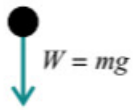
Forces and Modelling

Force questions and modelling go hand in hand, but you need to understand all the mechanics lingo. For starters, 'modelling' in maths doesn't have anything to do with plastic aeroplane kits... or catwalks.

Types of forces

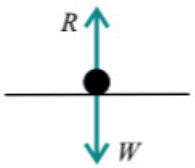
Weight (W)

Due to the particle's mass, m and the force of gravity, g: $W = mg$. Weight always acts **downwards**.



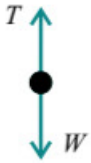
The Normal Reaction (R or N)

The reaction from a surface. Reaction always acts **perpendicular (90°) to the surface.**



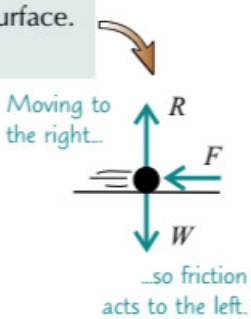
Tension (T)

Force in a taut rope, wire or string.



Friction (F)

A resistance force due to the **roughness** between a body and a surface. Always acts **against** motion, or likely motion.



Cake (C)
A force to be reckoned with. Always acts towards my mouth, and opposes likely hunger.

Air resistance and drag forces also resist motion.

Thrust or **Compression**

Force in a rod (e.g. the pole of an open umbrella).

Talk the Talk

Mechanics questions use a lot of words that you already know, but here they're used to mean something very **precise**. Learn these definitions so you don't get caught out:

Particle	the body is a point so its dimensions don't matter	**Rigid**	the body does not bend
Light	the body has no mass	**Thin**	the body has no thickness
Static	not moving	**Equilibrium**	no resultant force
Rough	the surface will oppose motion with friction / drag	**Plane**	a flat surface
Beam or Rod	a long particle (e.g. a carpenter's plank)	**Inextensible**	the body can't be stretched
Uniform	the mass is evenly spread out throughout the body	**Smooth**	the surface doesn't have friction / drag opposing motion
Non-uniform	the mass is unevenly spread out		

*You need to know the **S.I. Units**...*

S.I. units are a system of units that are designed to be consistent all around the world. The three main **base units** that you'll come across are:

Length: **metre (m)** | Time: **second (s)** | Mass: **kilogram (kg)**

Other units, such as newtons, are called **derived** S.I. units because they're **combinations** of the base units.

All quantities can be measured in units derived from the base S.I. units, which can usually be found using their formula. For example, the formula for speed is distance ÷ time. Distance is a length measured in metres, and time is measured in seconds, so the S.I. unit of speed is metres ÷ second, written m/s or ms^{-1}.

Watch out for non-S.I. units that sneak into questions here and there — you can measure length in inches and feet, but these are **imperial** units, not S.I. units. Certain units, like **miles per hour**, are **derived non-S.I.** units.

Forces and Modelling

*Always start by drawing a **Simple Diagram** of the **Model***

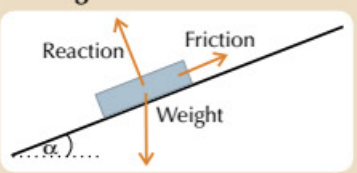
You'll have to make lots of **assumptions** when tackling **modelling** problems.

Example: Model the following situations by drawing a force diagram and listing any assumptions made.

> Modelling is a **cycle** — use the model to **solve** the problem, **compare** it to real life, **evaluate** your results, then **improve** the model and **start again**.

1 The book on a table

A book is put flat on a table. One end of the table is slowly lifted and the angle to the horizontal is measured when the book starts to slide.

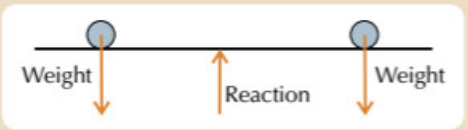


Assumptions:
The book is a **particle**, so its dimensions don't matter.
The table is **rigid**, and its surface is a **rough plane**.
There's **no** wind or other **external forces** involved.

2 The balance

A pencil is placed on a table and a ruler is put across the pencil. A 1p coin and a 10p coin are placed on the ruler either side of the pencil, so that the ruler balances on the pencil.

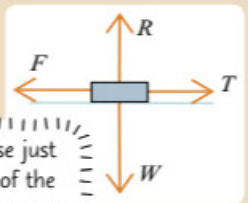
Assumptions:
The coins are **particles**.
The ruler is **rigid**.
The support acts at a **single point**.



3 The sledge

A sledge is being steadily pulled by a small child on horizontal snow.

Assumptions:
Friction is **too big** to be ignored (i.e. it's not ice).
The string is **horizontal** (it's a small child).
The sledge is a **particle** (so its size doesn't matter).

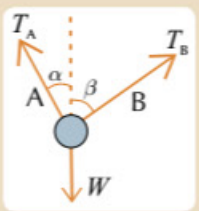


> It's easier to use just the first letter of the force in your diagram, e.g. F = friction.

4 The mass on a string

A ball is held by two strings, A and B, at angles α and β to the vertical.

Assumptions:
The ball is modelled as a **particle** (its dimensions don't matter).
The strings are **light** (their mass can be ignored).
The strings are **inextensible** (they can't stretch).



Practice Questions

Q1 The density of an object is given by its mass, divided by its volume.
Give the S.I. units of mass and volume and hence find the S.I. unit of density.

Q2 A ball is dropped onto a cushion from above. Draw a model, stating any assumptions made, showing the ball: a) as it is released, b) after it has landed.

Exam Question

Q1 A car is modelled as a particle travelling at a constant speed along a smooth horizontal surface. Explain two ways in which this model could be adjusted to be more realistic. [2 marks]

I can't get up yet — I'm modelling myself as a static particle in a rough bed...

Make sure you're completely familiar with the different forces and all the jargon that gets bandied about in mechanics. Keep your models as simple as possible — that will make answering the questions as simple as possible too.