P5 Knowledge Organiser – 4.5.1/4.5.2 – Forces and interactions

Contact forces	Non-contact forces
Friction	Gravitational
Air resistance	Electrostatic
Tension	Magnetic

Friction
A force that acts in the opposite direction of a moving object. Examples include air resistance and water resistance. Work done against frictional forces acting on an object causes a rise in temperature

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

Work done and energy transfer
When a force causes an object to move through a distance work is done on the object. So a force does work on an object when the force causes a displacement of the object, E.g. 1J of work is done when a force of 1N causes a displacement of 1 m. 1J = 1 Newton-metre

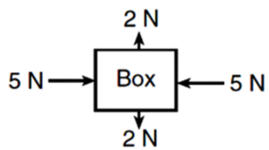
Work done (J) = Force (N) x Distance (m)

Scalar and Vector Quantities
Scalar quantities have magnitude only while vector quantities have magnitude and an associated direction. Scalars include time and speed while vectors include velocity. A vector quantity may be represented by an arrow. The length of the arrow represents the magnitude, and the direction of the arrow the direction of the vector.

Newtons First Law
If the resultant force acting on an object is zero and the object is stationary, the object will stay stationary. However, if the object is moving, the object continues to move at the same speed and in the same direction. This means the object continues to move at the same velocity. The velocity of an object will only change if there is a resultant force acting on the object. **The tendency of objects to continue in their state of rest or of uniform motion is called inertia.**

Newtons Third Law
Whenever two objects interact, the forces they exert on each other are equal and opposite. For example a man pushes on a wall with 100N and experiences a force of 100N in the opposite direction from the wall.

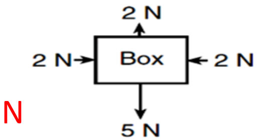
Free Body diagrams
Arrows represent the forces acting on an object. The bigger the arrow, the bigger the force. Balanced forces are represented by the same sized arrows. Arrows are always in pairs and act in opposite directions



Distance
Distance is how far an object moves. Distance does not involve direction. **Distance is a scalar quantity.**

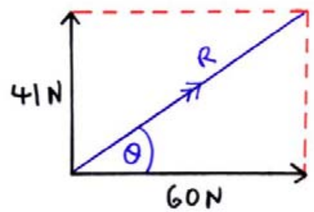
Displacement
Displacement includes both the distance an object moves, measured in a straight line from the start point to the finish point and the direction of that straight line.
Displacement is a vector quantity.

Resultant Force
A single force that has the same effect as all the forces acting on the object.
For example if there is a force of 100N to the right and 50N to the left then overall there will be a resultant force of 50N to the right. If forces are acting in the same direction add them together, if they are acting in opposite directions subtract them from each other.



Resultant forces = 5-2= 3N

Resolution of Forces
You need to be able to draw vector diagrams to illustrate resolution of forces and determine the magnitude and direction of this force. You will need a protractor and a ruler. Use a ruler to draw the forces to scale and use a protractor to measure the accurately the angle between these forces. Draw the resolving force line to complete the diagram. This should make a triangle. Measure the size of this line to measure the magnitude of this force.



P5 Knowledge Organiser – 4.5.6 – Forces and motion

Newtons Second Law

This is the rule that the acceleration of an object is proportional to the resultant force acting on an object, and inversely proportional to the mass of the object. The equation for this is:

Resultant Force = Mass x Acceleration

Inertial mass is a measure of how difficult it is to change the velocity of an object and is defined as the ration of force over acceleration.

Stopping Distance

The stopping distance of a vehicle is **the sum of the distance the vehicle travels during the driver's reaction time (thinking distance) and the distance it travels under the braking force (braking distance).** For a given braking force the greater the speed of the vehicle, the greater the stopping distance.

Momentum

Momentum can be calculated using the equation:

Momentum = Mass x Velocity

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.

Changing Speed

The velocity of an object increases if the resultant force is in the same direction as the velocity while an object will slow down if the resultant force acts in the opposite direction to its velocity.

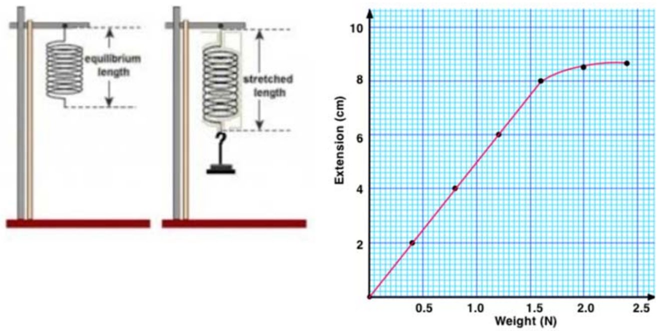
Terminal Velocity

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.

Hooke's law Required practical

The extension of a spring is directly proportional to the force applied as long as the limit of proportionality is not exceeded.

Force Applied = Spring Constant x Extension



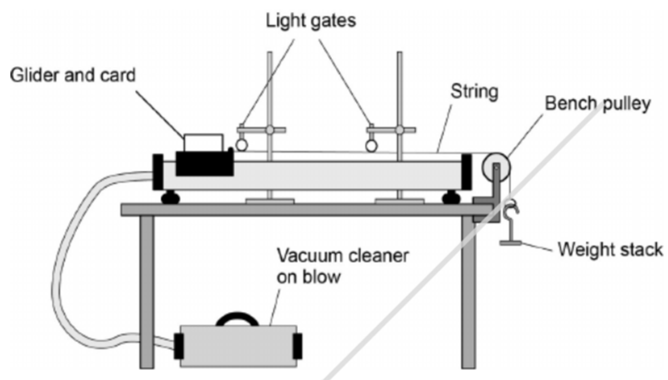
Quantity	Symbol	Unit
Resultant Force	F	N
Mass	m	kg
Acceleration	*a*	m/s^2
Weight	W	N
Gravitational Field Strength	g	N/kg
Velocity	v	m/s
Momentum	p	Kg m/s
Spring Constant	k	N/m
Extension	e	m

Forces and Elasticity

To change the shape of an object (by stretching, bending or compressing), more than one force has to be applied. If an object is elastic it will return to its original shape when the forces deforming it re removed.

Elastic potential energy = 0.5 x spring constant x (extension)^2

Required practical – Effect of force on acceleration



Braking distance

Is affected by the road and weather conditions, e.g. wet or icy conditions. The greater the speed of a vehicle the greater the braking force needed to stop the vehicle in a certain distance. The greater the braking force the greater the deceleration of the vehicle. Large decelerations may lead to brakes overheating and/or loss of control.

Weight

The weight of an object can be calculated using the equation:

Weight = mass x gravitational field strength

The weight of an object and the mass o an object are directly proportional and weight is measured using a calibrated spring-balance otherwise known as a newtonmeter.

P5 Knowledge Organiser – 4.5.6 – Forces and motion

Speed

Speed is a **scalar quantity** as it does not involve direction. The speed of a moving object is normally changing and so is rarely constant. The speed a person travels at can depend on their age, terrain (is it hilly or flat) fitness and distance travelled. Typically people travel at 1.5m/s when walking, 3m/s when running and 6m/s when cycling. The speed of sound and of the wind may change also. Sound typically travels at 330m/s. The formula to calculate the speed of an object is:

Speed = Distance / Time

Velocity

The velocity of an object is its speed in a particular direction. This means velocity is a vector quantity.

If you are travelling around a roundabout (in a circle) your speed may be constant, but the velocity will be changing as you are constantly changing direction.

Quantity	Symbol	Unit
Speed	v	m/s
Distance	s	m
Time	t	s
Change in Velocity	Δv	m/s
Initial Velocity	u	m/s
Final Velocity	v	m/s
Acceleration	a	m/s^2

Acceleration

This is a measurement of the rate in which an objects velocity changes. If an object is slowing down than it is said to be decelerating. It can be calculated using the equation:

Acceleration = change in velocity / time taken.

Be careful when calculating change in velocity. For example if you are told an object from standing accelerates to 12m/s then the change in velocity is 12m/s. However if you are told that the object was moving at 5m/s and accelerates to 12m/s the change in velocity is now 7m/s.

Uniform Acceleration

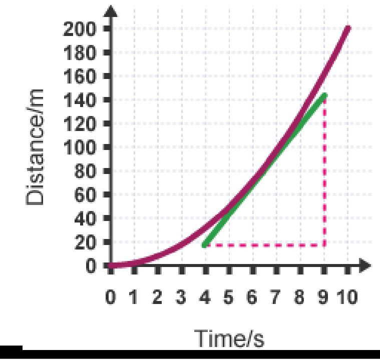
The following equation applies to uniform acceleration (you are given this one on your data sheet):

$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$

Near the Earth's surface any object falling freely under gravity has an acceleration of about $9.8 m/s^2$

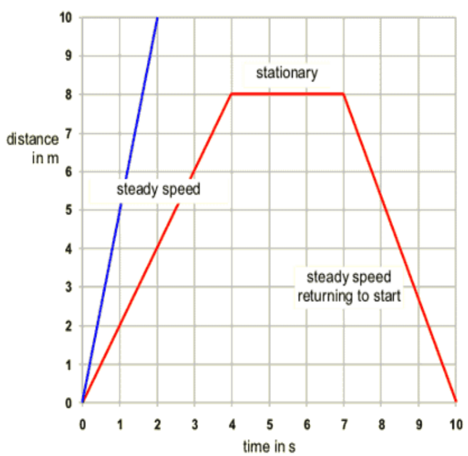
An object falling through a fluid initially accelerates due to the force of gravity. Eventually the resultant force will be zero and the object will move at its terminal velocity.

Drawing a Tangent on a Point of Acceleration



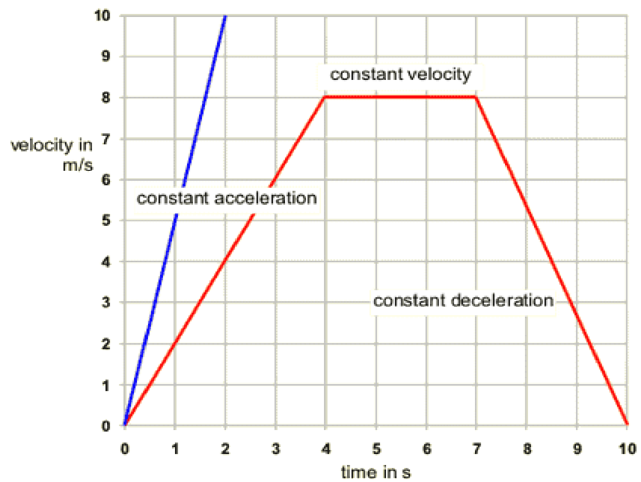
Distance Time Graphs

If an object moves along a straight line, the 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. If an object is accelerating, its speed at any particular time can be determined by drawing a tangent and measuring the gradient of the distance–time graph at that time.



Velocity Time Graphs

The acceleration of an object can be calculated from the gradient of a velocity–time graph. The distance travelled by the object can be calculated by measuring the area underneath the line of a velocity time graph.



P5 Knowledge Organiser – 4.5.5 – Pressure in fluids (Physics only)

Pressure in a Fluid

A fluid can either be a liquid or a gas and the pressure in fluids causes a force normal (at right angles) to any surface. The pressure of a fluid can be calculating using the equation:

Pressure = Force / Area

The pressure due to a column of liquid can be calculated using the equation:

Pressure = Height of Column x Density of Liquid x Gravitational Field Strength

Quantity	Symbol	Unit
Pressure	*p*	Pa
Force	*F*	N
Area	*A*	m^2
Height of Column	*h*	m
Density	*ρ*	kg/m^3
Gravitational Field Strength	*g*	N/kg

Pressure of a Liquid Column

The pressure due to a column of liquid can be calculated using the equation:

Pressure = Height of Column x Density of Liquid x Gravitational Field Strength

This equation shows that the pressure of a liquid depends on depth and also depends on the density of the liquid. The greater the height of fluid above a point the greater the pressure. This is because there is a greater mass of fluid above which means that there will be a greater weight of fluid exerting a force on that point. The greater the density of the fluid above a point the greater the pressure. This is because there is more mass per unit volume of fluid.

Atmospheric Pressure

The atmosphere is a thin layer or air around the Earth and it gets less dense with increasing altitude. Atmospheric pressure occurs because air molecules collide with a surface. As the distance from the ground increases the number of air molecules decreases. This means that at a higher height there is always less air above a surface than there is at a lower height. This explains where atmospheric pressure decreases with an increase in height.

Upthrust

A partially submerged object experiences a greater pressure on the bottom surface than on the top. This creases a resultant force acting upwards. This resultant force is called upthrust. This is also the case for objects that are fully submerged underwater.

Floating

An object floats when its weight acting downwards is equal to the upthrust acting upwards. If you have a floating object loaded with additional mass it will float lower and lower in the water. More water will be displaced and so the upthrust will increase. The upthrust and weight will still be of equal sizes acting in opposite directions.

Sinking

An object skins when its weight is greater than the upthrust. If you have a floating object and load on too much extra weight it will sink. This occurs because the object has displaced as much water as it cam and the upthrust can no longer support the total weight.

P5 Knowledge Organiser – 4.5.4 – Moments, levers and gears (Physics only)

Moments

A force of a system of forces which may cause an object to rotate. The turning effect of a force is called the moment force and it can be calculated using the equation below:

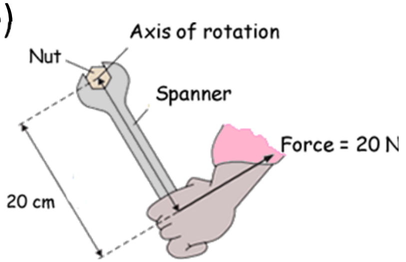
Moment of Force = Force x Distance

Distance is the distance from the pivot to the line of action of the force.

Quantity	Symbol	Unit
Moment of Force	*M*	N/m
Force	*F*	N
Distance	*d*	m

Levers

A simple lever and a simple gear system can both be used to transmit the rotational effects of forces. A spanner is an example of a lever. It can be used to produce a turning effect and unscrew a bolt. The weight of the object is called the load and the force that the person applies is called the effort. The point at which the object turns is called the pivot. To increase the moment of the force you could increase the size of the force or increase the distance between the effort and the pivot (use a spanner with a longer handle)



Gears

Gears are like levers as they can multiply the effect of a turning force. When a car is in low gear a small gear wheel turns a larger gear wheel multiplying the turning effect of the engine force producing a bigger turning effect on the car wheels.

Low Gear = Low Speed and a High Turning Effect

When a car is in a high gear a large gear wheel turns a smaller gear wheel on the output shaft. This causes the output shaft to spin faster causing a higher speeds but the turning effect is lower.

High Gear = High Speed and a Low Turning Effect.

Balanced Moments

If an object is balanced the total clockwise moment about a pivot equals the total anticlockwise moment about the pivot.

This means that:
The sum of all of the clockwise moments about any point = the sum of all the anticlockwise moments about the point.