

FACTFILE: GCE TECHNOLOGY & DESIGN

1.1 MATERIAL SELECTION PART 2



Material Choice and Selection: Part 1

Learning outcomes

Students should be able to:
Demonstrate knowledge and understanding of the following:

- physical properties – density, electrical and thermal conductivity;

Course content

When selecting a material for a specific part or component for a product, it is essential that the physical properties of potential materials are taken into consideration. The main physical properties that will be addressed in the CCEA GCE AS specification are:

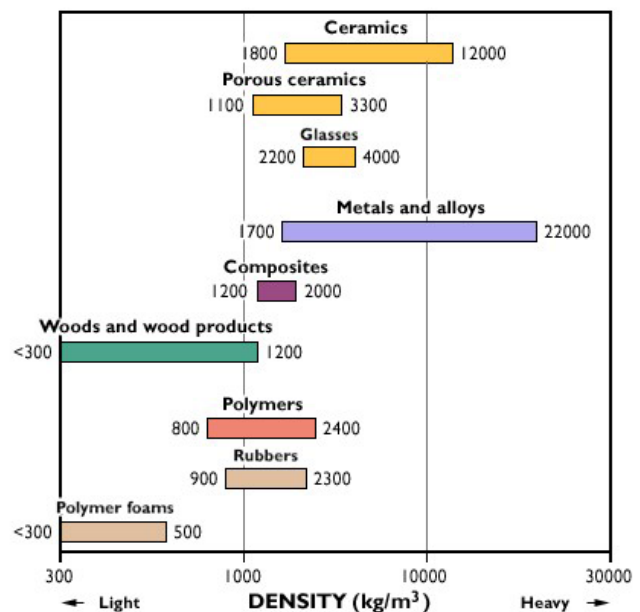
- Density
- Electrical conductivity
- Thermal conductivity

The aforementioned properties are characteristics that pupils will have considered, without necessarily realising, when selecting materials for GCSE project work.

Density

The density of material is the amount of matter (mass) in an object per unit of space occupied by the matter (volume). Densities of materials can be compared with water to provide a ratio called Relative Density. This ratio is calculated by

comparing the density of a material or object with pure water at a room temperature of 4°C. Density is a measure of how heavy an object is for a given size, i.e. the mass of material per unit volume. Changes in temperature do not significantly affect the density of a solid material - although materials do expand when they are heated, the change in size is very small.



Electrical conductivity

Electrical conductivity is the movement of electricity through a piece of material i.e. how conductive it is. Some materials, especially metals such as gold, silver and copper, liquids and some gases are good conductors, allowing electricity to pass through them.

Insulating materials (insulators) can resist the flow of electric current. These include woods, ceramics, glass and many plastics, such as nylon, PVC, acrylic and ABS.

Some materials possess semi-conducting properties and allow electric current to flow through them under certain conditions. These types of materials include silicon and germanium and are used in the production of electrical components.

Thermal conductivity

Thermal conductivity is the movement of heat through a material. Heat transfer by conduction involves transfer of energy within a material without any motion of the material as a whole. Conduction takes place when a temperature gradient exists in a solid material. Conductive heat flow occurs in the direction of decreasing temperature because higher temperature equates to higher molecular energy.

Conduction rates vary according to a material's reaction to heat and is important that the right materials are chosen for the specific task.



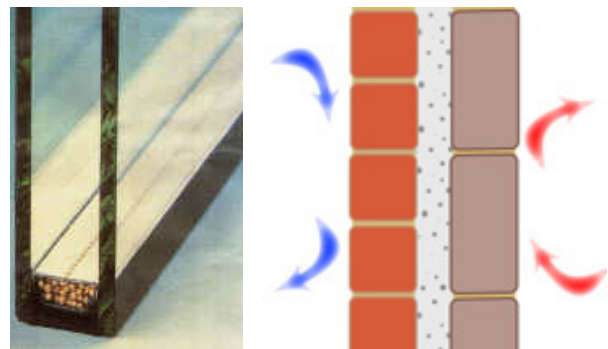
For example, space shuttles experience extremely low temperatures in space, but on re-entering the Earth's atmosphere, they must resist extremely high temperatures. Fire resistant materials like asbestos and silica tiles are used to prevent vaporisation.

In general, materials with a high insulating value have low conducting values. They are used to prevent heat gain or loss and are often materials that are used in products in which consumers are protected from heat. E.g. cooking utensils.

Air is one of the best insulators and is often used in conjunction with other materials to reduce heat loss. Modern housing is a good example of this.

Double-glazed windows use a combination of glass and air to create a barrier to prevent heat escaping from houses and preventing cold air entering the house.

Polystyrene is included in modern building materials. It is pumped into cavities between exterior brick and interior block. The polystyrene beads and air in the spaces between each bead, keeps warm air inside the house and cold air outside.



Thermal expansion is related to thermal conductivity and must be taken into account when selecting materials. It is related to linear expansion, which is when a material increases in length (fractional change) as a result of heat. The material will also shrink slightly when it cools.



Revision Questions

1 Explain what is meant by the following properties:

- a) Electrical conductivity.
- b) Thermal conductivity.
- c) Density.

2 Explain what is meant by 'physical properties' of a material.

3 What type of materials would be used in producing the following products:

- a) Pliers used by an electrician.
- b) Saucepan handle.
- c) Main body of a saucepan

