Foxford Learning Plan | KS4 Physics P05a – Forces and Motion

Understanding - Over the course of the topic, I will understand:

- ☐ How to apply the equation *distance = speed x time (s = vt)*
- ☐ How to interpret distance-time graphs
- ☐ How to apply the equation *acceleration = change in velocity / time (a= Δv/t)*
- ☐ How to apply the equation *final velocity² – initial velocity² = 2 × acceleration × distance ($v^2 - u^2 = 2\,a\,s$)*
- ☐ How to interpret distance-time graphs
- ☐ How to calculate distance travelled from the area under a distance-time graphs (HT)
- ☐ How to calculate a resultant force
- ☐ That a force can be resolved into two components acting at right angles to each other.
- ☐ That if the resultant force on an object is zero it will either stay at rest or move at a constant velocity. (Newton 1)
- ☐ The acceleration of an object is proportional to the force on the object and inversely proportional to its mass (Newton 2)
- ☐ Whenever two objects interact, the forces they exert on each other are equal and opposite. (Newton 3)
- ☐ How to apply the equation *resultant force = mass × acceleration ($F = m\,a$)*
- ☐ How to carry out Required Practical 7 – the effect of force on acceleration and the effect of mass on acceleration.
- ☐ That an object falling through a fluid will move at its terminal velocity when resistive forces and gravity are balanced.
- ☐ The effect of braking distance and thinking distance of the stopping distance of and vehicle.
- ☐ How to apply the equation *momentum = mass × velocity ($p = m\,v$)*
- ☐ How to apply the equation *Force = mass x change in momentum / time ($F=m\,\Delta v/\Delta t$)* (HT)
- ☐ How some safety features such as air bags and seat belts depend on the rate of change of momentum. (HT)

Skills - Over the course of the topic, I will:

- ☐ Recognise and use expressions in decimal form
- ☐ Use ratios, fractions and percentages
- ☐ Make estimates of the results of simple calculations
- ☐ Use an appropriate number of significant figures
- ☐ Construct and interpret frequency tables and diagrams, bar charts and histograms
- ☐ Make order of magnitude calculations
- ☐ Understand and use the symbols: =, <>, >, ∝ , ~
- ☐ Change the subject of an equation
- ☐ Substitute numerical values into algebraic equations using appropriate units for physical quantities
- ☐ Translate information between graphical and numeric form
- ☐ Understand that y = mx + c represents a linear relationship
- ☐ Plot two variables from experimental or other data
- ☐ Determine the slope and intercept of a linear graph
- ☐ Draw and use the slope of a tangent to a curve as a measure of rate of change
- ☐ Understand the physical significance of area between a curve and the x-axis and measure it by counting squares as
- ☐ Use angular measures in degrees
- ☐ Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects
- ☐ Calculate areas of triangles and rectangles, surface areas and volumes of cubes
- ☐ Use a variety of models
- ☐ Explain everyday and technological applications of science
- ☐ Evaluate risks both in practical science and the wider societal context
- ☐ Plan experiments or devise procedures to make observations
- ☐ Carry out and represent mathematical and statistical analysis
- ☐ Interpret observations and other data
- ☐ Evaluate data for accuracy, precision, repeatability and reproducibility and identify sources of random and systematic error
- ☐ Recognise the importance of scientific quantities and understand how they are determined
- ☐ Use appropriate apparatus to measure and observe the effects of forces
- ☐ Use appropriate apparatus and techniques for measuring motion

What is the difference between speed and velocity?

A scalar only has magnitude (size).
A vector has magnitude and direction.
Distance and speed are scalars.
Displacement and velocity are vectors.
Typical values of speed are:

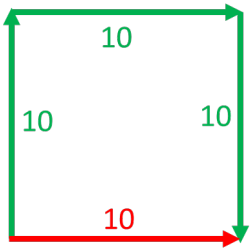
- walking – 1.5 m/s
- running – 3 m/s
- cycling – 6 m/s.

Distance, speed and time are linked by the equation

distance travelled = speed × time

$s = v\,t$

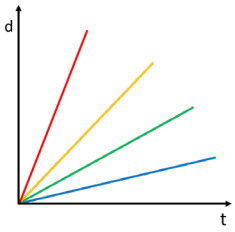
Displacement is the distance **and direction** from an object's starting point.



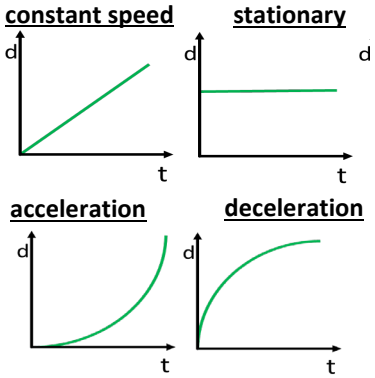
e.g.
The distance it has travelled is 30 km
The displacement is 10 km east

What is a distance-time graph for?

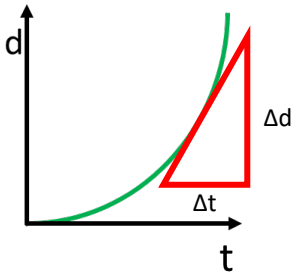
Distance travelled can be represented by a distance–time graph.
The speed of an object can be calculated from the gradient of its distance–time graph.



The shape of a d-t graph depends on the type of motion.



(HT)
If an object is accelerating, its speed can be determined by drawing a tangent and measuring the gradient of the distance–time graph at that time.



What is acceleration?

The average acceleration of an object can be calculated using the equation:

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

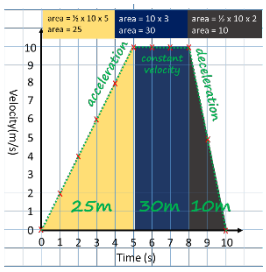
$$a = \frac{\Delta v}{t}$$

acceleration, a, in metres per second squared, m/s^2
change in velocity, Δv, in metres per second, m/s
time, t, in seconds, s

This equation applies to uniform acceleration:
final velocity² – initial velocity² = 2 × acceleration × distance
$v^2 - u^2 = 2\,a\,s$

Why are velocity-time graphs useful?

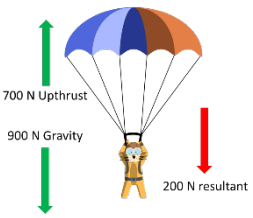
The acceleration of an object can be calculated from the gradient of a velocity–time graph.
The area enclosed in a velocity–time graphs tells us the distance travelled (or displacement).



If the velocity-time graph is a curve, then we can estimate the area by counting squares.

What is a force?

Forces are pushes or pulls.
They can be divided in to contact and non-contact forces.
Contact forces include friction, air resistance, tension, and normal contact force.
Non-contact forces are gravitational force, electrostatic force, and magnetic force.
A resultant force is a single force that has the same effect as all the original forces acting together.



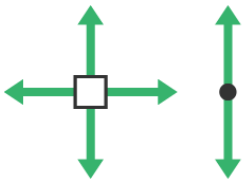
Newton's First Law states that if the resultant force acting on an object is zero and:

- the object is stationary, the object remains stationary
- the object is moving, the object continues to move at the same speed and in the same direction.

(HT) The tendency of objects to continue in their state of rest or of uniform motion is called inertia.
Whenever two objects interact, the forces they exert on each other are equal and opposite.

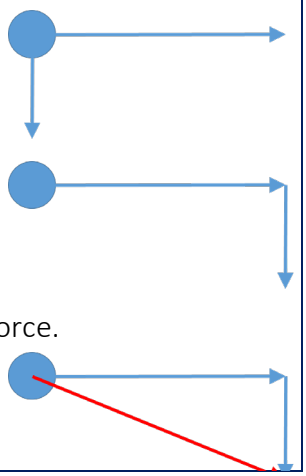
How can we work out the effect of multiple forces?

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



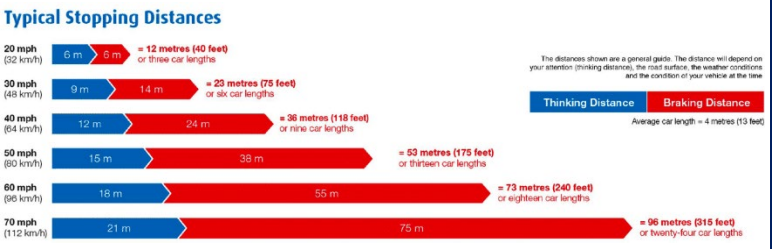
Free body diagrams can be used where several forces lead to a resultant force on an object.

(HT)
A single force can be resolved into two components acting at right angles to each other.
The two component forces together have the same effect as the single force.
Vector diagrams are used illustrate resolution of forces by using scale



What affects the stopping distance of a vehicle?

Reaction times vary from person to person but are usually in the range from 0.2 s to 0.9 s.
The thinking distance is the distance travelled during the driver's reaction time. A driver's reaction time can be affected by tiredness, drugs, alcohol, and distractions.
The braking distance of a vehicle can be affected by adverse road and weather conditions and poor condition of the brakes or tyres



stopping distance = thinking distance + braking distance

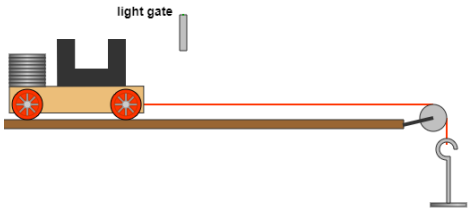
What is Newton's second law?

The acceleration of an object is proportional to the resultant force acting on the object,
The acceleration of an object is inversely proportional to the mass of the object.

resultant force = mass × acceleration
F = m a

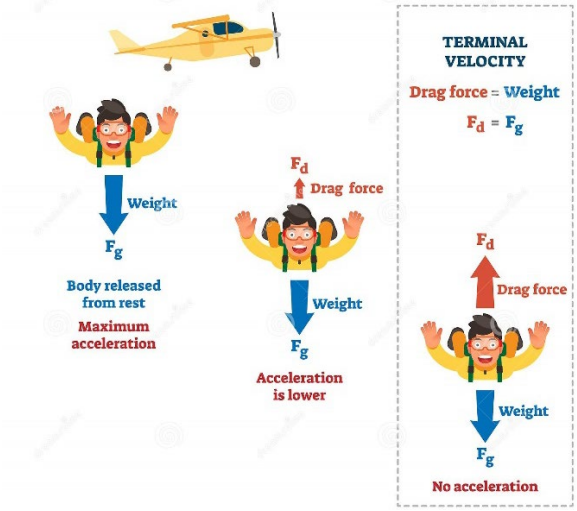
force, F, in newtons, N
mass, m, in kilograms, kg
acceleration, a, in metres per second squared, m/s^2

The link between force, mass and acceleration can be investigated using a trolley and light gates. The force on the trolley is increased by increasing the masses on the end of the string. The acceleration of the trolley can be measured using the light gates.



When does and object reach terminal velocity?

An object falling through a fluid initially accelerates due to the force of gravity.
As its speed increases the friction forces increase.
Eventually the resultant force will be zero and the object will move at a constant speed called terminal velocity.



What is momentum?

Momentum is defined by the equation:
momentum = mass × velocity
$p = m\,v$
momentum, p, in kilograms metre per second, kg m/s mass, m, in kilograms, kg
velocity, v, in metres per second, m/s

In a closed system, the total momentum before an event is equal to the total momentum after the event. This is called conservation of momentum.

When a force acts on an object a change in momentum occurs.

$$F = \frac{m\Delta v}{\Delta t}$$ where mΔv = change in momentum

In a collision the change of velocity causes a change in momentum. If we increase the time taken for the change then we will reduce the force of the collision.
Car safety belts, crumple zones and airbags are designed to increase the Δt of a collision and so reduce the force.

Key vocabulary

Acceleration	Speeding up. The rate of change of velocity.
At rest	Not moving.
Balanced forces	Where the forces are equal in size and opposite in direction – the resultant is zero.
Contact force	A force that can only act if it touches an object.
Deceleration	Slowing down.
Displacement	The change in position of and object.
Distance-time graph	A graph showing how the distance of an object varies with time.
Force	A push or a pull.
Gradient	The slope of a line. Calculated by *change in Y / change in X.*
Inertia (HT)	The tendency of objects to continue being at rest or in uniform motion.
Momentum	***mass x velocity***
Non-contact force	A force that can act if from a distance.
Resultant force	The overall effect of several forces.
Scalar	A quantity that has only magnitude (size).
Speed	How fast an object is going. The rate of change of distance.
Stationary	Not moving.
Tangent (HT)	A straight line that touches only curve at one point.
Terminal velocity	The constant velocity reached by an object when the driving force = resistance force.
Unbalanced forces	Where the resultant force is not zero.
Vector	A quantity that has both magnitude (size) and direction.
Velocity	Speed and direction. The rate of change of displacement.
Velocity-time graph	A graph showing how the velocity of an object varies with time.