FORM 4 SPM PHYSICS SHORTHAND NOTES
Chapter 2 Force and Motion 1
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2.1 Linear Motion

Distance: The distance traveled by an object is the total length that is traveled by that object.

SI unit: meters (m)

Speed: Rate of change in distance.

SI unit: meter per second (m/s)
Quantity: scalar

$$v = \frac{d}{t}$$

v is the speed; *d* is the distance traveled, and *t* is the time taken

Velocity: Is speed with a given direction!

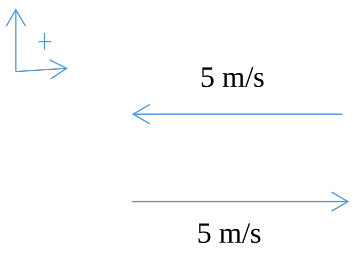
SI unit: meter per second (m/s)
Quantity: vector

$$v = \frac{s}{t}$$

v is the speed, *s* is the displacement and *t* is the time taken

Note: In velocity the positive/ negative sign indicates direction.

e.g.



Speed of top arrow: 5 m/s
Velocity of top arrow: -5 m/s
Speed of bottom arrow: 5 m/s
Velocity of bottom arrow: 5 m/s

Acceleration: Rate of change of velocity.

SI unit: meter per second squared (m/s^2)
Quantity: vector

$$a = \frac{v - u}{t}$$

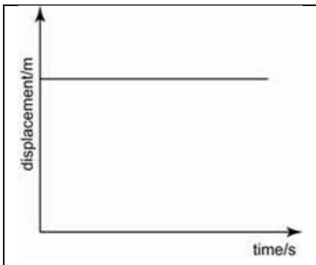
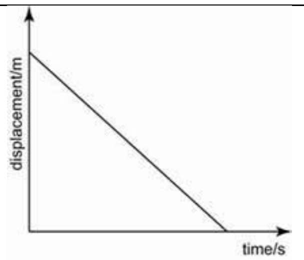
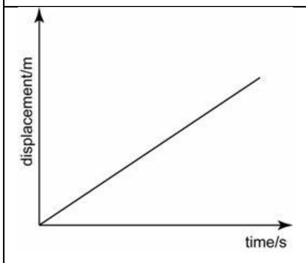
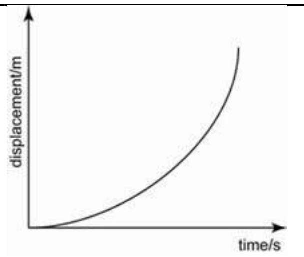
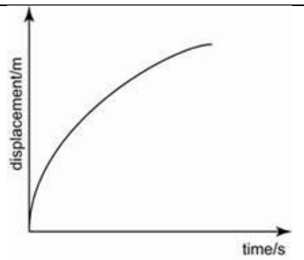
v is the speed, s is the displacement, and t is the time taken

Direction	+	+	-	-
Change of speed	+	-	+	-
Acceleration	+	-	-	+

Note: Negative acceleration IS NOT deceleration!!!!!

2.2 Linear Motion Graphs

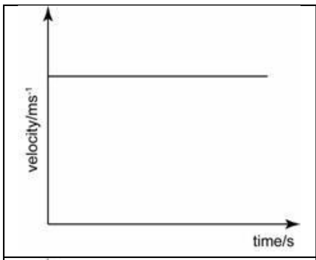
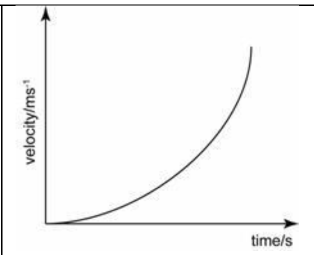
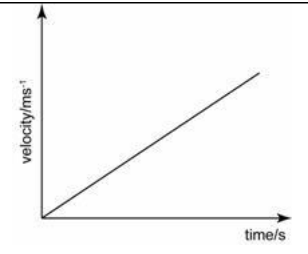
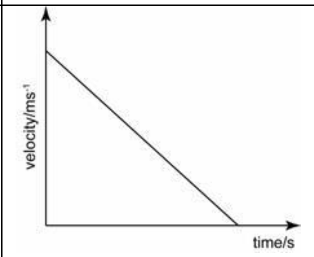
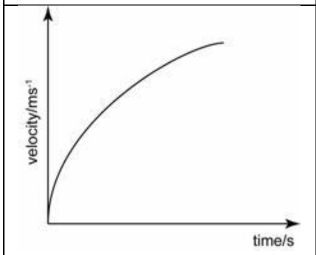
Displacement-Time graph

	0 VEL.		- VEL.
	+VEL.		INC. VEL.
			DEC. VEL.

Flex your brain!

A car starts from rest and accelerates at a constant acceleration of $3m/s^2$ for 10 seconds. The car then travels at a constant velocity for 5 seconds. The brakes are then applied, and the car stops in 5 seconds. What is the total distance traveled by the car?

Velocity-Time graph

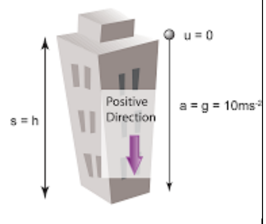
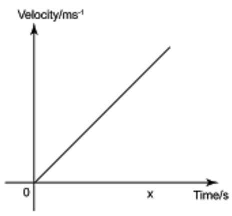
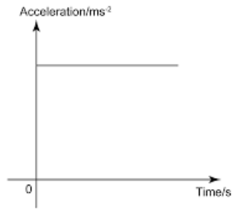
	0 ACC.		INC. ACC.
	+ACC.		-ACC.
	DEC. ACC.		

For a V-T graph, the area underneath the graph is the distance traveled.

2.3 Freefall Motion

Free fall refers to the motion of an object solely under the influence of gravity. During free fall, an object is subject to no other force except the force of gravity.

Acceleration (g): The acceleration of an object in free fall near the surface of the Earth is denoted by 'g' and has a standard value of approximately **9.8 m/s².** Without air resistance, an object in free fall will accelerate at a rate of 9.8 meters per second squared.

Motion	Velocity-Time Graph	Acceleration-Time Graph
		

A ball is dropped from a height of 40 meters. Calculate the following:

1) The time it takes for the ball to reach the ground.
2) The ball's final velocity just before it hits the ground.
3) The distance the ball travels during the last second before hitting the ground.

Given: Acceleration due to gravity (g) is 9.8 m/s^2

Direction: The acceleration due to gravity always acts **downward** towards the center of the Earth.

One can determine the acceleration due to gravity by calculating the gradient of a v-t graph. The gradient value is typically 9.8 m/s².

The kinematic equations that describe the motion of an object in free fall are:

$$s = ut + \frac{1}{2}gt^2$$
$$v = u + gt$$
$$v^2 = u^2 + 2gs$$

s is the displacement
u is the initial velocity
v is the final velocity
t is the time
g is the acceleration due to gravity

2.4 Inertia

Inertia is the property of matter that resists any change in its motion. An object at rest tends to stay at rest, and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an external force.

Newton's first law states **that an object will remain at rest or in uniform motion in a straight line unless acted upon by a net external force**. This law is also known as the law of inertia.

Inertia is **directly proportional to mass**. The greater the mass of an object, the greater its inertia.

Everyday examples of inertia: A book sliding off a car seat when it suddenly stops, a passenger feeling pushed back into their seat when a car accelerates, etc.

Celestial Bodies: The motion of planets and other celestial bodies follows the principles of inertia.

Vehicle Safety: Inertia plays a crucial role in vehicle safety, as seen in the design of seatbelts and airbags to protect occupants during sudden deceleration.

2.5 Momentum

Momentum is defined by the equation:

Momentum = mass x velocity

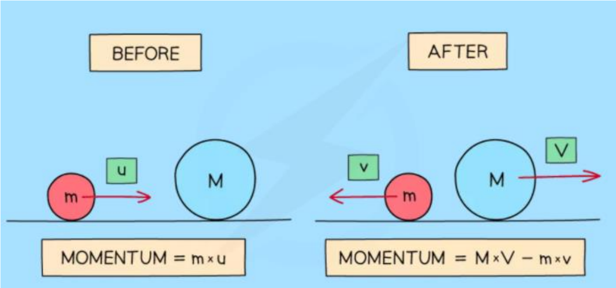
$$p = m \times v$$

The SI units of momentum are **kg/ ms^{-1}**

Momentum is a vector quantity

The conservation of momentum states that in the **absence of external forces (such as friction), the total momentum of a system remains the same**.

i.e., *mom before = mom after*



2.6 Force

Force is a vector quantity that can change an object's state of motion or shape. It is characterized by its magnitude, direction, and point of application. Forces can cause objects to accelerate, decelerate, or deform.

Newton's Second Law:

The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.

$$F=ma$$

where
F is the net force,
m is the mass, and
a is the acceleration

Unit of Force: The SI unit of force is the newton (N).

Forces have both **magnitude and direction**, making them **vector** quantities. A force can be fully described by specifying its magnitude, direction, and point of application.

Balanced Forces: Result in no change in motion.
Unbalanced Forces: Result in acceleration or deceleration.

Both of Objects are in the Same Direction before Collision
A Car A of mass 600 kg moving at 40 ms^{-1} collides with a car B of mass 800 kg moving at 20 ms^{-1} in the same direction. If car B moves forwards at 30 ms^{-1} by the impact, what is the velocity, v, of the car A immediately after the crash?

Both Objects are in opposite direction before collision
A 0.50kg ball traveling at 6.0 ms^{-1} collides head-on with a 1.0 kg ball moving in the opposite direction at a speed of 12.0 ms^{-1}. The 0.50kg ball moves backward at 14.0 ms^{-1} after the collision. Find the velocity of the second ball after collision.

Explosion
A man fires a rifle which has a mass if 2.5kg. If the mass of the bullet is 10g and it reaches a velocity of 250 ms^{-1} after shooting, what is the recoil velocity of the pistol?

A 500 kg car is accelerating at 2 m/s². Calculate the net force acting on the car.

2.7 Impulse and Impulsive Force

Impulse is the **change in momentum**

$$Impulse = mv - mu$$

OR

$$F \times t = mv - mu$$

Where
F is the impulsive force
t is the time in contact
m is the mass of the object
v is the final velocity of the object
u is the initial velocity of the object

The SI units for Impulse are the same as momentum, **kgms^{-1}**.

A 2000 kg car traveling at 20 m/s comes to a stop in 5 seconds. Calculate the average force exerted to stop the car.

2.8 Weight

Weight is the **force exerted on an object due to gravity**. It is a vector quantity with both magnitude and direction, acting vertically downward towards the center of the Earth.

$$Weight(W) = Mass(m) \times Acceleration\ due\ to\ Gravity(g)$$

$$W = m \times g$$

Where:
W is weight,
m is mass,
g is the acceleration due to gravity (approximately 9.8 m/s^2 on the surface of the Earth).

Since weight is a force, the SI unit of weights is also **Newtons**.

If an astronaut has a mass of 80 kg on Earth, what is their weight on the Moon? (Use gMoon≈1.625m/s^2)