About density

Regular or irregular?

Working out the **density** of an object is quite easy; you simply use the equation:

Density (in kilograms per cubic metre) = mass (in kilograms) divided by volume (in metres cubed)

The equation, in symbols, is written $\rho = m/v$.

All you need to know is the **mass** (which you can determine by weighing the object) and the **volume**. If you have a regular-shaped object (for example, a cube, cylinder or sphere), you can measure its dimensions with, say, a ruler or Vernier callipers, and use a known equation to determine the volume. If the object is irregular-shaped (for example, a lump of stone), you can use displacement to determine the volume.

But it's not quite that straightforward. This method determines the **density of an object - not the density of the material the object's made of**.

What if the object is made of a **porous** material, or is hollow? In other words, what if it has holes in it? By measuring its dimensions, or by using displacement, you can determine the object's volume. But you haven't accounted for the holes - you haven't determined the volume of the material.

Take, for example, a pumice stone (that's one of those dark-grey stones people use to rub dead skin off their feet). If you used displacement to determine its volume, you would only be able to determine what's called the "**apparent density**" (the density of the object). To get a "**real**" density (the density of the material) you would have to determine the volume in a different way. One way would be to crush the stone into a fine powder and pack it tightly together into a cube. You're left with a sample of the material without any of the holes (or "**air cavities**"). The mass will still be the same, so you can use $\rho = m/v$ to determine the "**real**" density.

Fortunately, at this stage of your engineering career, you'll rarely need to know the real density of a material. So the following Comparative Tests just describe the methods for determining the density of regular- and irregular-shaped objects. If the object has no air cavities, the density determined will be the real density of the material the object's made of. But if the material you're testing is porous or your sample may be hollow, remember to record the fact that you've only worked out the "apparent" density.

CT 0002:2003 Methods of testing density -

Part 1: Determining the density of regular-shaped objects

Part 2: Determining the density of irregular-shaped objects

COMPARATIVE TEST CT 0002-1:2003

Methods of testing density - Part 1: Determining the density of regular-shaped objects

1 Scope

This Comparative Test can be used to determine the real density of any non-porous, regular-shaped object, or the apparent density of any porous, regular-shaped object.

2 Principle

Density (in kilograms per cubic metre) = mass (in kilograms) divided by volume (in metres cubed)

3 Apparatus

- calibrated balance that can record mass to the nearest 0.1 g
- metre rule, or similar instrument measuring to nearest mm

4 Test specimens

The test specimens should be regular-shaped. This Comparative Test gives equations for cuboids and cylinders. However, any regular-shaped object may be used, provided you know a formula to calculate its volume by measuring its dimensions.

Test specimens should be small enough to fit on your chosen balance. They should be large enough to measure the dimensions to the nearest millimetre using your chosen measuring instrument.

At least three specimens of each material should be tested.

5 Procedure

- Place the test specimen in the centre of the balance. Record its mass in kilograms.
- Measure the test specimen's dimensions:

(a) if it is cuboid, measure its height, width and length.

(b) if it is cylindrical, measure its length and diameter. Halve the diameter to calculate the radius.

(c) For other regular shapes, measure the dimensions needed for the formula you are using to calculate the volume.

6 Expression of Results

The density of an object is determined using

$\rho = m/v$

where

ρ is the density, in kilograms per cubic metre

m is the mass, in kilograms

v is the volume, in metres cubed

To calculate v:

If the test specimen was cuboid:

$v = xyz$

where

x,y,z are the lengths of the sides, in metres

If the test specimen was cylindrical:

$v = \pi r^2 l$

where,

π is 3.1416

r is the raidus of the cross-section, in metres

l is the length of the cylinder, in metres

7 Test Report

Your test report should include:

(a) The density of each test specimen in kg/m^3

(b) The average density (calculated by adding the densities of all test specimens and dividing the total by the total number of test specimens used).

(c) Whether the real or apparent density was determined

COMPARATIVE TEST CT 0002-2:2003

Methods of testing density - Part 2: Determining the density of irregular-shaped objects

1 Scope

This Comparative Test can be used to determine the real density of any non-porous, irregular-shaped object, or the apparent density of any porous, irregular-shaped object. The method also works for regular-shaped objects, although CT 0002-1:2003 details an easier method.

2 Principle

Density (in kilograms per cubic metre) = mass (in kilograms) divided by volume (in metres cubed)

3 Apparatus

- calibrated balance that can record mass to the nearest 0.1 g
- displacement can, larger than the test specimen
- measuring cylinder, big enough to catch any displaced water
- thread, as thin as possible, but strong enough to hold the test specimen
- water

4 Test specimens

Test specimens should be small enough to fit on your chosen balance.

They should be small enough to fit in the displacement can, and should not displace more water than the measuring cylinder can hold.

At least three specimens of each material should be tested.

5 Procedure

- Place the test specimen on the centre of the balance. Record its mass in kilograms.
- Fill the displacement can with water, level with the overflow spout (see figure 1)
- Tie the thread to the test specimen and lower it gently into the displacement can
- Record the volume of displaced water, using the scale on the side of the measuring cylinder. This is the same as the volume of the specimen.

6 Expression of Results

The density of an object is determined using

$\rho = m/v$

where

ρ is the density, in kilograms per cubic metre

m is the mass, in kilograms

v is the volume, in metres cubed

7 Test Report

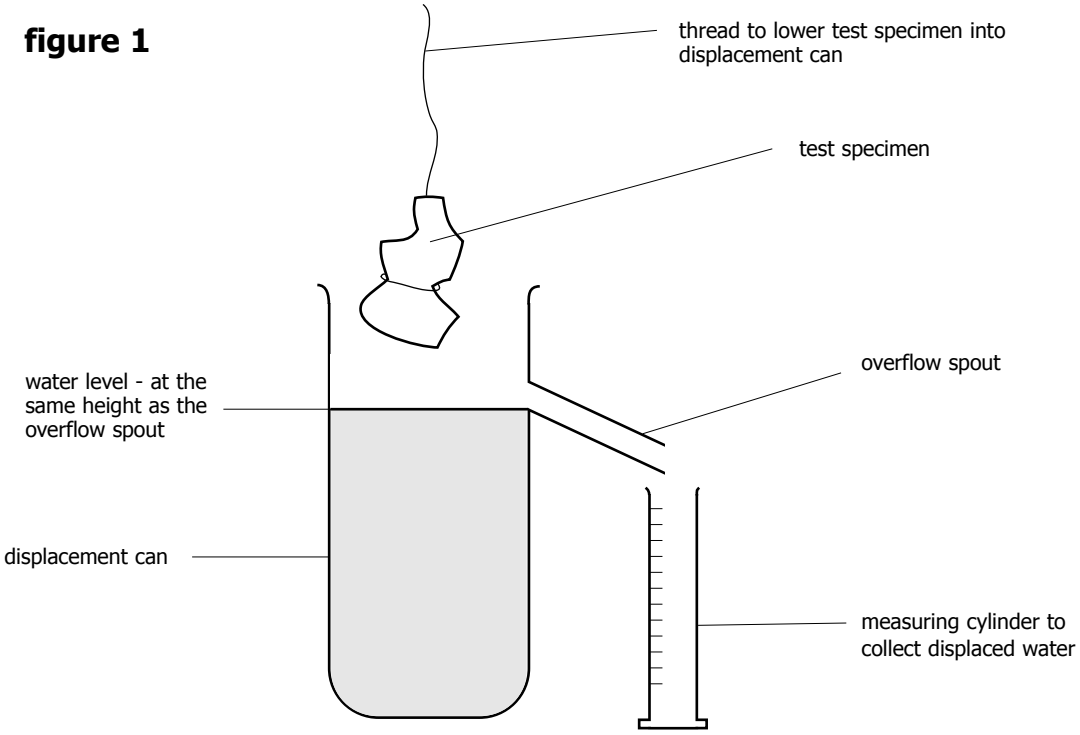
Your test report should include:

(a) The density of each test specimen in kg/m^3

(b) The average density (calculated by adding the densities of all test specimens and dividing the total by the total number of test specimens used).

(c) Whether the real or apparent density was determined

figure 1


thread to lower test specimen into displacement can
test specimen
overflow spout
water level - at the same height as the overflow spout
displacement can
measuring cylinder to collect displaced water