Distance and Displacement

25th Nov

A scalar quantity just has a magnitude (size/number that goes with it).

A vector has a magnitude AND a direction.

DISTANCE is a SCALAR. It tells us how far an object travelled.

DISPLACEMENT is a VECTOR. It tells us how far an object travelled in a straight line from where it started. We also give the DIRECTION of the line.

Speed and Velocity

3rd Dec

Speed is a measure of how much distance an object covers in a certain amount of time.

Speed is a SCALAR (it doesn't need a direction).

$$\text{average speed} = \frac{\text{total distance travelled}}{\text{time taken}}$$

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

- v — in metres per second, m/s
- s — in metres, m
- t — in seconds, s

$$s = vt$$ (easier to rearrange)

We can be asked to ESTIMATE reasonable values of speed, distance and time.

Walking ≈ 1.5 m/s	Car ≈ 20 m/s
Jogging ≈ 3.0 m/s	Plane ≈ 150 m/s
Cycling ≈ 10 m/s	Sound (in air) ≈ 330 m/s

Light ≈ 300,000,000 m/s

VELOCITY is the SPEED in a certain DIRECTION. It is a VECTOR quantity (it has a size and a direction).

Acceleration

3rd Dec

Acceleration is the RATE OF CHANGE OF VELOCITY.

It tells us how much the velocity of an object changes each second.

If an object speeds up, slows down or change direction then its velocity changes. This means it is accelerating.

① acceleration = $\frac{\text{change in velocity}}{\text{time}}$

② change in velocity = final velocity – initial velocity

$$a = \frac{\Delta v}{t}$$ ①

- a in metres per square second, m/s^2
- Δv in metres per second, m/s
- t in seconds

② $\Delta v = v - u$

Sometimes we wish to know how far an object travels whilst it accelerates, or the change in velocity if an object accelerates over a certain distance.

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

$$v^2 - u^2 = 2as$$

Worked example: An object is dropped from rest from the top of the eiffel tower. It falls 324 m. Calculate the maximum speed it can have when it hits the floor.

acceleration due to gravity = 9.8 m/s^2

$$v^2 - 0^2 = 2 \times 9.8 \times 324$$

$$v^2 = 6350.4$$

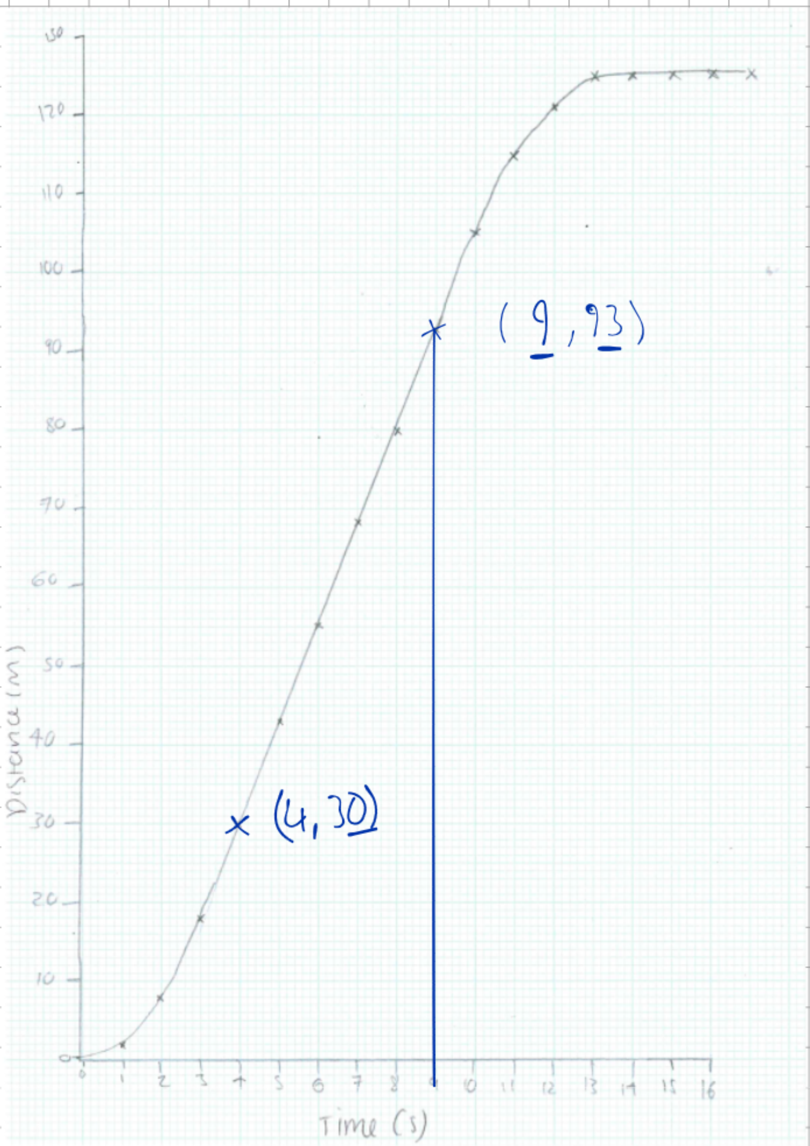
$$v = \sqrt{6350.4}$$

$$= 79.7 \text{ m/s}$$

'from rest' means its initial velocity was 0

Distance and Displacement-time graphs

6th Dec



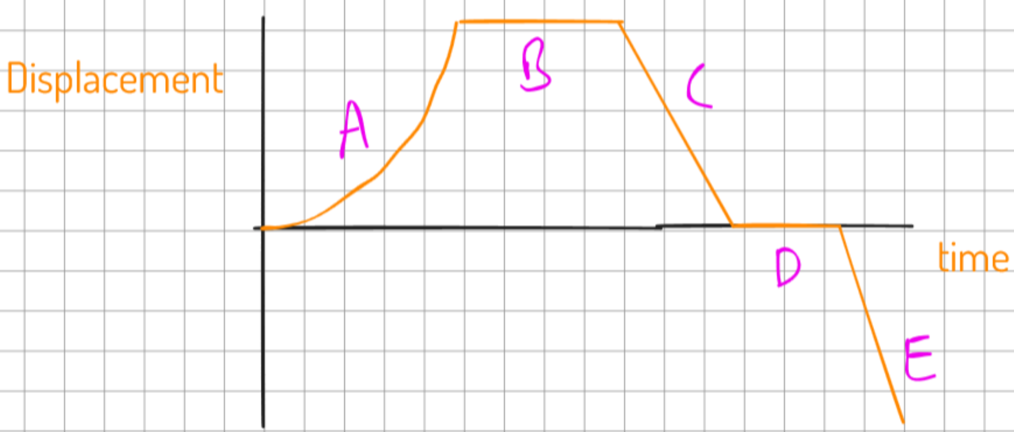
Gradient = $\frac{\text{change in y}}{\text{change in x}}$

$= \frac{93 - 30}{9 - 4}$

$= 12.6 \text{ m/s}$

The GRADIENT of a distance-time graph gives us the SPEED of an object.

The STEEPER THE LINE the GREATER THE SPEED of the object.



A: object is speeding up

B: stopped

C: moving back to start position at a constant speed

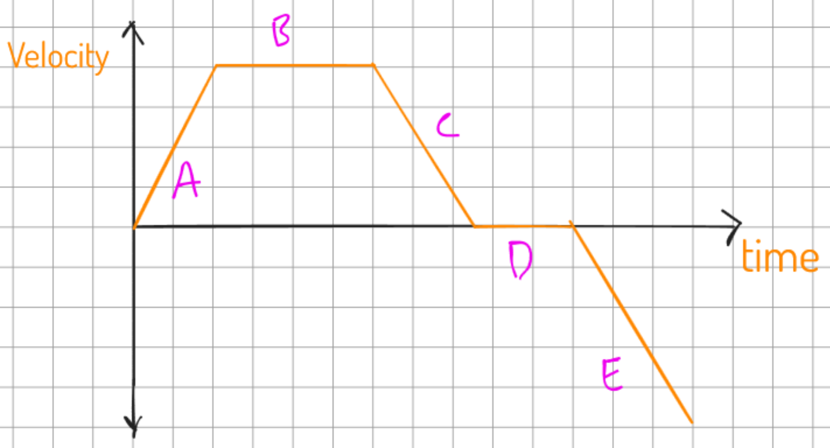
D: stopped back at start point

E: moves away from start position in opposite direction at constant speed

Velocity-time graphs

A graph with VELOCITY on y-axis and TIME on x-axis.

The GRADIENT of a velocity-time graph gives us the ACCELERATION.



A: accelerating at a constant rate

B: constant velocity

C: decelerating at a constant rate to a stop

D: stopped

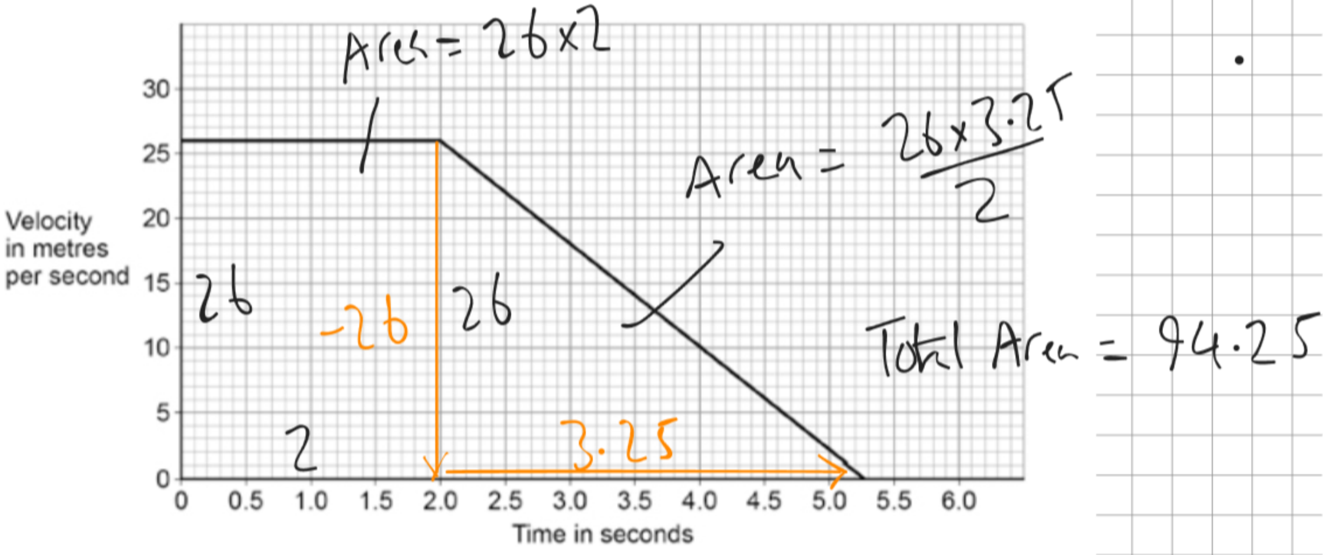
E: accelerating at a constant rate backwards

The AREA between the line of best fit and the x-axis on a velocity-time graph gives us the DISTANCE TRAVELLED.

A car contains a device called a black box. The black box records the velocity and acceleration of the car.

The car was travelling at a constant velocity. The driver then reacted to a hazard.

The figure below shows the velocity–time graph for the car.



(a) Determine the deceleration of the car. — gradient of sloped part

Give the unit.

gradient = $-\frac{26}{3.25}$

$= -8$ m/s^2

(b) Determine the braking distance of the car.

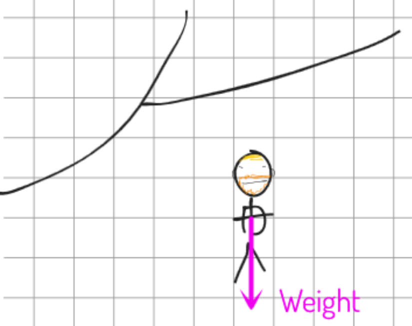
Use the Physics Equations Sheet.

Use the figure above.

Area =

Terminal Velocity

12th Dec



At the instant this skydiver steps out of the plane the only force acting vertically is their WEIGHT.

There is a LARGE RESULTANT FORCE downwards so they ACCELERATE downwards.

A few seconds later....

The DRAG FORCE (or air resistance) INCREASE as the SPEED INCREASES.

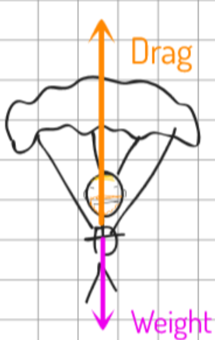
The RESULTANT FORCE = Weight - drag

Drag has increased, so the resultant force has DECREASED. This means the ACCELERATION also DECREASES.

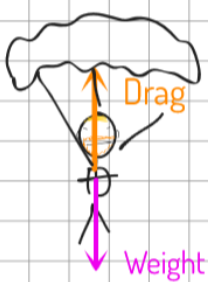
Eventually..

Eventually the DRAG is the same size as the WEIGHT. There is NO RESULTANT FORCE. The person STOPS ACCELERATING and moves with a CONSTANT VELOCITY which we call the TERMINAL VELOCITY.

Finally..



Opening a parachute INCREASES DRAG which creates a RESULTANT FORCE UPWARDS which causes the person to SLOW DOWN.



As SPEED DECREASES so does DRAG until it balances with weight again, and the person reaches a new but lower constant velocity.

Stopping Distances

9th Jan

Thinking distance: how FAR you travel between seeing a hazard and hitting the brakes

Braking distance: how FAR you travel between pressing the brakes and coming to a stop

Stopping distance = thinking distance + braking distance

Anything that affects your REACTION TIME affects your THINKING DISTANCE.

Anything that affects FRICTION affects your BRAKING DISTANCE.

Factor	Thinking distance	Braking distance
1 tiredness	✓	
2 faulty brakes		✓
3 use of mobile phone	✓	
4 alcohol	✓	
5 use of drugs or medicine	✓	
6 weather		✓
7 colour of car		
8 mass of car		✓
9 speed of car	✓	✓
10 tyre wear		✓

Reaction Time

A typical reaction time is approximately 0.5s. We can measure reaction times with computer software or experiments such as the 'ruler drop' test.

Drop distance / m Drop 1	Drop 2	Drop 3	Mean
0.31	0.15	0.26	0.24

Factors Affecting Braking Distance

If you are driving faster then your braking distance will be greater.

When braking WORK IS DONE by the brakes.

The kinetic energy of the vehicle DECREASES and the thermal store of the brakes INCREASES.

Doubling your speed increases your kinetic energy by factor of four (because speed is squared when we calculate kinetic energy).

This means the work done by your brakes also increases by a factor of four, as does the braking distance.

Momentum

17th Jan

When objects collide they can accelerate (or decelerate). A large deceleration means a large resultant force.

This can cause much greater risk of injury.

During collisions there is a transfer of MOMENTUM.

Momentum = mass x velocity

$$p = mv$$

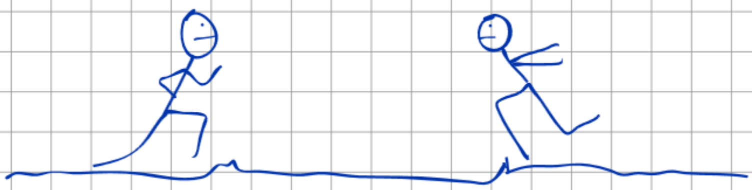
v — in metres per second, m/s

m — in kilograms, kg

p — in kilogram metres per second, kg m/s

Momentum is a VECTOR quantity. This means it has MAGNITUDE (a size) and DIRECTION.

Whenever we do calculations with momentum we consider motion in one direction to be positive (usually left to right), and motion in the OPPOSITE direction to be negative.



m = 60 kg
$v = 4$ m/s
$p = 60 \times 4$
$= 240$ kg m/s

m = 60 kg
$v = -4$ m/s
$p = 60 \times -4$
$p = -240$ kg m/s

These people have the same magnitude of momentum (240) but it is in opposite directions (240 and -240 kg m/s).

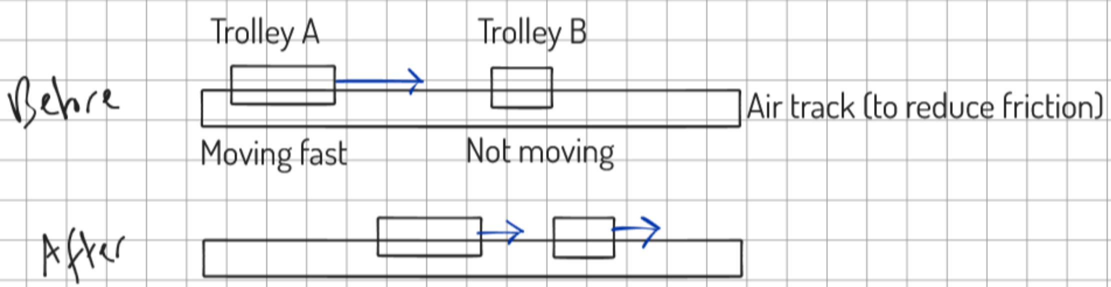
Their TOTAL MOMENTUM = 240 + (-240) = 0 kg m/s

In any collision, or explosion, when there are no other forces involved (an isolated system) the TOTAL MOMENTUM IS CONSERVED - IT DOES NOT CHANGE.

p = 0 kg m/s

Conservation of Momentum

20th Jan



Momentum is CONSERVED in collisions. The total momentum is the same before and after.

Trolley A loses momentum so SLOWS DOWN. Trolley B GAINS the same amount of momentum.