# Section Two — Knowledge Organiser

Knowing the properties of different materials is essential for selecting the right materials for the job. These pages are a good summary of the key information — but it's really important that you know the whole topic in detail for the exam.

## Properties of Materials

### Working properties

- Strength — ability to withstand forces without breaking
- Hardness — ability to withstand scratching/abrasion
- Toughness — hard to break or snap
- Malleability — can be bent and shaped
- Elasticity — can stretch/bend and return to original shape
- Ductility — can be drawn into a wire

### Physical properties

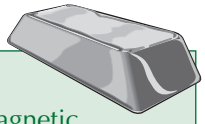
- Electrical conductivity
- Thermal (heat) conductivity
- High fusibility = low melting point
- Density — mass per unit volume
- Absorbency — ability to soak up moisture

**Alloy**: a mixture of two or more metals or a metal mixed with one or more elements.

**Metals**: usually strong, malleable, good electrical and thermal conductors, not very fusible.

**Non-metals**: generally more brittle and less dense than metals, poor electrical conductors.

## Metals, Alloys and Polymers



**Ferrous metals**: contain iron, are magnetic.

**Non-ferrous metals**: no iron, don't rust, not magnetic.

### Ferrous Metals

**Cast iron** — very strong, but brittle and not malleable. Used for bench vices, brake discs, manhole covers.

**Low-carbon steel** — strong and cheap but rusts easily and can't be hardened. Used for car bodies, screws, nuts, bolts.

**High-carbon steel** (tool steel) — harder than low-carbon steel but not as easy to work, and it rusts. Used to make tools, e.g. chisels, files, saws.

### Non-ferrous metals

- Copper: electrical wiring
- Aluminium: aeroplanes, cans
- Tin: foil, tin cans
- Zinc: coating steel

Examples of **alloys**:

- High speed steel: iron, > 0.6% carbon and other metals
- Brass: 65% copper + 35% zinc
- Stainless steel: iron, carbon, chromium and nickel

### Thermoforming Plastics

- Easily formed into new shapes by heating
- Easy to recycle
- E.g. acrylic, PVC, PET, high-density polyethylene (HDPE)

### Thermosetting Plastics

- Resist heat and fire
- Chemically change after heating and moulding
- Non-recyclable
- E.g. epoxy resin, polyester resin, formaldehydes

## Paper, Board and Timber

### Types of Paper

- cartridge paper
- layout paper
- tracing paper
- grid paper
- bleed-proof paper

### Types of Board

- solid white board
- ink jet card
- corrugated card
- duplex board
- foam core board
- foil-lined board

### Softwoods

- E.g. pine, larch, spruce.
- Mostly evergreen trees, with needle-like leaves and cones.
- Fast growing and grow in colder climates so cheap and accessible.

### Hardwoods

- E.g. oak, mahogany beech, balsa, ash.
- Mostly broad-leaved, deciduous trees that grow in warm climates.
- Slow growing so hardwoods are generally more expensive than softwoods.
- Generally denser and harder than softwoods, with a tighter grain.

### Manufactured Boards

- E.g. Medium Density Fibreboard (MDF), plywood, chipboard.
- Made of wood parts (e.g. thin layers, fibres, woodchips, sawdust) glued together.
- Usually cheaper than softwoods or hardwoods.

## Textiles

| Natural Fibres | Synthetic Fibres |
|---|---|
| Renewable resources | Mostly made from non-renewable fossil fuels |
| Biodegradable | Not biodegradable |
| Absorbent | Not very absorbent |
| Poor resistance to biological damage | Resistant to biological damage |
| E.g. cotton (jeans, t-shirts, blouses), wool (suits, jumpers coats), silk (lingerie, underwear, dresses). | E.g. elastane (sportswear, underwear), polyester (sportswear, bed sheets), polyamide (sportswear, socks). |

**Yarns** — made of short length fibres (staple fibres) or longer length fibres (filaments).

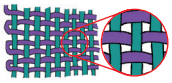
**Blended fabrics** — two or more fibres in same yarn, woven/knitted into a fabric.

**Mixed fabrics** — two or more yarns of different fibres, woven/knitted into a fabric.

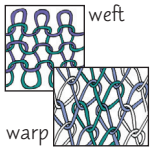
## Making Fabrics

Three main ways of turning fibres/yarns into fabric:

1. **Woven** fabrics — made by interlacing two sets of yarns — the weft (right to left) and the warp (up and down).



2. **Knitted** fabrics — made by interlocking one or more yarns together using loops.
Weft-knitted — yarns run across fabric
Warp-knitted — yarns run up fabric




3. **Non-woven** fabrics — layers of fibres held together by bonding (webs of fibre glued/stitched/melted together) or felting (pressure, moisture and heat interlock fibres).

## Electronic Systems

INPUT → signal → PROCESS → signal → OUTPUT

### Electronics & Circuits

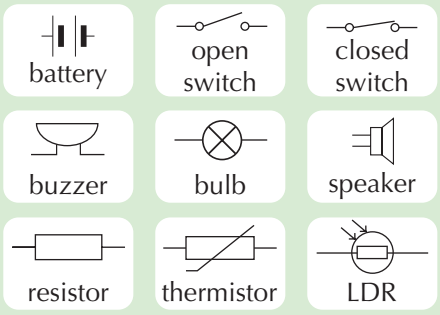
**Circuit** — components joined by wires.

**Printed circuit board** (PCB) — board where thin copper tracks join components in circuit.

**Voltage** — pushes electric current around circuit. Provided by cells, batteries and power supplies.

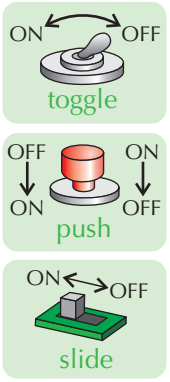
**Resistance** — reduces the current that can flow. Larger resistance = less current. Measured in ohms, Ω.

### Circuit Symbols




Input devices: switches, variable resistors
Output devices: bulbs/LEDs, buzzers, speakers

### Switches



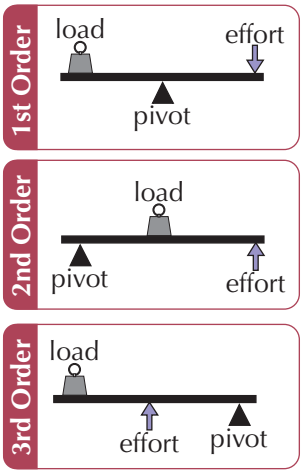

### Integrated Circuits

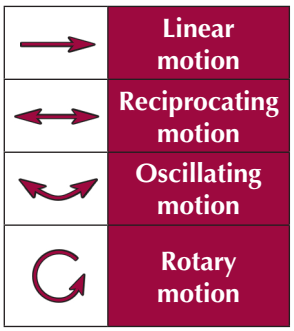
**Integrated circuit** (IC) — tiny, self-contained circuit. Systems with ICs are cheaper, smaller and use less power than ones without.

**Microcontrollers** — ICs designed for a particular function. Use electrical pulses to work as: e.g. timers, counters, decision makers (using logic gates).

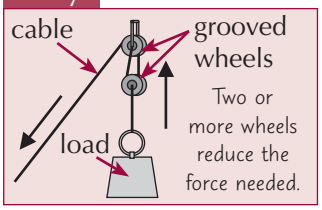
## Mechanical Systems

### Levers

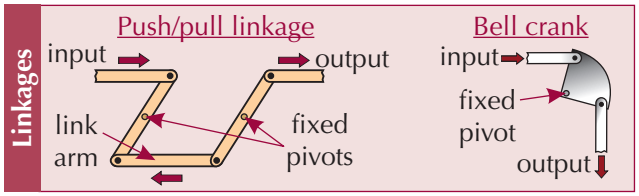



### Pulleys



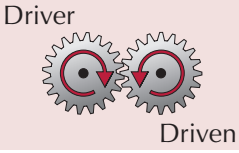

### Linkages



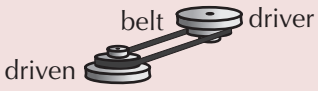

### Gear Trains

$$\text{Gear ratio} = \frac{\text{no. of teeth on driven gear}}{\text{no. of teeth on driver gear}}$$

$$\text{Output speed} = \frac{\text{speed of driver gear (input speed)}}{\text{gear ratio}}$$



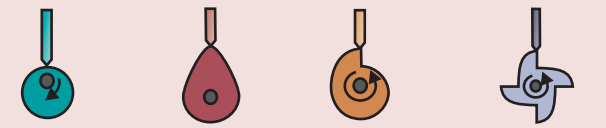

### Belt Drives




$$\text{Velocity ratio} = \frac{\text{diameter of driven pulley wheel}}{\text{diameter of driver pulley wheel}}$$

$$\text{Output speed} = \frac{\text{speed of driver wheel (input speed)}}{\text{velocity ratio}}$$

### Cams




## Modern Materials

Examples:

- graphene
- metal foams
- titanium
- coated metals
- liquid crystal displays (LCDs)
- nanomaterials, e.g. carbon nanotubes

**Smart Materials**
- shape memory alloys
- photochromic and thermochromic pigments

**Composites**
- glass reinforced plastic (GRP)
- Carbonfibre reinforced plastic (CRP)

**Technical Textiles**
- Kevlar®
- Fire-resistant fabrics
- Conductive fabrics

## A myriad of materials to memorise...

...plus their main properties. Don't forget to learn the key details of electronic and mechanical systems too.