GCSE Physics Key Facts – Forces

Forces and their interactions

Scalar quantities have magnitude (size) only. Vector quantities have magnitude and direction e.g. force. Vector quantities are represented by an arrow (size of arrow represents magnitude)

Contact forces happen when objects are touching e.g. friction, air resistance, tension and normal contact force. Non-contact forces happen when objects aren't touching e.g. gravitational force, electrostatic force and magnetic force

When two objects interact with each other, they produce equal and opposite forces on each other.

Weight is the force acting on an object due to gravity. The weight of an object depends on the gravitational field strength at the
point where the object is.

Weight equation:

$W = mg$

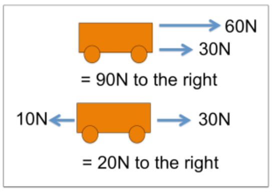
W = weight (Newtons)
m = mass (kg)
g = gravitational field strength (N/kg)

The centre of mass is the point on an object where its weight appears to act

Weight is measured using a newtonmeter

Weight is proportional to mass. This can be written as: $W \propto m$

A number of forces acting on an object may be replaced by a single force called a resultant force. This has the same effect as all the original forces acting together.



Higher Tier only
A single force can be resolved into 2 forces acting at right angles

Work Done and energy transfer

Work is done when a force causes an object to move.

Work done equation:

$W = Fs$

W = work done (Joules)
F = force (Newtons)
s = distance moved along the line of action of the force (m)

One joule of work is done when a force of one newton causes a displacement of one metre.
1 joule = 1 newton-metre

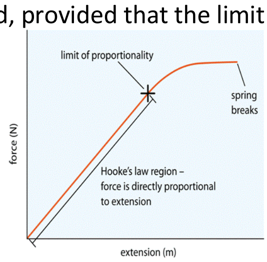
When work is done against friction, the temperature of an object will increase.

Forces and elasticity (Hooke's Law)

Forces can stretch, bend and compress an object

Elastic deformation: object returns to its original shape when the stretching forces are removed. Inelastic deformation: object doesn't return to its original shape when the stretching forces are removed.

The extension of an elastic object, e.g. a spring, is directly proportional to the force applied, provided that the limit of proportionality is not exceeded.



Hooke's Law equation:

$\mathbf{F = ke}$

F = force (N)
k = spring constant (N/m)
e = extension (m)

This equation can also be used for compression (squashing) of an object. e then is compression.

When a force stretches or compresses a spring, elastic potential energy is stored in the spring. If the spring is not inelastically deformed, the work done on the spring and the elastic potential energy stored are equal.

Energy stored in a spring equation:

$\mathbf{E = \frac{1}{2} k e^2}$

E = elastic potential energy (J)
k = spring constant (N/m)
e = extension (m)

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Forces and motion	
Distance is a scalar quantity, it is how far an object moves	Displacement is a vector quantity. It includes distance and direction.
Speed is a scalar quantity (it doesn't have a direction)	Speed of a person running, walking or cycling depends on things such as age, terrain and fitness
Typical values for the speed of a moving person are: Walking 1.5m/s, Running 3m/s, Cycling 6m/s	Typical speeds of different transportation systems are car:100km/h, train: 200km/h, plane: 900km/h
Speed of sound in air is 330m/s	Speed equation: **s = vt** s = distance in metres, v = speed in m/s, t = time in s
Velocity is speed in a particular direction, it is a vector quantity.	**HIGHER ONLY: An object moving in a circle with constant speed has a changing velocity. This is because its direction is changing.**
In distance-time graphs: • A horizontal line means the object is stationary. • A straight line that slopes means a constant speed. • The gradient represents speed	In velocity-time graphs: • A horizontal line means a constant velocity. • A straight line that slopes means a constant acceleration . • The gradient represents the acceleration.
HIGHER TIER ONLY If an object is accelerating, its speed at a particular time can be determined by drawing a tangent on a distance-time graph and working out the gradient.	Acceleration equation: $a = \Delta v/t$ a = acceleration (metres per second squared, m/s^2) Δv = change in velocity (metres per second, m/s) t = time (seconds, s)
HIGHER TIER ONLY The distance or displacement of an object can be calculated from the area under a velocity-time graph. This may be calculated by counting squares.	SUVAT equation: $v^2 - u^2 = 2as$ v = final velocity (metres per second, m/s) u = initial velocity (metres per second, m/s) a = acceleration (metres per second squared, m/s^2) s = distance (metres, m)
Acceleration of a falling object close to the surface of the Earth is about $9.8m/s^2$	An object falling through a fluid initially accelerates due to the force of gravity. Eventually the resultant force will be zero and the object will move at its terminal velocity.
Newton's First Law: If the resultant force acting on an object is zero it will continue to move at the same velocity. If the object is stationary, the object remains stationary. If the object is moving, the object continues to move at the same speed and in the same direction.	An object that slows down is decelerating
(HT only) The tendency of objects to continue in their state of rest or of uniform motion is called inertia. Intertial mass is a measure of how difficult it is to change the velocity of an object. It is F/a	When a vehicle travels at a steady speed, the resistive forces balance the driving force.
Newton's 2nd Law equation: F = ma F = Force (N) m = mass (kg) A = acceleration (m/s^2)	**Newton's Second Law:** The acceleration of an object is proportional to the resultant force acting on it ($a \propto F$) and is inversely proportional to the mass of the object.
Newton's Third Law: Whenever two objects interact, the forces they exert on each other are equal and opposite.	~ is the symbol used for an approximate answer
For a certain braking force the faster the vehicle, the greater the stopping distance.	**Stopping distance = thinking distance + braking distance** Thinking distance = distance the vehicle travels during the driver's reaction time Braking distance = distance it travels under the braking force
Typical reaction times are 0.2 s to 0.9s	The greater the speed of a vehicle the greater the braking force needed to stop the vehicle in a certain distance.

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Describe a method used to measure reaction time (e.g. catching a falling ruler)	A driver's reaction time can be affected by tiredness, drugs and alcohol. Distractions may also affect a driver's ability to react.
When a braking force is applied work done by the friction force between the brakes and the wheel reduces the kinetic energy of the vehicle and the temperature of the brakes increases.	The braking distance of a vehicle can be affected by road and weather conditions and by the condition of the vehicle (e.g. tyres and brakes)
Large decelerations may lead to brakes overheating and/or loss of control.	HIGHER TIER ONLY Conservation of momentum: In a closed system, total momentum before an event equals total momentum after the event.