BRIEF NOTES ON FORCES

Newtons 1st law of motion

If an object has zero net force acting on it, it will remain at rest, or continue moving with constant velocity.

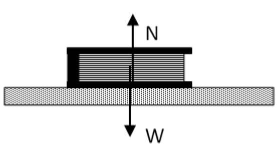
An important consequence of this law was the realisation that an object can be in motion without a force being constantly applied to it. Whenever you see the key words ***constant velocity*** in a question, you should highlight them. The realisation that the object is travelling at a constant velocity, and hence that the net force on the object is zero, will be essential for solving the problem.

Newtons 2nd law of motion

$\boldsymbol{a} = \frac{\boldsymbol{F_{net}}}{m}$. this is commonly written as $\mathbf{F}_{net} = m\mathbf{a}$.

Newtons 3rd law of motion

For every action force acting on one object, there is an equal but opposite reaction force acting on the other object. $F_{A\ on\ B} = -F_{B\ on\ A}$



Note: in this example normal force and weight (gravitational) force **ARE NOT** a Newton's thirds law pair, because they both act on the same object. You need to appreciate that these action/reaction forces act on **DIFFERENT OBJECTS** and so you do not add them to find a resultant force.

The Normal Force

The normal force acts perpendicular to a surface, and is the force responsible for stopping an object from falling through a surface (e.g. a table, floor, wall etc.). For flat horizontal surfaces, the normal force opposes the weight force directly.

Drawing Force Diagrams

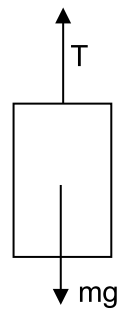
There are several considerations when drawing force diagrams:

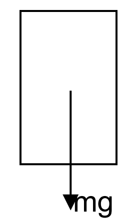
- The arrows that represent the forces should point in the direction of applied force. The length of the arrow represents the strength of the force, so some effort should be made to draw the arrows to scale.

- All forces should be labelled.

Some sample force diagrams of common situations are drawn below.

Mass on a string | **Mass in free flight**



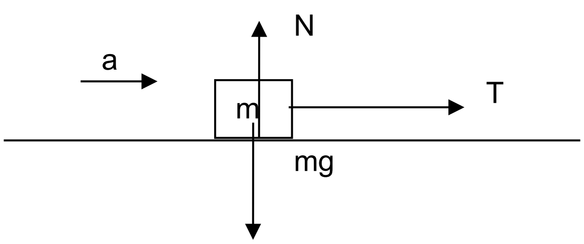


Velocity v = 0, so T = mg
Velocity v = constant upwards, so T = mg
Velocity v = constant downwards, so T = mg
Accelerating Upwards, T - mg = ma.
Acceleration Downwards, mg - T = ma.

$\Sigma F = mg = ma$

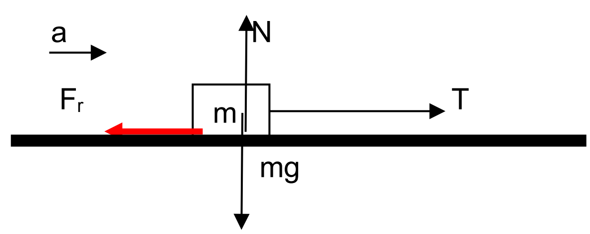
Mass pulled along a plane

<u>Smooth (No Friction)</u>



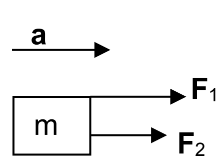
T = m**a**, **N** + m**g** = 0

<u>Rough (Friction)</u>

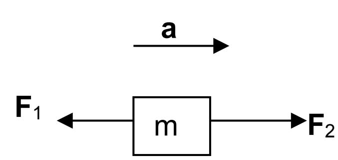


T – $\mathbf{F_{net}}$ = m**a**, **N** + m**g** = 0

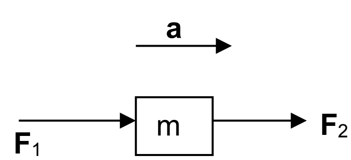
Bodies with parallel forces acting



$F_1 + F_2 = ma$

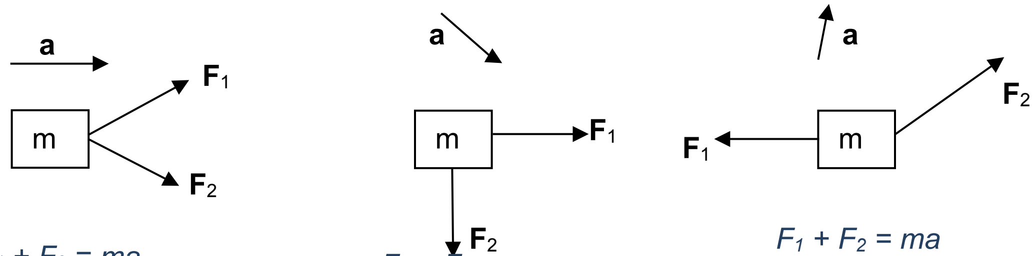


$F_2 - F_1 = ma$



$F_1 + F_2 = ma$

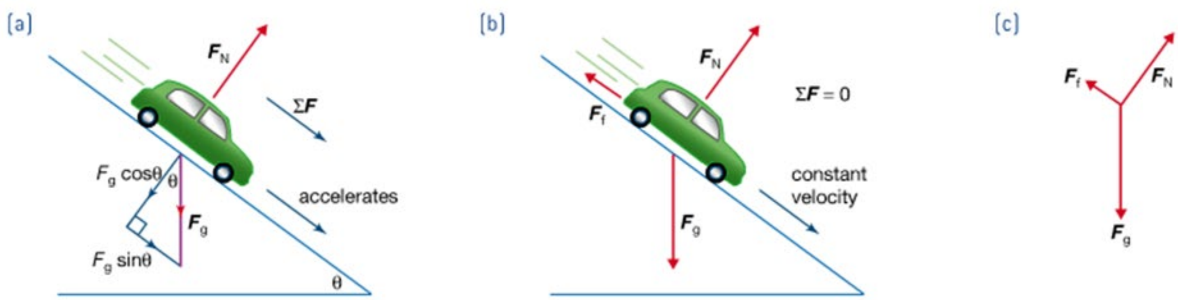
Bodies with non-parallel forces acting



$F_1 + F_2 = ma$ $F_1 + F_2 = ma$ $F_1 + F_2 = ma$

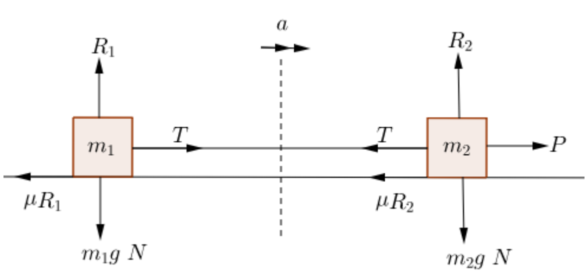
The vectors need to be resolved in order to solve for the acceleration.

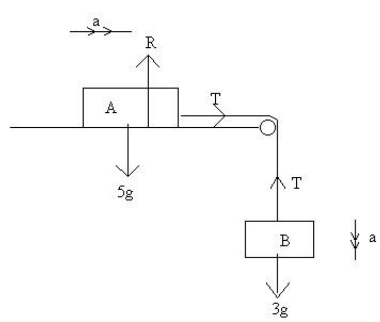
Inclined Plane



Component of the gravity (weight force) along the plane is equal $mg\sin\theta$, perpendicular to the plane $mg\cos\theta$ so along the plane $mg\sin\theta - F_{fr} = ma$, perpendicular $N - mg\cos\theta = 0$.

Connected objects





Tension in the same string (rope etc.) always the same at both ends and always acting on the objects away from them.

Hooke's law.

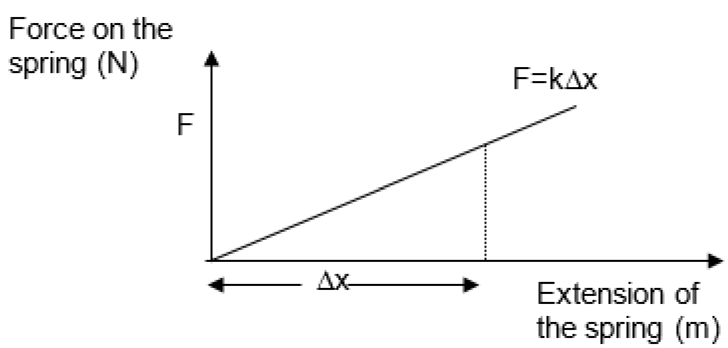
Extending a spring is an example of a situation where the force on an object is not constant. As the spring gets compressed, the force required to further compress it increases. The mathematical equation that represents this type of situation is called Hooke's Law

$$F = -k\Delta x$$

Where F is the magnitude of the force required, Δx is the extension (or compression) of the spring, a k is called the spring constant. The minus sign in the equation is to show the vector relationship, the restoring force is in the opposite direction to the change in length. Typically we will not use the negative sign as the questions will just want the magnitude of the force.

The spring constant has a specific value for each individual spring. It depends on the size, thickness and material from which the spring is made. It is very important to use Δx, as this demonstrates that you are only interested in the **change in the length** of the spring.

The equation is illustrated in the graph below



The spring constant 'k' is the gradient of the line in the linear region. (Hooke's law only holds in the linear region, before the material deforms as it goes beyond its elastic limit).

The spring constant has the units: Newtons per metre, ($N\ m^{-1}$).