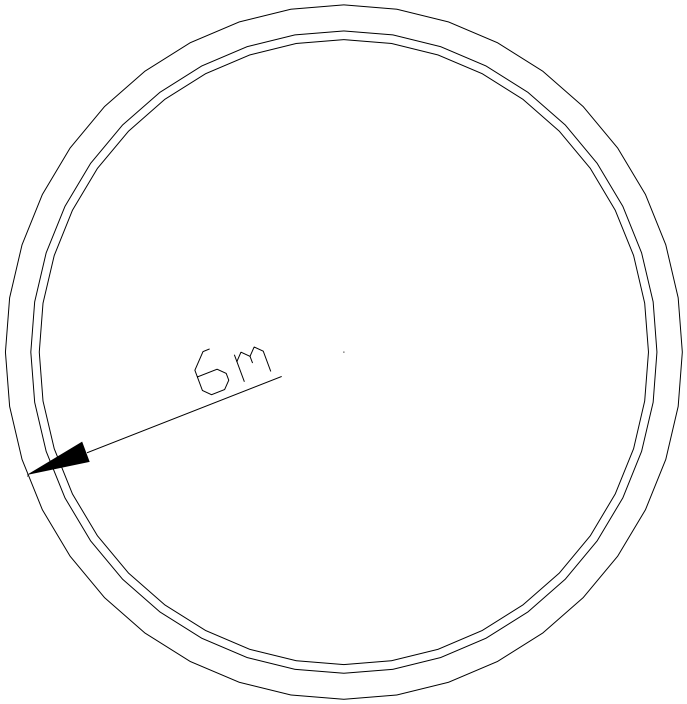
Q. 4 How many metres of 115mm wide flooring are required to cover a floor measuring 4.9m x 3.25m?

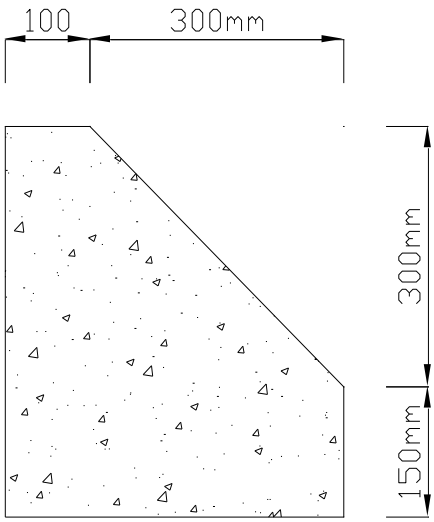
Q. 5 Calculate the number of linear metres of floorboards required to cover a floor measuring 3.65m x 2.85m if the boards are 80mm wide.

Q. 6 The length of a ridge board is 19.5m and the common rafter length is 4.8m. Calculate the number of tiles required to cover the roof if one tile covers an area of 300mm x 300 mm.



Q. 7 Calculate the volume of concrete required for the roundabout shown in plan and in sectional detail below.





QUESTIONS ON VOLUME AND AREA (ANSWERS)

Q. 1 Volume = 2.75 x 0.4 x 0.4 = 0.44m³

Q. 2 Volume = 4.1 x 0.4 x 0.3 = 0.492m³

Q. 3 Volume = 4.8 x 0.112 x 0.044 = 0.024m³

Q. 4 Area = 4.9 x 3.25 = 15.925m² / 0.115 = 138.478
= 139m of flooring

Q. 5 Area = 3.65 x 2.85 = 10.4025m² / 0.080 = 130.031
= 131m of flooring

Q. 6 Area = 19.5 x 4.8 x 2 = 187.2m²
Area of tile = 0.3 x 0.3 = 0.09m² = 2080 tiles

Q. 7 Total Vol. = Vol. of Cylinder + Vol. of Frustum – (Vol. of Cylinder)
(in bottom portion) (in top portion) (hollow in centre)

Vol. Of Cylinder = π r² h
(in bottom portion) = π x 3² x 0.150 = 4.241m³

Vol. Of Frustum = ⅓ π h (R² + R r + r²)
(in top portion) = ⅓ x π x 0.3 (3² + { 3 x 2.7 } + 2.7²)
= ⅓ x π x 0.3 (24.39) = 7.662m³
Total Volume including centre = 11.903m³

Less Vol. Of Cylinder = π r² h
(hollow portion in centre) = π x 2.6² x 0.45 = 9.557m³
Total Volume of Concrete = 2.346m³