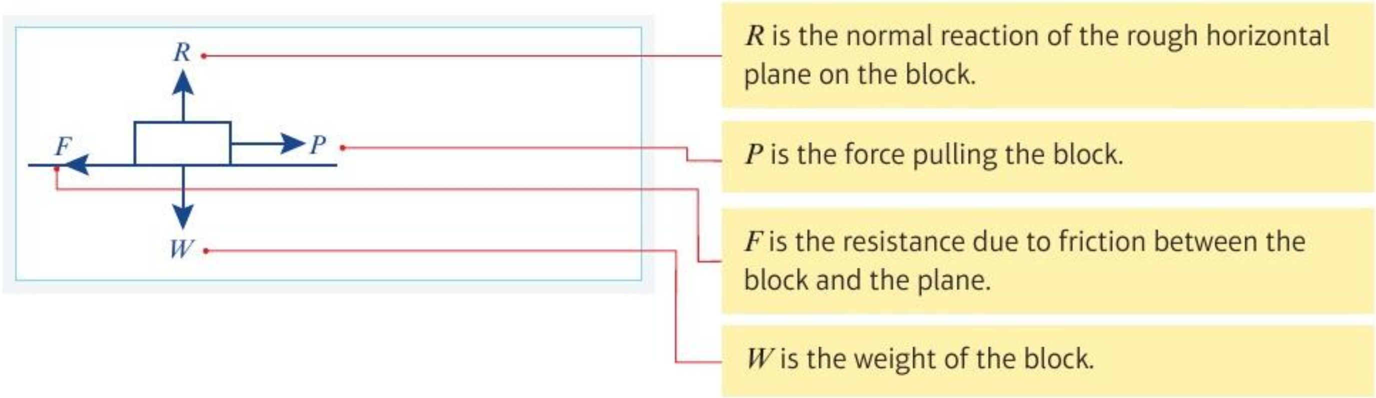
AS Mechanics – Chapter 10 – Forces and Motion

Force Diagrams

When the forces acting upon an object are balanced, the object is said to be in equilibrium.

In the diagram below, the block is in equilibrium if the vertical forces $R = W$ **and** the horizontal forces $P = F$:



Newton's first law of motion states that **an object at rest will stay at rest** (and that an object moving with constant velocity will continue to move with constant velocity) **unless acted on by an external force**.

Constant velocity means that neither the speed nor the direction is changing.

When there is more than one force acting on an object you can resolve the forces in a certain direction to find the resultant force in that direction. The direction you are resolving in becomes the positive direction. You add forces acting in this direction and subtract forces acting in the opposite direction.

You can use R together with an arrow to indicate the direction in which you are resolving forces: $R(\uparrow)$, $R(\rightarrow)$

In Y12 you will only resolve forces that are horizontal or vertical.

A resultant force acting on an object will cause it to accelerate in the same direction as the resultant force.

Column Vectors

You can write forces as vectors using $\boldsymbol{i} - \boldsymbol{j}$ notation or as column vectors.

You can find the resultant of two or more forces given as vectors by adding the vectors.

If two forces $(p\boldsymbol{i} + q\boldsymbol{j})$ N and $(r\boldsymbol{i} + s\boldsymbol{j})$ N are acting on a particle, the resultant force will be $(p + r)\boldsymbol{i} + (q + s)\boldsymbol{j}$ N.

When a particle is in equilibrium the resultant vector force will be $0\boldsymbol{i} + 0\boldsymbol{j}$

Forces and Acceleration

A non-zero resultant force that acts on a particle will cause it to accelerate in the direction of the resultant force.

Newton's second law of motion states that the force needed to accelerate a particle is equal to the product of the mass of the particle and the acceleration produced:

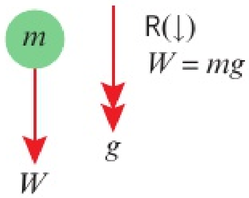
$$\boldsymbol{F = ma}$$

A force of one newton will accelerate a mass of one kilogram at a rate of 1 ms^{-2} .

If a force F N acts on a particle of mass m kg causing it to accelerate at a ms^{-2} , the **equation of motion** for the particle is $F = ma$.

Gravity

Gravity is the force between any object and the Earth. The force due to gravity acting on an object is called the weight of the object, and it acts **vertically downwards**.



A body falling freely experiences an acceleration of g = 9.8 ms^{-2}.

Using the relationship $F = ma$ you can write the equation of motion for a body of mass m kg with weight W N:

$$\boldsymbol{W = mg}$$

Connected Particles

If a system involves the motion of more than one particle, the particles may be considered separately. However, if all parts of the system are moving in the same straight line, you can also treat the whole system as a single particle.

Particles must remain in contact, or be connected by an inextensible rod/string, to be considered as a single particle.

Newton's third law states that for every action there is an equal and opposite reaction.

Newton's third law means that when two bodies A and B are in contact, if body A exerts a force on body B, then body B exerts a force on body A that is equal in magnitude and acts in the opposite direction.

You can write a separate equation of motion ($F = ma$) for each particle in the system, and for the whole system.

Pulleys

You will see how to model systems of connected particles involving pulleys. The problems you answer will assume that particles are connected by a light, inextensible string, which passes over a smooth pulley.

This means that the tension in the string will be the same on both sides of the pulley. The parts of the string each side of the pulley will be either horizontal or vertical.

You cannot treat a system involving a pulley as a single particle. This is because the particles are moving in different directions. You can work around this by considering movement **along the string** as you would left and right.