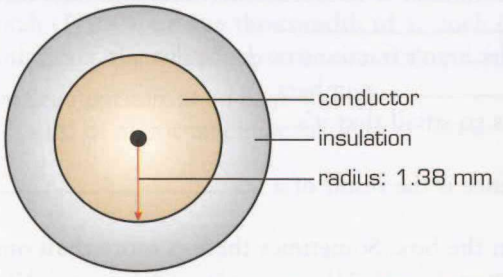
9 Area, size and mass

A Area

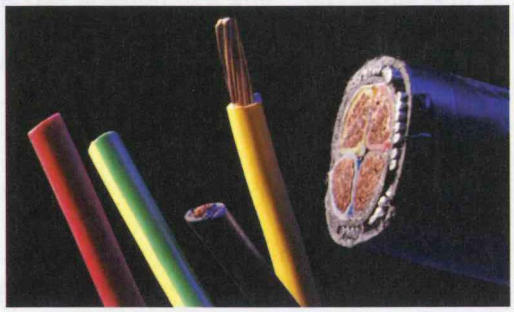
The textbook extract below looks at different aspects of **area**.

Dimensions of wires and cables

The sizes of electrical wires are specified by a number which gives an area in **square millimetres**. For example, in a home, a 6 mm² wire may be specified to supply an electric oven in a kitchen. This number gives the **cross-sectional area** of the conductor. Increasing the cross-sectional area allows the conductor to carry more current safely, without overheating.

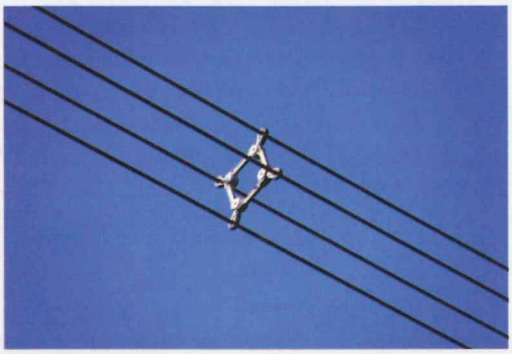


Cross-sectional area = $\pi r^2 = 3.14 \times 1.38^2 = 6$



▲ *Cross-section of 6 mm² wire*

In high-voltage power lines, it is not only the cross-sectional area of conductors that is important, but also their **surface area** – the amount of surface that is in contact with the air, to allow cooling. Therefore, instead of using single cables with large sections for each conductor, power lines often use groups of two, three or four **small-section** cables, to give more surface area than a single, **large-section** cable.



B Weight, mass, volume and density

In everyday language, the term **weight** means how heavy things are (how much they **weigh**), and **grams** and **kilograms** are used as units of weight. But in physics and in engineering, grams and kilograms are units of **mass**. Whether an object is on earth – where it is subjected to **gravity** (the pull of the earth) – or floating **weightless** in space, its mass is always the same. The mass of an object depends on:

- the **volume** of the object, measured in **cubic metres** (m^3) – as an object's volume increases, its mass increases
- the **density** of the object, measured in **kilograms per cubic metre** (kg/m^3) – as density increases, mass **per unit of volume** increases.

The mass of an object is the object's volume multiplied by its density. The weight of an object is the force exerted on the object's mass by gravity.

Some materials are very **dense**, and therefore very heavy. An example is lead (Pb), which has a density of 11,340 kg/m^3. Other materials, such as expanded polystyrene (which can have a density as low as 10 kg/m^3), are very **lightweight**.

9.1 The component below is made of mild steel. It has a radius of 40 mm and it is 1,200 mm long. Complete the calculations using the words in the box. Look at A and B opposite to help you.

cross-sectional area	density	mass	surface area	volume

(1) ..... of mild steel: 7,850 kg/m^3

(2) ..... : $\pi r^2 = 3.14 \times 40^2 = 5\,024\,mm^2 = 0.005024\,m^2$

(3) ..... : $0.005024\,m^2 \times 1.2\,m = 0.0060288\,m^3$

(4) ..... : $0.0060288\,m^3 \times 7{,}850\,kg/m^3 = 47.32608\,kg$

Circumference: $2\pi r = 3.14 \times 40\,mm = 251\,mm = 0.251\,m$

Total (5) ..... to be painted: $0.251\,m \times 1.2\,m + 0.005\,m^2 + 0.005\,m^2 = 0.311\,m^2$

9.2 Now write the whole words for the unit abbreviations in the calculation in 9.1 above. Look at A and B opposite to help you. The first one has been done for you.

1	m	metres	4	m^2	7 kg/m^3
2	mm		5	m^3	
3	mm^2		6	kg	

9.3 Complete the extract from an article about satellite design using the words in the box. Look at A and B opposite to help you.

cubic	gravity	lightweight	mass	square	weigh	weightless

Satellites need to be designed to cope with two very different phases: deployment (the journey into space by rocket) and operation (working in space).

For the first phase, engineers are faced with the problem that every (1) ..... metre of volume taken up within the rocket will add millions of dollars to its ticket into space. And each extra gram of (2) ..... added to the craft will increase the fuel needed to propel it upwards against the pull of (3) ..... . That extra fuel, in turn, will (4) ..... a little more, further adding to the total weight of the craft. With the cost of kilograms so high, the satellite must therefore be as (5) ..... as possible.

In the second phase, with the orbiting satellite now (6) ..... , its mass is practically irrelevant. As for the amount of space occupied, the situation is completely reversed. The satellite's solar panels, which transform sunlight into battery power, must unfold to cover as wide an area as possible – opening out to cover an area of several (7) ..... metres – in order to maximize their exposure to the sun.

Over to you

Talk about different materials that are suitable for specific engineering uses due to their density – because they are either very dense, or very lightweight.