AQA Physics GCSE Student Progress

Unit 4.5 - Forces

4.5.1. Forces and Their Interactions

4.5.1.1. Scalar and Vector Quantities

a	I know that scalar quantities have magnitude only.			
b	I know that vector quantities have magnitude and an associated direction.			
c	I know that 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 quantity.			

4.5.1.2. Contact and Non-Contact Forces

a	I know that a force is a push or pull that acts on an object due to the interaction with another object.			
b	I know that force is a vector quantity.			
c	I know that all forces between objects are either: • contact forces – the objects are physically touching; • non-contact forces – the objects are physically separated.			
d	I can give examples of contact forces (including friction, air resistance, tension and normal contact force).			
e	I can give examples of non-contact forces (including gravitational force, electrostatic force and magnetic force).			
f	I can describe the interaction between pairs of objects which produce a force on each object.			

4.5.1.3. Gravity

a	I know that the force of gravity close to the Earth is due to the gravitational field around the Earth.			
b	I know that weight is the force acting on an object due to gravity and that the weight of an object depends on the gravitational field strength at the point where the object is.			
c	I know that the weight of an object may be considered to act at a single point referred to as the object's 'centre of mass'.			
d	I know that the weight of an object and the mass of an object are directly proportional.			
e	I know that weight is measured using a calibrated spring-balance (a newton metre).			
f	I can recall and apply the following equation: weight = mass × gravitational field strength $W = m\ g$ weight, W, in newtons, N mass, m, in kilograms, kg gravitational field strength, g, in newtons per kilogram, N/kg (In any calculation this value will be given.)			

4.5.1.4. Resultant Forces

a	I know that a number of 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.			
b	I can calculate the resultant of two forces that act in a straight line.			
c	I can describe examples of the forces acting on an isolated object or system (HT Only).			
d	I can use free body diagrams to describe qualitatively examples where several forces lead to a resultant force on an object, including balanced forces when the resultant force is zero (HT Only).			
e	I know that 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 (HT Only).			
f	I can use vector diagrams to illustrate resolution of forces, equilibrium situations and determine the resultant of two forces, to include both magnitude and direction (HT Only).			

4.5.2. Work Done and Energy Transfer

a	I know that 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.			
b	I can recall and apply the following equation: work done = force × distance moved along the line of action of the force $W = F s$ work done, W, in joules, J force, F, in newtons, N distance, s, in metres, m			
c	I know that one joule of work is done when a force of one newton causes a displacement of one metre (1 joule = 1 newton-metre) and I can convert between newton-metres and joules.			
d	I can describe the energy transfer involved when work is done.			
e	I know that work done against the frictional forces acting on an object causes a rise in the temperature of the object.			

4.5.3. Forces and Elasticity

a	I can give examples of the forces involved in stretching, bending or compressing an object.			
b	I can explain why, to change the shape of an object (by stretching, bending or compressing), more than one force has to be applied (limited to stationary objects).			
c	I can describe the difference between elastic deformation and inelastic deformation caused by stretching forces.			
d	I know that the extension of an elastic object, such as a spring, is directly proportional to the force applied, provided that the limit of proportionality is not exceeded.			
e	I can recall and apply the following equation; force = spring constant × extension $F = k\ e$ force, F, in newtons, N spring constant, k, in newtons per metre, N/m extension, e, in metres, m			
f	I know that this relationship (above) also applies to the compression of an elastic object, where 'e' would be the compression of the object.			
g	I know that a force that stretches (or compresses) a spring does work and elastic potential energy is stored in the spring and that, provided the spring is not inelastically deformed, the work done on the spring and the elastic potential energy stored are equal.			
h	I can describe the difference between a linear and non-linear relationship between force and extension.			
i	I can calculate a spring constant in linear cases.			
j	I can interpret data from an investigation of the relationship between force and extension.			
k	I can apply the following equation (given on the physics equations sheet) to calculate work done in stretching (or compressing) a spring (up to the limit of proportionality) using the equation: elastic potential energy = 0.5 × spring constant × extension^2 $E_e = \frac{1}{2}\ k\ e^2$			
l	I can calculate relevant values of stored energy and energy transfers.			

4.5.4. Moments, Levers and Gears (Physics Only)

a	I know that a force or a system of forces may cause an object to rotate.			
b	I can describe examples in which forces cause rotation.			
c	I know that the turning effect of a force is called the moment of the force.			
d	I can recall and apply the following equation to calculate the size of a force, or its distance from a pivot, acting on an object that is balanced: moment of a force = force × distance $M = F d$ moment of a force, M, in newton-metres, (Nm) force, F, in newtons, (N) distance, d, is the perpendicular distance from the pivot to the line of action of the force, in metres, (m).			
e	I know that if an object is balanced, the total clockwise moment about a pivot equals the total anticlockwise moment about that pivot.			
f	I know that a simple lever and a simple gear system can both be used to transmit the rotational effects of forces.			
g	I can explain how levers and gears transmit the rotational effects of forces.			

4.5.5. Pressure and Pressure Differences in Fluids (Physics Only)

4.5.5.1. Pressure in Fluid 1 (Physics Only)

a	I know that a fluid can be either a liquid or a gas.			
b	I know that the pressure in fluids causes a force normal (at right angles) to any surface.			
c	I can recall and apply the following equation to calculate the pressure at the surface of a fluid: $\text{pressure} = \frac{\text{force normal to a surface}}{\text{area of that surface}}$ $p = \frac{F}{A}$ pressure, p, in pascals, (Pa) force, F, in newtons, (N) area, A, in metres squared, (m^2)			

4.5.5.1. Pressure in Fluid 2 (Physics Only) (HT Only)

a	I can apply the following equation (given on the physics equation sheet) to calculate the pressure due to a column of liquid can be calculated using the equation: pressure = height of the column × density of the liquid × gravitational field strength p = h g pressure, p, in pascals, (Pa) height of the column, h, in metres, (m) density, , in kilograms per metre cubed, (kg/m^3) gravitational field strength, g, in newtons per kilogram, (N/kg)			
b	I can explain why, in a liquid, pressure at a point increases with the height of the column of liquid above that point and with the density of the liquid.			
c	I know that a partially (or totally) submerged object experiences a greater pressure on the bottom surface than on the top surface. This creates a resultant force upwards and that this force is called the upthrust.			
d	I can calculate the differences in pressure at different depths in a liquid.			
e	I can describe the factors which influence floating and sinking.			

4.5.5.2. Atmospheric Pressure (Physics Only)

a	I know that the atmosphere is a thin layer (relative to the size of the Earth) of air round the Earth.			
b	I know that the atmosphere gets less dense with increasing altitude.			
c	I know that air molecules colliding with a surface create atmospheric pressure.			
d	I know that the number of air molecules (and so the weight of air) above a surface decreases as the height of the surface above ground level increases.			
e	I know that as height increases there is always less air above a surface than there is at a lower height. So atmospheric pressure decreases with an increase in height.			
f	I can describe a simple model of the Earth's atmosphere and of atmospheric pressure.			
g	I can explain why atmospheric pressure varies with height above a surface.			

4.5.5. Pressure and Pressure Differences in Fluids (Physics Only)

4.5.5.1. Pressure in Fluid 1 (Physics Only)

4.5.6.1.1. Distance and Displacement

a	I know that distance is how far an object moves, does not involve direction and that distance is a scalar quantity.			
b	I know that 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 and that displacement is a vector quantity.			
c	I can express a displacement in terms of both the magnitude and direction.			

4.5.6.1.2. Speed

a	I know that speed does not involve direction and that it is a scalar quantity.			
b	I know that the speed of a moving object is rarely constant. When people walk, run or travel in a car their speed is constantly changing.			
c	I know that the speed at which a person can walk, run or cycle depends on many factors including: age, terrain, fitness and distance travelled and I can recall typical values of speed for a person walking, running and cycling as well as the typical values of speed for different types of transportation systems. Typical values may be taken as: walking 1.5 m/s running 3 m/s cycling 6 m/s.			
d	I know that it is not only moving objects that have varying speed; The speed of sound and the speed of the wind also vary.			
e	I can make measurements of distance and time and then recall and apply the following equation to calculate speeds of objects; distance travelled = speed × time $s = v\ t$ distance, s, in metres, m speed, v, in metres per second, m/s time, t, in seconds, s			
f	I can calculate average speed for non-uniform motion.			

4.5.6.1.3. Velocity

a	I know that the velocity of an object is its speed in a given direction and that velocity is a vector quantity.			
b	I can explain the vector–scalar distinction as it applies to displacement, distance, velocity and speed.			
c	I can explain qualitatively, with examples, that motion in a circle involves constant speed but changing velocity (HT Only).			

4.5.6.1.4. The Distance - Time Relationship

a	I know that if an object moves along a straight line, the distance travelled can be represented by a distance–time graph.			
b	I know that the speed of an object can be calculated from the gradient of its distance–time graph.			
c	I know that 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 (HT Only).			
d	I can draw distance–time graphs from measurements and extract and interpret lines and slopes of distance–time graphs, translating information between graphical and numerical form.			
e	I can determine speed from a distance–time graph.			

4.5.6.1.5. Acceleration

a	I can recall and apply the following equation to calculate the average acceleration of an object: acceleration = change in velocity / time taken a = Δv / 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			
b	I know that an object that slows down is decelerating.			
c	I can estimate the magnitude of everyday accelerations.			
d	I know that the acceleration of an object can be calculated from the gradient of a velocity–time graph.			
e	I know that the distance travelled by an object (or displacement of an object) can be calculated from the area under a velocity–time graph (HT Only).			
f	I can draw velocity–time graphs from measurements and interpret lines and slopes to determine acceleration.			
g	I can interpret enclosed areas in velocity–time graphs to determine distance travelled (or displacement) (HT Only).			
h	I can measure, when appropriate, the area under a velocity– time graph by counting squares (HT Only).			
i	I can apply the following equation (given on the physics equation sheet): $(\text{final velocity})^2 – (\text{initial velocity})^2 = 2 × \text{acceleration} × \text{distance}$ $v^2 - u^2 = 2\ a\ s$ final velocity, v, in metres per second, m/s initial velocity, u, in metres per second, m/s acceleration, a, in metres per second squared, m/s^2 distance, s, in metres, m			
j	I know that near the Earth's surface any object falling freely under gravity has an acceleration of about 9.8 m/s^2.			
k	I know that an object falling through a fluid initially accelerates due to the force of gravity but eventually the resultant force will be zero and the object will move at its terminal velocity.			

4.5.6.2. Forces, Accelerations and Newton's Laws of Motion

4.5.6.2.1. Newton's First Law

a	I can state Newton's First Law: 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 (so the object continues to move at the same velocity).			
b	I know that when a vehicle travels at a steady speed the resistive forces balance the driving force.			
c	I know that the velocity (speed and/or direction) of an object will only change if a resultant force is acting on the object.			
d	I can apply Newton's First Law to explain the motion of objects moving with a uniform velocity and objects where the speed and/or direction changes.			
e	I know that the tendency of objects to continue in their state of rest or of uniform motion is called inertia (HT Only).			

4.5.6.2.2. Newton's Second Law

a	I can state Newton's Second Law: The acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object.			
b	I can recall and apply the following equation: 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)			
c	I can recognise and use the symbol for proportionality, ∝			
d	I can explain that: • inertial mass is a measure of how difficult it is to change the velocity of an object • inertial mass is defined as the ratio of force over acceleration. (HT Only)			
e	I can estimate the speed, accelerations and forces involved in large accelerations for everyday road transport.			
f	I can recognise and use the symbol that indicates an approximate value or approximate answer, ~			

4.5.6.2.3. Newton's Third Law

a	I can state Newton's Third Law: Whenever two objects interact, the forces they exert on each other are equal and opposite.			
b	I can apply Newton's Third Law to given examples of equilibrium situations. Whenever two objects interact, the forces they exert on each other are equal and opposite.			

4.5.6.3. Forces and Braking

4.5.6.3.1. Stopping Distance

a	I know that 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).			
b	I know that for a given braking force, the greater the speed of the vehicle, the greater the stopping distance.			

4.5.6.3.2. Reaction Time

a	I know that reaction times vary from person to person and that typical values range from 0.2 s to 0.9 s.			
b	I know that a driver's reaction time can be affected by tiredness, drugs (e.g. alcohol) and distractions.			
c	I can explain methods used to measure human reaction times and recall typical results.			
d	I can interpret and evaluate measurements from simple methods to measure the different reaction times of students.			
e	I can evaluate the effect of various factors on thinking distance based on given data.			

4.5.6.3.3. Factors Affecting Braking Distance 1

a	I know that the braking distance of a vehicle can be affected by adverse road and weather conditions (e.g. wet or icy) and poor condition of the vehicle's brakes or tyres.			
b	I can explain the factors which affect the distance required for road transport vehicles to come to rest in emergencies, and discuss the implications for safety.			
c	I can estimate how the distance required for road vehicles to stop in an emergency varies over a range of typical speeds.			

4.5.6.3.4. Factors Affecting Braking Distance 2

a	I know that when a force is applied to the brakes of a vehicle, 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.			
b	I know that the greater the speed of a vehicle, the greater the braking force needed to stop the vehicle in a fixed distance.			
c	I know that the greater the braking force, the greater the deceleration of the vehicle.			
d	I can explain how large decelerations may lead to brakes overheating and / or loss of control of the vehicle.			
e	I can estimate the forces involved in the deceleration of road vehicles in typical situations on a public road (HT Only).			

4.5.7. Momentum (HT Only)

4.5.7.1. Momentum is a Property of Moving Objects

a	I can recall and apply the following 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)			

4.5.7.2. Conservation of Momentum

a	I know that in a closed system, the total momentum before an event is equal to the total momentum after the event and that this is called conservation of momentum.			
b	I can use the concept of momentum as a model to describe and explain examples of momentum in an event, such as a collision.			

4.5.7.3. Conservation of Momentum (Physics Only) (HT Only)

a	I know that when a force acts on an object that is moving, or able to move, a change in momentum occurs.			
b	I can apply the following equations (given on the physics equation sheet): $F = m \times a$ and $a = \frac{v - u}{t}$ combine to give the equation $F = \frac{m\,\Delta v}{\Delta t}$ where $m\Delta v$ = change in momentum (i.e. force equals the rate of change of momentum).			
c	I can explain safety features such as: air bags, seat belts, gymnasium crash mats, cycle helmets and cushioned surfaces for playgrounds with reference to the concept of rate of change of momentum.			
d	I can apply equations relating force, mass, velocity and acceleration to explain how the changes involved are inter-related.			