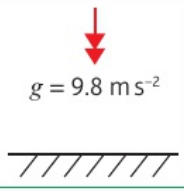
AS Mechanics – Chapter 8 – Modelling in Mechanics

**Mathematical models** can be constructed to simulate real-life situations.

Modelling assumptions can be used to simplify your calculations.

These are some common models and modelling assumptions you need to be familiar with:

| Model | Modelling assumptions |
|---|---|
| **Particle –** Dimensions of the object are negligible. | • mass of the object is concentrated at a single point<br>• rotational forces and air resistance can be ignored |
| **Rod –** All dimensions but one are negligible, like a pole or a beam. | • mass is concentrated along a line<br>• no thickness<br>• rigid (does not bend or buckle) |
| **Lamina –** Object with area but negligible thickness, like a sheet of paper. | • mass is distributed across a flat surface |
| **Uniform body –** Mass is distributed evenly. | • mass of the object is concentrated at a single point at the geometrical centre of the body – the **centre of mass** |
| **Light object –** Mass of the object is small compared to other masses, like a string or a pulley. | • treat object as having zero mass<br>• tension the same at both ends of a light string |
| **Inextensible string –** A string that does not stretch under load. | • acceleration is the same in objects connected by a taut inextensible string |
| **Smooth surface** | • assume that there is no friction between the surface and any object on it |
| **Rough surface –** If a surface is not smooth, it is rough. | • objects in contact with the surface experience a frictional force if they are moving or are acted on by a force |
| **Wire –** Rigid thin length of metal. | • treated as one-dimensional |
| **Smooth and light pulley –** all pulleys you consider will be smooth and light. | • pulley has no mass<br>• tension is the same on either side of the pulley |
| **Bead –** Particle with a hole in it for threading on a wire or string. | • moves freely along a wire or string<br>• tension is the same on either side of the bead |
| **Peg –** A support from which a body can be suspended or rested. | • dimensionless and fixed<br>• can be rough or smooth as specified in question |
| **Air resistance –** Resistance experienced as an object moves through the air. | • usually modelled as being negligible |
| **Gravity –** Force of attraction between all objects. Acceleration due to gravity is denoted by $g$.   | • assume that all objects with mass are attracted towards the Earth<br>• Earth's gravity is uniform and acts vertically downwards<br>• $g$ is constant and is taken as $9.8\ \text{m s}^{-2}$, unless otherwise stated in the question |

Units

The base SI units most commonly used in mechanics are:

| Quantity | Unit | Symbol |
|---|---|---|
| Mass | kilogram | kg |
| Length/Displacement | metre | m |
| Time | second | s |

## Vector and Scalar Quantities

A **vector** is a quantity which has both **magnitude** and **direction**. Vectors can be **positive or negative**.

| Vector quantity | Definition | Unit |
|---|---|---|
| Displacement | Distance in a particular direction | metre (m) |
| Velocity | Rate of change of displacement | metres per second ($ms^{-1}$) |
| Acceleration | Rate of change of velocity | metres per second per second ($ms^{-2}$) |
| Force/Weight | Described by magnitude, direction, point of application | newton (N) |

A **scalar** quantity has magnitude only. Scalar quantities are **always positive**.

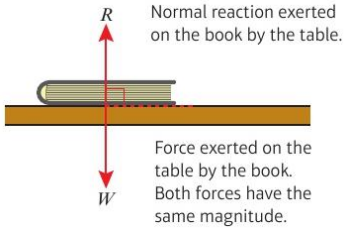
| Scalar quantity | Definition | Unit |
|---|---|---|
| Distance | Measure of length | metre (m) |
| Speed | Measure of how quickly a body moves | metres per second ($ms^{-1}$) |
| Time | Measure of ongoing events taking place | second (s) |
| Mass | Measure of the quantity of matter contained in an object | kilogram (kg) |

**Distance** is the magnitude of the **displacement** vector, and **speed** is the magnitude of the **velocity** vector.

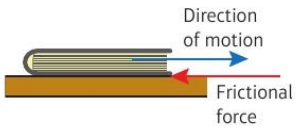
## Forces

These **force diagrams** show some of the most common forces you will encounter in mechanics:

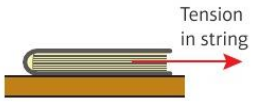
- The **weight** (or gravitational force) of an object acts vertically downwards.
- The **normal reaction** is the force which acts perpendicular to a surface when an object is in contact with the surface. In this example the normal reaction is due to the weight of the book resting on the surface of the table.



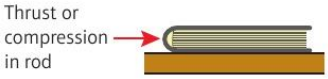

- The **friction** is a force which opposes the motion between two rough surfaces.



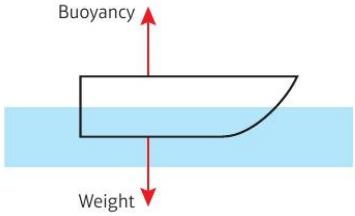

- If an object is being pulled along by a string, the force acting on the object is called the **tension** in the string.




- If an object is being pushed along using a light rod, the force acting on the object is called the **thrust** or **compression** in the rod.




- **Buoyancy** is the upward force on a body that allows it to float or rise when submerged in a liquid. In this example buoyancy acts to keep the boat afloat in the water.




- **Air resistance** opposes motion. In this example the weight of the parachutist acts vertically downwards and the air resistance acts vertically upwards.