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Forces in action – Forces and motion

Section 1: Key terms

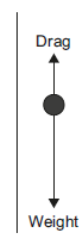
Displacement	The **distance** an object moves in a given **direction**. A **vector** quantity.
Velocity	The **speed** of an object in a **given direction**. A **vector**.
Acceleration	The **change** of an object's **velocity per second**.
Resultant force	The **overall force** once all the forces have been considered.
Terminal velocity	The **velocity** an object **eventually reaches** when it is falling. The **weight of the object** is then **equal** to the **frictional force** on the object.
Stopping distance	The **shortest distance** a vehicle can **safely stop** in. It depends on **thinking distance** and **braking distance**.
Momentum	A **moving object** with **mass** has momentum. Momentum is "**mass in motion**" It is a vector quantity.
Conservation of momentum (HT)	In a closed system, **total momentum before** an event **is the same** as the **total momentum after** the event.
Closed system (HT & Triple)	A **system** with **no external forces** acting on it.

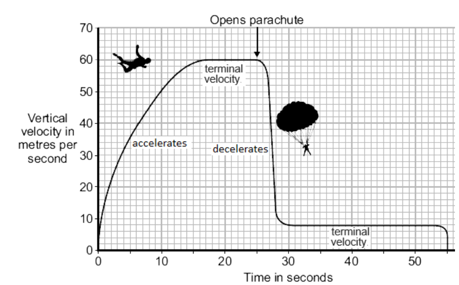
Section 2: Forces and acceleration

Newton's second law of motion	The acceleration of an object is: • Directly proportional to the force • Indirectly proportional to mass	We can **investigate** the **relationship** between force and acceleration by using a trolley with constant mass, newton-meter, motion sensor and a computer.
Effect of force	The **greater the resultant force** on an object, the **greater** the objects **acceleration**. If an object is not accelerating then the resultant force on the object must be zero.	
Effect of mass	The **greater the mass** of an object, the **smaller** its **acceleration** for a given force.	
Calculation of resultant force	Resultant force = mass x acceleration f = m x a	Force – newtons (N) Mass – kilograms (kg) Acceleration = metres per second squared (m/s^2)
Inertia (HT)	the inertia of an object is its tendency to stay at rest or in uniform motion (moving at constant speed in a straight line.)	

Section 3: Weight and terminal velocity

Weight	The weight of an object is the force acting on the object **due to gravity**. Measured in newtons, N.
Mass	The **quantity** of matter in it. Measured in Kg.
Gravitational field strength.	The gravitational force on a 1kg object is called the gravitational field strength. An object acted on only by gravity accelerates at about $10m/s^2$ on the Earth.
Calculating weight	weight = mass x gravitational field strength. w = m x g Weight – newtons (N) Mass – kilograms (kg) GFS – newtons per kilogram (N/kg)
Terminal velocity Ball bearing falling though a fluid. The ball bearing reaches its terminal velocity when the **drag is equal to the weight.**	When a parachutist jumps out of a plane, the only force acting is weight (gravity.) As the parachutist falls air resistance acts upwards. The resultant force is downwards as weight is greater than air resistance, hence the parachutist accelerates. As velocity increases, so does air resistance. **Terminal velocity** is reached **when** the **forces are balanced** (when air resistance = weight.) When the parachute opens, the surface area increases hence there's much more air resistance. The weight (downwards force) is still the same, hence the **terminal velocity decreases** allowing the parachutist to hit the ground at a safe speed.





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Section 4: Forces and braking

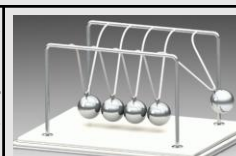
Thinking distance	The **distance** a **car travels** while the **driver reacts**.
Factors affecting thinking distance	1. Tiredness 2. Drugs 3. Alcohol 4. Distractions (e.g. mobile phones)
Braking distance	The **distance a car travels** while the car is **stopped** by the **brakes**.
Factors affecting braking distance	1. How fast you are going 2. Road conditions (weather e.g. Water or ice) 3. Conditions of tyres and brakes. 4. Type of road surface 5. Mass of vehicle
Stopping distance	The **sum** of the **thinking distance** and **braking distance**.

Section 5: Momentum (HT)

All moving objects have momentum. The greater the mass **and** velocity of an object, the greater its momentum. Momentum has size **and** direction so is a vector quantity.

Calculating Momentum	Momentum = mass x velocity p = m x v	Momentum – Kg m/s Mass - Kg Velocity – m/s

In a **closed** system, **total momentum before** an event **is the same** as the **total momentum after** the event. Momentum is conserved in a collision or an explosion as no external forces act on the objects. After a collision, the colliding objects may move off together or may move apart.



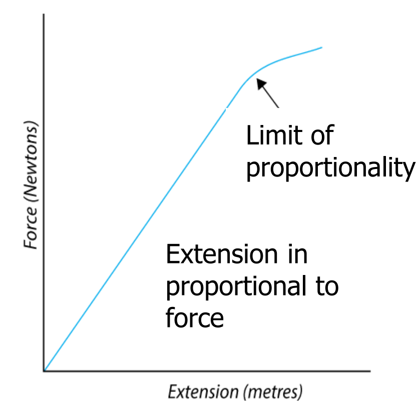
Section 6: Forces and elasticity

Elastic deformation	Occurs when a **spring is stretched** and **can** then **return** to its **original length**.
Inelastic deformation	Occurs when a **spring is stretched** and its **length** is **permanently altered**.
Limit of proportionality	The **length** a spring can be **stretched before it no longer is able to return to its original length.** Beyond the limit of proportionality, a force-extension graph is curved.
Extension	Difference between the length of an object and its original length.

Force extension graph

If you hang small weights from a spring it will stretch. If you plot a graph of the spring's extension against force applied, you get a straight line that passes through the origin. The **extension** is **directly proportional** to the **force applied.**

However if you **apply too much force**, the line begins to **curve** because you have exceeded the **line of proportionality**.



Objects and materials that behave like this are said to obey **Hooke's law**. Hooke's law states that extension is directly proportional to the force applied, provided the limit of proportionality is not exceeded.

Hooke's law	Force applied = spring constant x extension F = k x e	Force – newtons, N Spring constant N/m Extension – metres m

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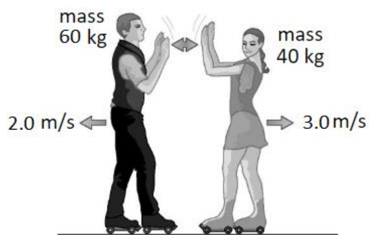
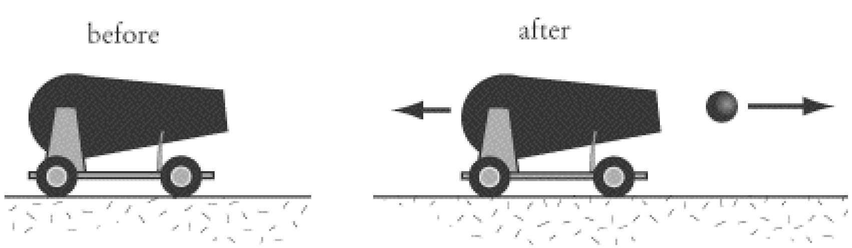
Forces in action – Forces & motion (triple)

Section 7: Using conservation of momentum (triple only)

When two objects push each other apart, they move with **different speeds** if they have **unequal masses** and with equal and opposite momentum, so their **total momentum is zero**. This means that the **momentum lost** by one of the objects will be **gained** by the other object. Hence whenever two objects collide or interact, **momentum is conserved**.

Calculating Momentum	Momentum = mass x velocity p = m x v	Momentum – Kg m/s Mass - Kg Velocity – m/s

Two roller skaters, a girl and a boy stand facing each other on flat level ground. When one of the roller skaters pushes the other one away, they **move away** in **opposite directions** at **different velocities** because they have **different masses**.	 Momentum of boy = 60 x 2 = 120 Kg m/s Momentum of girl = **-**40 x 3 = **-**120 Kg m/s **Total momentum** = 120 – 120 **= 0 Kg m/s** The **minus sign** tells you that the momentum of the girl is in **the opposite direction** to the momentum of the boy.
Explosions	Total momentum after an explosion is the same as before the explosion. The total momentum **after** the explosion is **zero**. **Momentum before = Momentum after**



Section 8: Impact forces (HT triple only)

Collisions	When two vehicles collide, the **force of the impact depends** on the **mass, change of velocity** and **length** of the impact time. • They exert **equal and opposite forces** on each other • Their **total momentum** is **unchanged**.
Length of impact time	**Longer** the **impact time**, the **more the impact force** is **reduced**.
Impact force	Impact force = change in momentum / time taken $$F = \frac{m\Delta v}{\Delta t}$$

Force	F	Newtons, N
mΔυ	Change in momentum	Kg m/s
Δt	Time taken	s

Section 9: Safety first (HT triple only)

When you are driving in a car or riding a bike you want to feel safe if you crash. Different safety features have been designed to **increase the impact time** and hence **decrease the rate of change in momentum.**

Cycle helmets & cushioned surfaces in playgrounds/gyms	Reduce impact forces by increasing impact time.
Seat belts & air bags	Spread force across chest and increase impact time. Hence reduces impact force on head.
Crumple zones & collapsible steering wheels.	Give way in an impact and hence increase the impact time.
Car safety features