Materials

2015 EdExcel A Level Physics

Topic 4

Density and upthrust

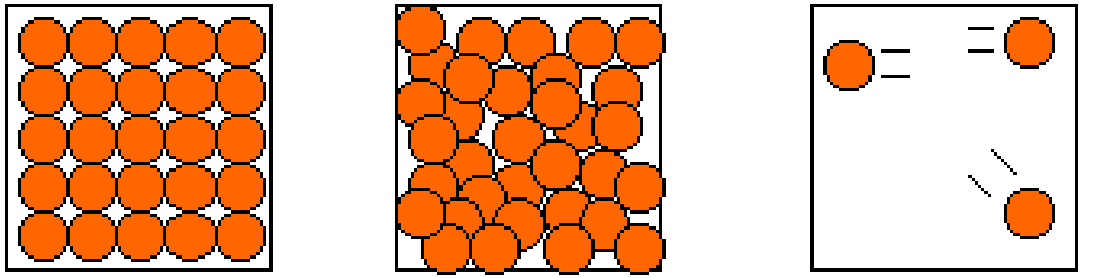
Physics Tutor Online

What is Density?

Density is Mass per unit volume

How closely packed the matter ('stuff') is within an object

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \qquad \rho = \frac{m}{V}$$



More dense

Less dense

Example

What is the density of a piece of wood of volume $4m^3$

and mass 1600kg?

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$\rho = m/V$

$=1600 / 4 = 400\ kgm^{-3}$

Practice Questions

1) If a mixture of gasses has a density of $1.6 kgm^{-3}$, what is the volume of 12kg of air?

2) Calculate the density of Nitrogen. If the volume of container is $1m^3$ and the mass of nitrogen is 0.40kg.

3) A container has a volume of $1x10^{-4}m^3$. If the density of the gas present in that container is $1360kgm^{-3}$. What is the mass of gas?

Density examples

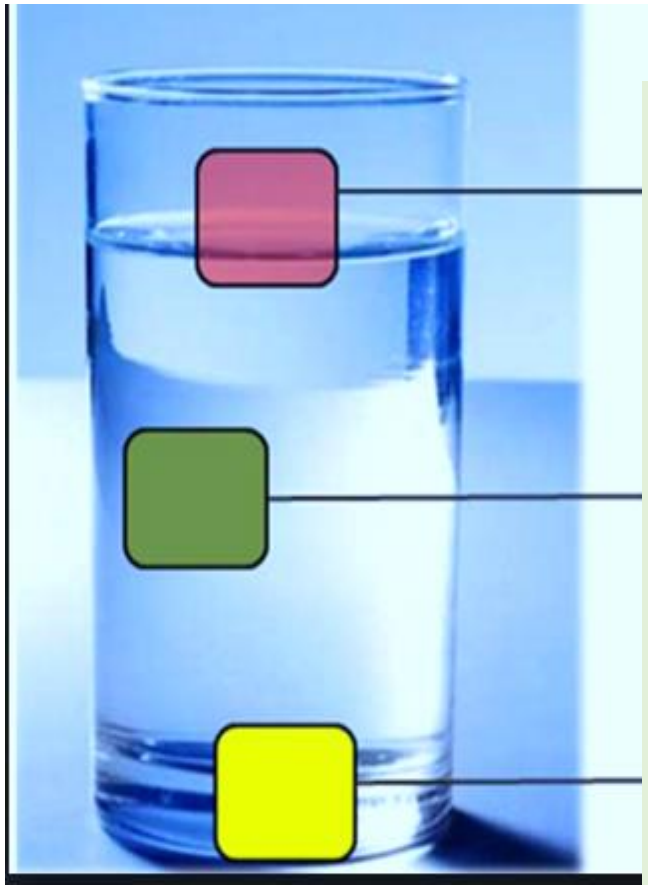
Object	Mass/kg	Volume/m^3	Density/ kgm^{-3}
Piece of wood	0.5		893
The air in a balloon		0.064	1.2
Aluminium sheet	320	0.12	

Density examples

Object	Mass/kg	Volume/m^3	Density/ kgm^{-3}
Piece of wood	0.5	$5.6x10^{-4}$	893
The air in a balloon	0.077	0.064	1.2
Aluminium sheet	320	0.12	2700

Float or sink?

Water has a density of 1.0 gcm^{-3}
=1000 kgm^{-3}



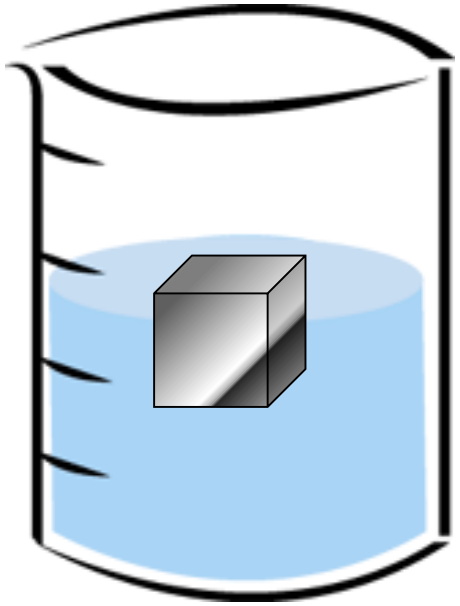
If an object has a density less than water, it floats

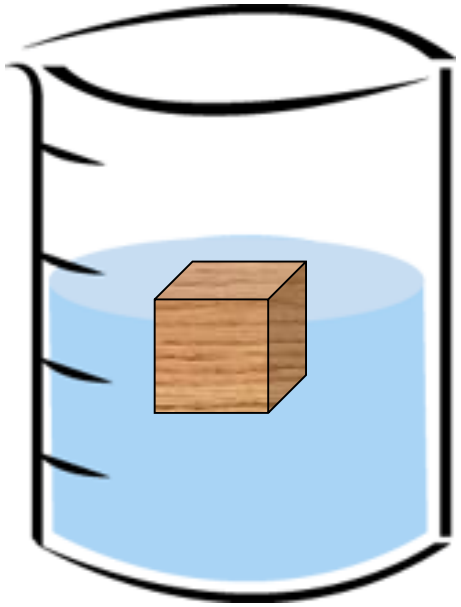
If it has the same density as the medium it suspends

If an object has a density greater than water, it sinks.

Floating

The density of an object tells whether it will float or not. For example:

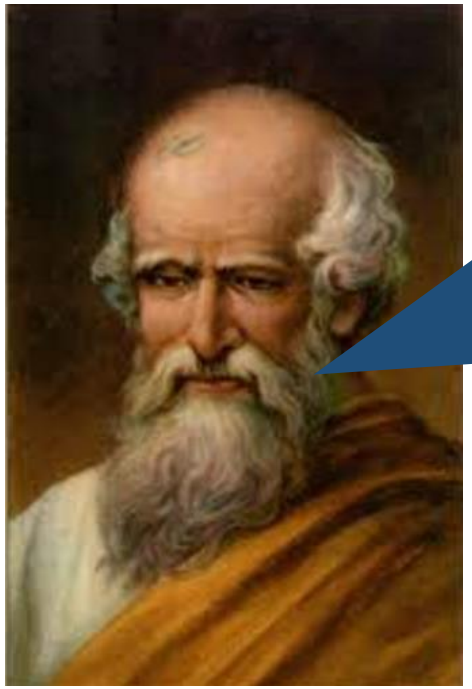




The metal block is _____ dense than water and so it will _____.

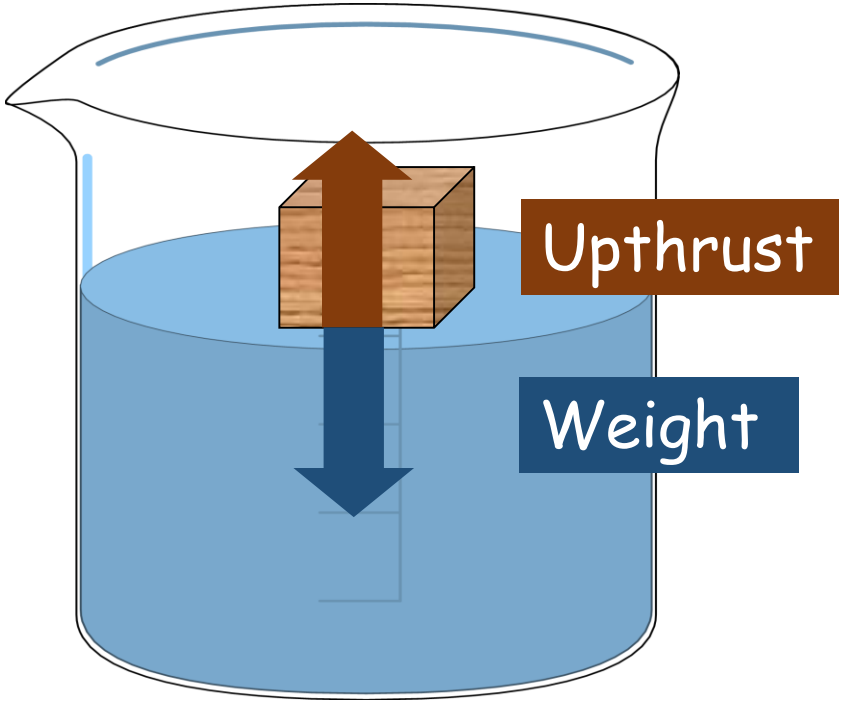
The wooden block will is _____ dense than water and so it will _____.

Upthrust in Fluids

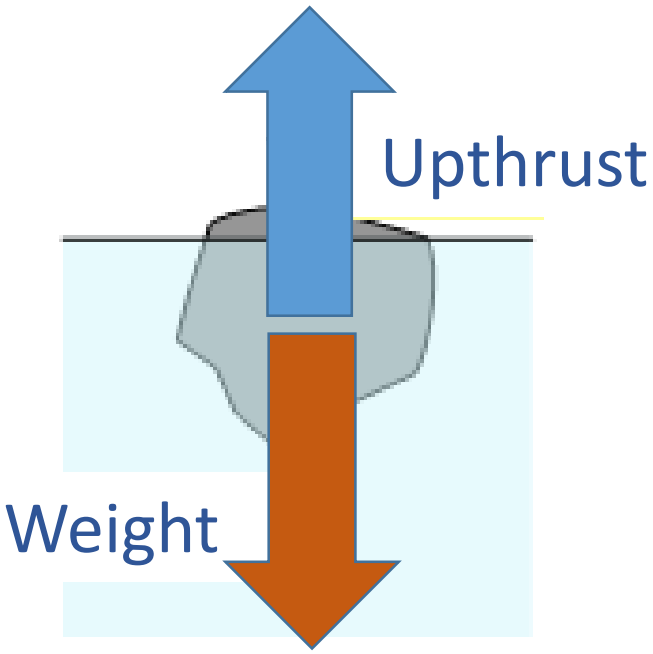


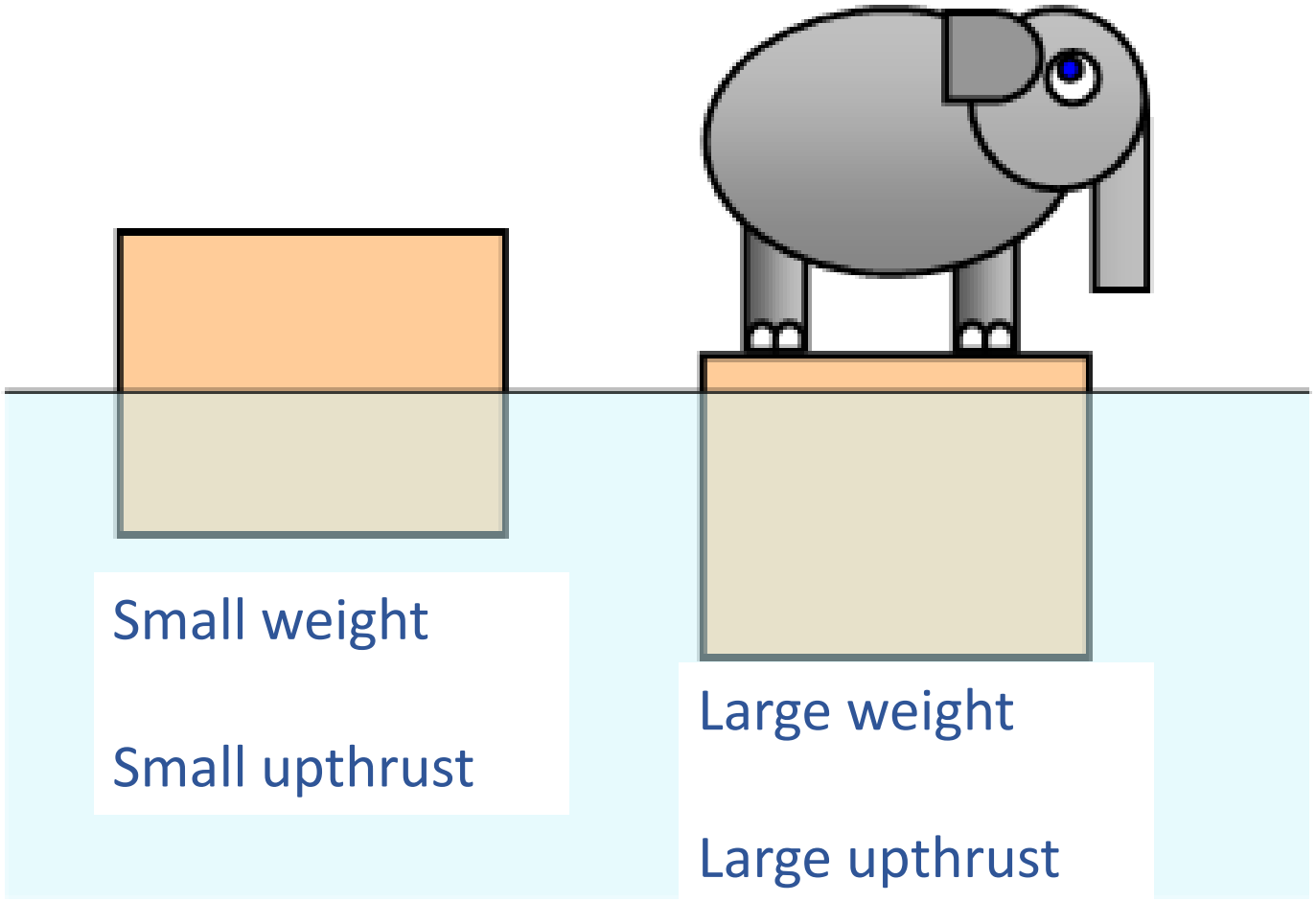
When an object is completely or partially submerged in a liquid, the liquid exerts a force on the object. This upward force is called upthrust. We can use my principle to calculate how big that upthrust is:

Upthrust = weight of fluid displaced



Upthrust in Fluids





Example 1

A block of copper is suspended from a Newton meter. It is then submerged in water. The block's volume is $10m^3$. If copper has a density of $960kgm^{-3}$ calculate:

1) The block's mass

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Solution:

$V = 10m^3$

$\rho = 960kgm^{-3}$

$m = \rho V$

$m = 960x10=9600\ kg$

Example 1 cont.

2) Calculate the block's weight (what the Newton meter reads before submerging)

3) Calculate the weight of the water the block displaces (i.e. the upthrust)

Example 1 cont.

2) Calculate the block's weight (what the Newton meter reads before submerging)

Solution:

$w = mg$

$w = 9600 \times 9.8 = 94080\ kgms^{-2}$

3) Calculate the weight of the water the block displaces (i.e. the upthrust)

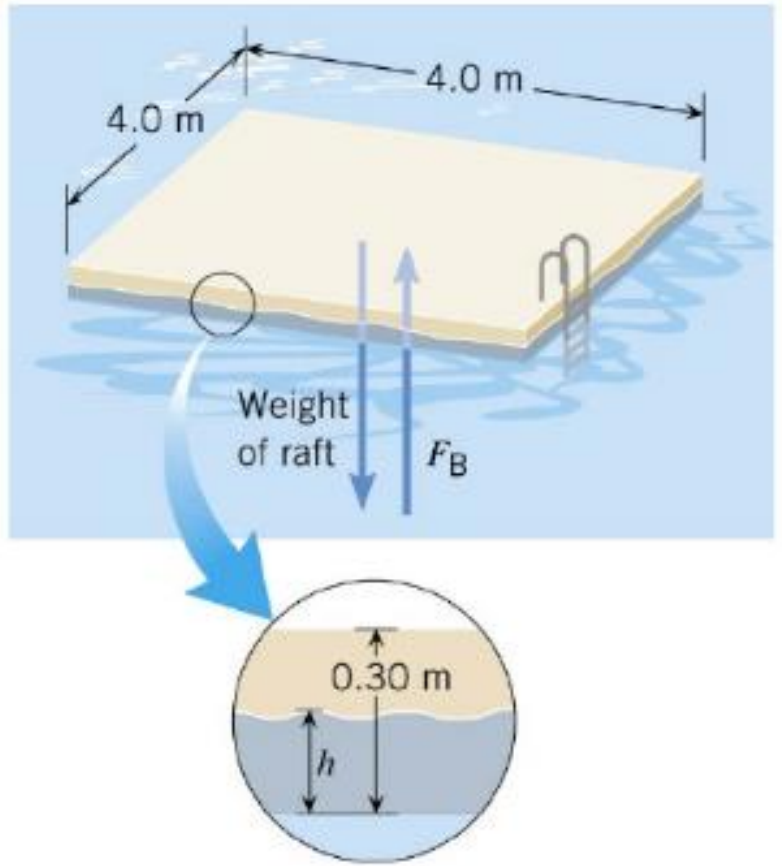
upthrust = weight of fluid displaced

upthrust = density of water x volume of water displaced x g

upthrust = 1000 x10 x 9.8=98000 N

Example 2

The swimming Raft is made of solid square pine wood having mass 9600kg. If the raft is floating determine how much of the raft is beneath the surface?



Example 2

The swimming Raft is made of solid square pine wood having mass 9600kg. If the raft is floating determine how much of the raft is beneath the surface?

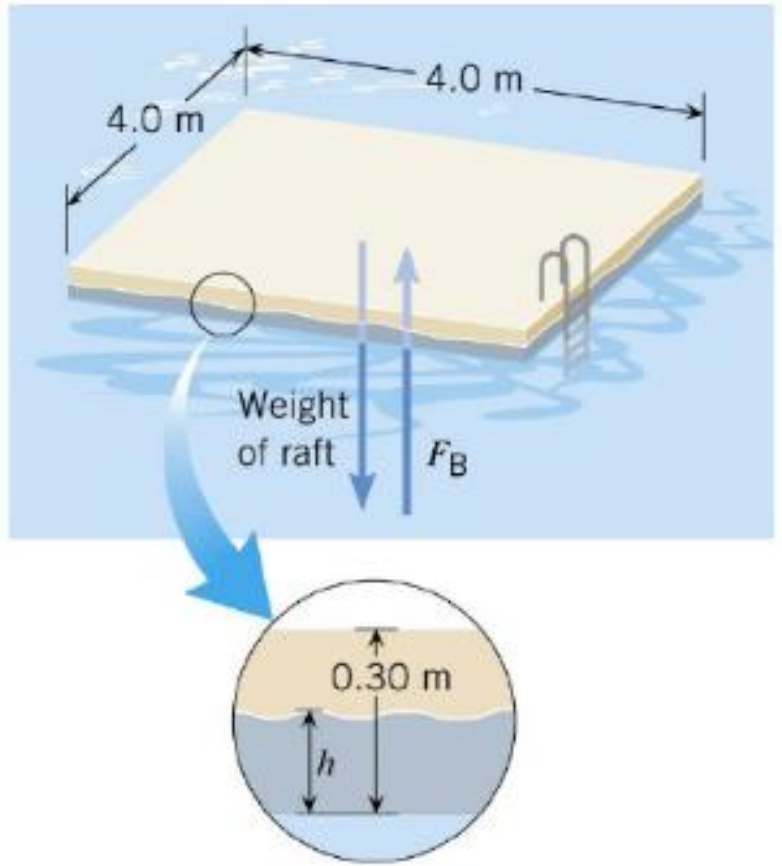
Solution:

$weight\ of\ raft = w = mg$

$w = 2400x9.8 = 23520\ kgms^{-2}$

As the raft is floating

$weight\ of\ raft = upthrust\ of\ water$



Example 2 cont.

$upthrust = density\ of\ water\ x\ volume\ of\ water\ displaced\ xg$

$volume\ of\ water\ displaced = length\ x\ width\ x\ height$
$volume\ of\ water\ displaced = 4\ x4\ x\ h = 16h$
$upthrust = 1000\ x\ 16h\ x\ 9.8 = 156800h$

As the raft is floating

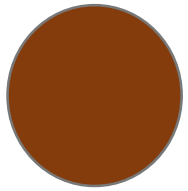
$weight\ of\ raft = upthrust\ of\ water$

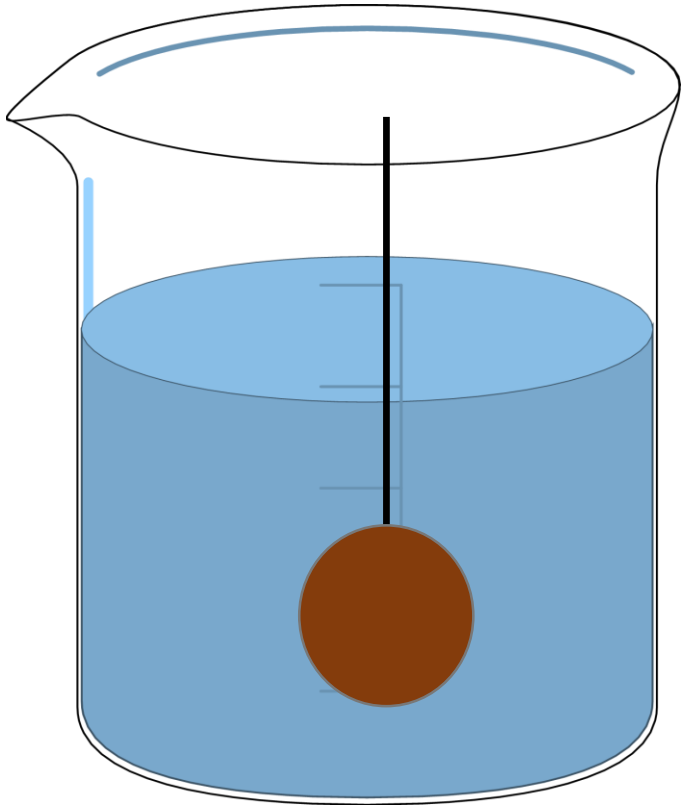
$23520 = 156800\ h$

$h = 0.15m$

Practice Question

This ball of radius 5 cm and density 7450kgm^{-3}. The ball is suspended from a Newton meter and placed in water. What will the reading on the Newton meter be?





Practice Question cont.

This block of granite is a cube of density 2500kgm^{-3}. The cube is suspended from a Newton meter and placed in water. The reading on the Newton meter decreased by 0.02N. What is the size of the cube?