KNOWLEDGE — Physics Paper 2 Topic 5: Forces — ORGANISER

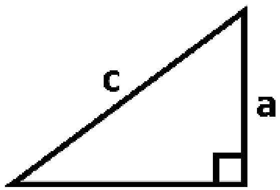
Section 1: Key Terms and Definitions

1.	Scalar	A value with **magnitude (size) only**, e.g. **mass, speed, distance, time**
2.	Vector	A value with **magnitude (size) and direction**, e.g. **all forces, acceleration, displacement, velocity.**
3.	Contact Force	Forces between objects that are **touching** e.g. **friction, air resistance, tension, reaction forces.**
4.	Non-Contact Force	Forces between **separate objects** e.g. **gravitational, magnetic, electrostatic, nuclear**
5.	Weight	The **force of gravity** acting on **an object's mass**. **Measured in Newtons**, using a **newtonmeter**
6.	Mass	The **amount of matter** an object has. **Measured in kilograms (kg)**
7.	Centre of Mass	The **single point** at which the **object's weight appears to act**.
8.	Resultant Force	A resultant force is a **single force** that has the **same effect as all the forces** acting on an object.
9.	Work Done	Work is done when an object is moved through a distance. When work is done **against friction**, there is a **temperature rise**.
10.	Joule	Force of 1 Newton displaces an object of 1 metre (1 joule = 1 Newton-metre)

Section 1 continued: Key Terms and Definitions

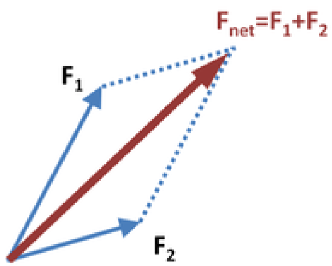
11.	Hooke's Law	**Extension** of an elastic object is **directly proportional to the force** applied
12.	Distance	A **scalar** quantity that measures how much ground an object covers when moved.
13.	Displacement	A vector quantity that measures how far out of place an object is from A to B.
14.	Speed	A scalar quantity – how fast an object is moving, defined as the distance travelled per unit of time.
15.	Velocity	A **vector** quantity – **speed in a given direction**
16.	Acceleration	A **vector** quantity – the **rate of change of velocity**
17.	Terminal Velocity	The maximum speed objects reach when falling. Occurs when weight = resistive forces or when there is no resultant force.
18.	Stopping Distance	The amount of distance it takes to stop. Thinking distance + braking distance (in metres)
19.	Momentum	Moving object with mass have momentum. Momentum is "**mass in motion**" It is a vector quantity
20.	Conservation of Momentum	In a closed system, the **total momentum before an event is equal to the total momentum after the event**.

Section 2: Forces and Vectors (HT)



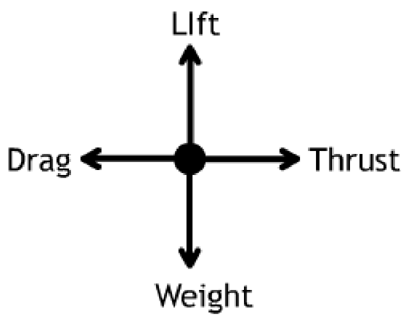
$$c^2 = a^2 + b^2$$

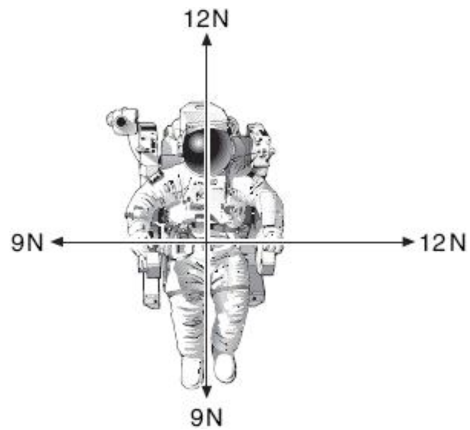
Measure the overall vector with a ruler on a scale diagram or by using Pythagoras



Section 3: Free Body Diagrams

Free-body diagrams show the magnitude and the direction of the forces acting on an object. The force arrows always start from the centre of the point.





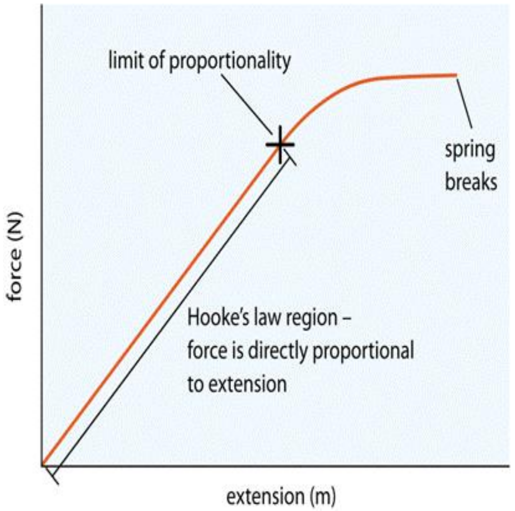
Section 4: Gravitational Field Strength

Weight is the result of gravity. The gravitational field strength of Earth is 10 N/kg (ten newtons per kilogram). This means an object with a mass of 1 kg would be attracted towards the centre of Earth by a force of 10 N. We feel forces like this as weight.

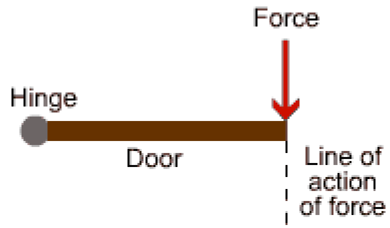
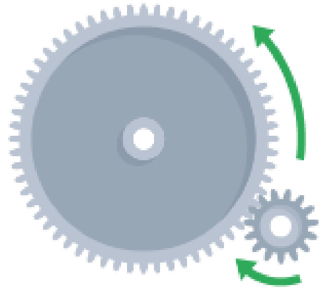
You would weigh less on the Moon because the gravitational field strength of the Moon is one-sixth of that of Earth (1.6 N/kg). But note that your mass would stay the same.

KNOWLEDGE — Physics Paper 2 Topic 5: Forces — ORGANISER

Section 5: Elasticity and Hooke's Law

1.	Elastic Deformation	Occurs when a **spring is stretched** and can then **return to its original length**
2.	Inelastic Deformation	Occurs when a **spring is stretched**, and its **length is permanently altered**
3.	Limit of Proportionality	The **length** a spring can be **stretched before it no longer can return to its original length.** Beyond the limit of proportionality, a force-extension graph is curved. 

Section 6: Moments and Gear Systems (Physics)

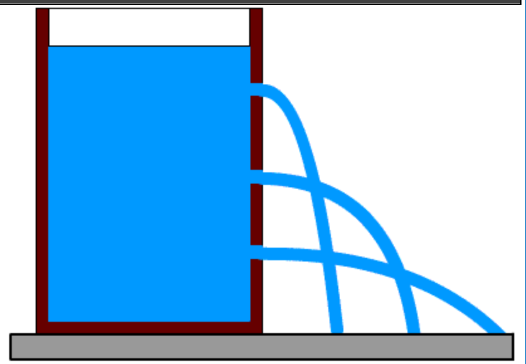
1.	Moments	A moment is defined as a force multiplied by the perpendicular distance from the line of action of the force to the pivot. 
2.	Principle of Moments	The sum of the clockwise moments about a point = sum of the anticlockwise moments about that point.
3.	Gears	Gears are wheels with toothed edges that rotate on an axle or shaft. When one gear turns, it causes the other gear to rotate in the opposite direction. 
4.	Low to High gear	If a larger gear is driven by a smaller gear, the large gear will rotate slowly but with a greater moment. e.g. a low gear on a bike or car.
5.	High to Low gear	If a smaller gear is driven by a larger gear, the smaller gear will rotate quickly but with a smaller moment. e.g. a high gear on a bike or car.

Section 6: Pressure in a Fluid (Physics)

Fluids are either liquids or gases. The pressure in a fluid acts in all directions and causes a force at right angles to (normal to) any surface.

Going deeper in a liquid increases the pressure. This is because the deeper you go, the greater weight of liquid there is above you.

Pressure at depths in a fluid depends on the height of the fluid above the point in the fluid being measured, the density of the fluid and the gravitational field strength – see equation knowledge organiser.



Section 7: Floating and Sinking (Physics)

When an object floats it experience a **greater pressure on** its **base**, **compared to** the **top surface**. This creates a **resultant force** upwards called **upthrust.**

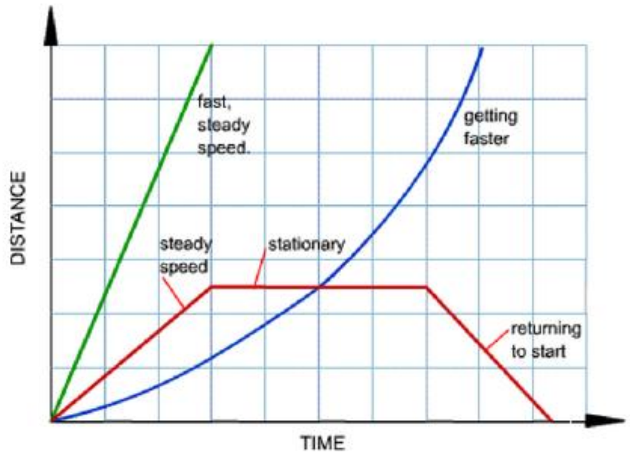
The **density** of an object placed in water determines whether it floats or sinks.

If the object **sinks** – its **density is greater** than the water and its **weight** is **greater than** the **upthrust**.

If the object **floats** – its **density is equal to or less than** the water and its **weight** is **equal** to the **upthrust**.

KNOWLEDGE | Physics Paper 2 Topic 5: Forces | ORGANISER

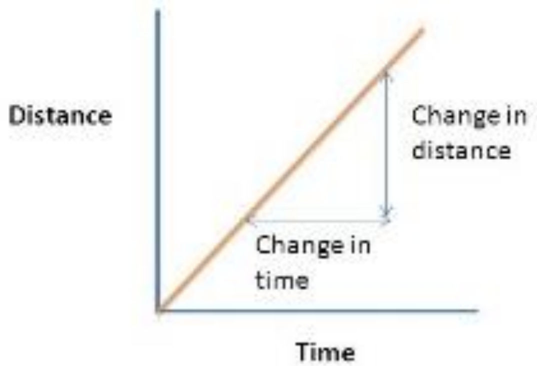
Section 8: Distance-Time Graphs



Section 9: Using the tangent to determine the gradient (HT)

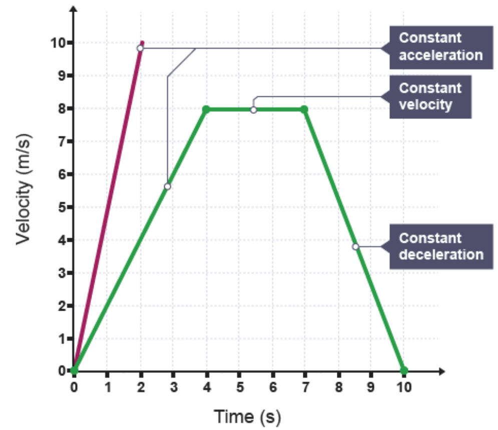
To find the speed at a particular point, draw a tangent to the line and calculate the gradient

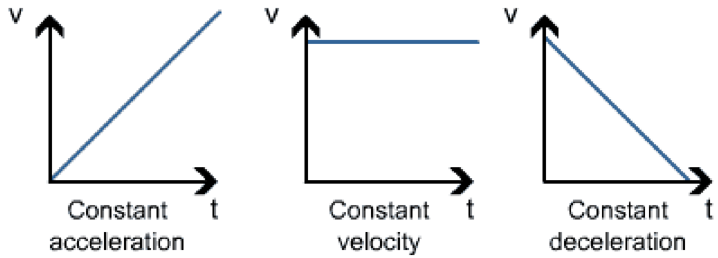
$$\text{Gradient of a graph} = \frac{\text{change in y values}}{\text{change in x values}}$$

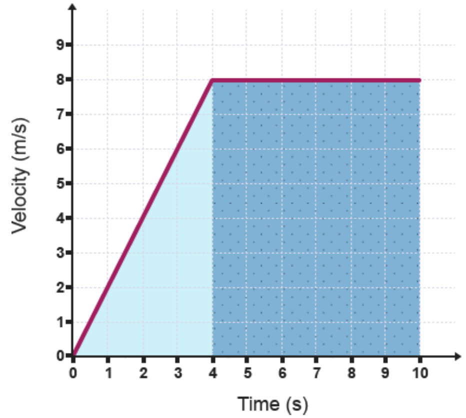


Section 10: Velocity-Time Graphs

1.	Acceleration	The gradient of a velocity-time graph represents the acceleration of the object. Steeper the gradient = greater acceleration
2.	Velocity	If the object is going backwards, the velocity will be negative (negative values on the y-axis)
3.	Distance	The area under the graph gives the distance travelled. Calculate by splitting into simpler shapes, like the second graph.





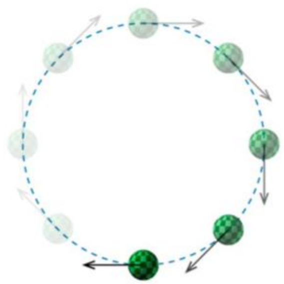


Section 11: Circular Motion (HT)

For an object to move in a circle, the direction the object is moving in must always be changing. This means that the object's velocity is always changing, so the object is always accelerating even though its speed remains the same

The force acting on the object and therefore its acceleration is always acting towards the centre of the circle.

The velocity is always perpendicular to the acceleration.



KNOWLEDGE

Physics Paper 2 Topic 5: Forces

ORGANISER

Section 12: Newton's Law

1.	First Law	An object at rest will remain at rest or moving with a constant velocity unless acted on by a net resultant force. (Law of Inertia, resistance to change of velocity is inertia)
2.	Second Law	The acceleration on an object is proportional to the resultant force acting on it and inversely proportional the object's mass. (Force = Mass × Acceleration)
3.	Third Law	For every force acting on an object, there is an equal and opposite reaction.

Section 14: Impact Forces and Car Safety (Physics)

1	Collisions and Forces	When your body is in a collision, a force brings it to a sudden stop. The larger the stopping force on the body, the more it is damaged. To prevent injury we must reduce the force. This means: • reducing the acceleration (force = mass × acceleration) which means reducing the velocity of the body more slowly. This the same as: • reducing the momentum of the body more slowly. If the collision takes place over a longer time, say 0.5 s instead of 0.05 s – ten times as long – then the stopping force will only be one tenth of the size.
2	Crumple Zones	The car occupants are in a strong safety cage. The front and back of the car are designed to crumple in a collision, increasing the time over which the occupants are brought to a stop.
3.	Airbags	The body hits the airbag, which is compressed, increasing the time it takes to stop.
4.	Seatbelts	These are designed to stretch slightly so that the body moves forward and comes to a stop more slowly than it would if it hit the windscreen or front seats. After a collision, the seatbelts should be replaced because having stretched once, they may not work properly again.
5.	Cycle and motorcycle helmets	These contain a layer of material which will compress on impact so that the skull is brought to a stop more slowly. They should be replaced after a collision as the material will be damaged and may not protect again in another collision.

Section 13: Forces and Braking

1.	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**)
2.	Thinking Distance	The **distance a vehicle travels** while a driver is **reacting**
3.	Reaction Time	The **time it takes for a driver to react**, typically **0.2-0.9s**. Affected by **tiredness, drugs, alcohol** and **distractions**.
4.	Braking Distance	The **distance a vehicle travels under braking**. Affected by **weather conditions** (e.g. rain or ice) and the conditions of the **brakes** and **tyres** of a vehicle.
5.	Braking Force	When the brakes are pressed, **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 **greater the speed** of a vehicle, the **greater the force** needed to stop the vehicle. **Large decelerations** may lead to **loss of control** or **overheating** of the brakes.

Typical Stopping Distances

Velocity - time graph for stopping a car