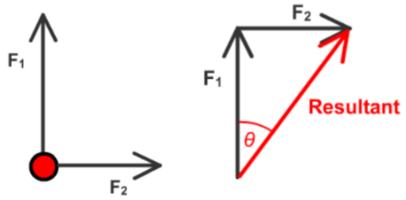
Vectors and Scalars

A scalar quantity has a magnitude/size only. Examples: time, mass, speed

A vector quantity has magnitude/size AND direction

Combining vectors

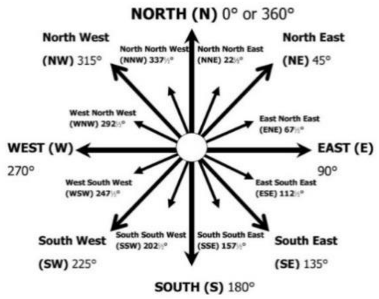


Two vectors should be added 'tip to tail'!

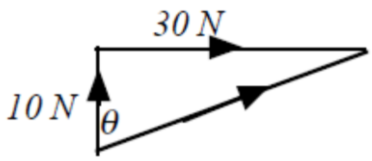
A straight line from the tail of the first vector to the head of the last= the resultant. Use scale drawings or Pythagoras to calculate magnitude

Calculate direction by using $tan\,\theta = \frac{F_2}{F_1}$

Direction should be given as a three figure bearing measured from North. A bearing of 90° would be written as (090).



Using Pythagoras for vector addition



$$R^2 = 30^2 + 10^2$$

$$R = 31.6\,N$$

$$tan\theta = \frac{opp}{adj},\quad tan\theta = \frac{30}{10}$$

$$tan^{-1}\theta = 3, \theta \quad = 72°$$

distance = 50 m

Speed = 50 ms^{-1}

quantity magnitude unit direction quantity magnitude unit direction

Displacement = 50 m South

Velocity = 50 ms^{-1} East

Vector Quantities @N5: Velocity, displacement, acceleration, force (e.g weight, thrust, friction), gravitational field strength

Average and Instantaneous Velocity

Average velocity is calculated by dividing the length of entire journey by total time taken.

Instantaneous velocity is calculated by dividing a very small distance (often 'length of mask') by the time taken for that small distance to pass.

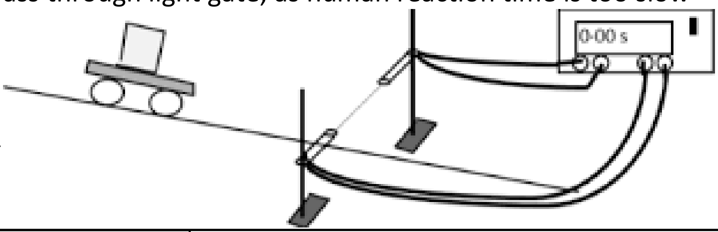
Measuring Instantaneous and Average speed

To measure average speed, the distance for the journey would be measured using a tape measure/metre stick/trundle wheel. The time for the whole journey would be measured using a stopwatch, use

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

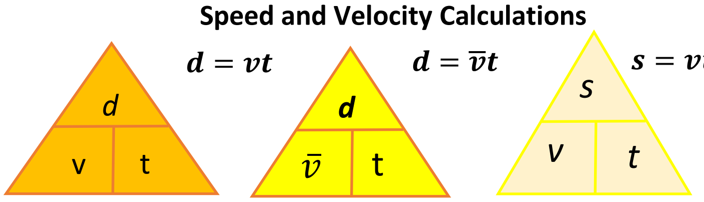
To measure instantaneous speed, measure the length of mask using a ruler. Time the mask to pass through light gate, as human reaction time is too slow

$$use\ v = \frac{length\ mask}{time\ taken}$$



Speed and Velocity Calculations

$$d = vt \qquad d = \bar{v}t \qquad s = vt$$

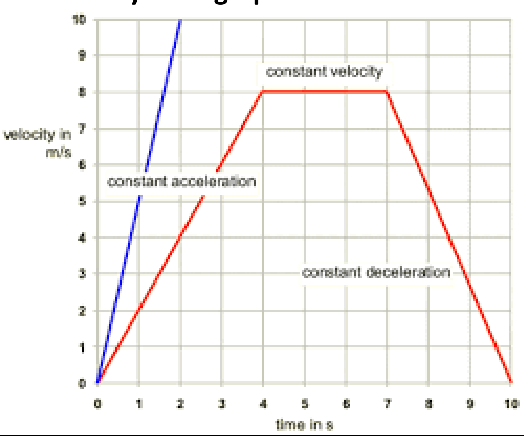


d = distance (m), v = speed (ms^{-1}),

t = time (s), s = displacement (m)

$\bar{v}$ = average speed (ms^{-1})

Velocity-time graphs

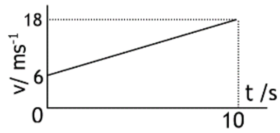


Shape tells you about the motion (see labels on graph)

Acceleration: gradient of slope on a v-t graph

Displacement/distance: Area under v-t graph

Average speed/velocity: calculate the area under the graph divided by the total time from the x-axis



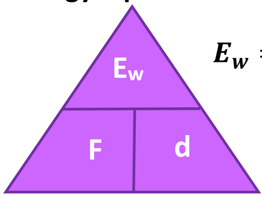
SOLUTION USING GRADIENT

$$m = \frac{y_2 - y_1}{x_2 - x_2}$$

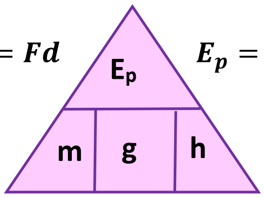
$$m = a = \frac{18-6}{10-0} = 1.2\ ms^{-2}$$

Using equation v=18; u=6; t=10 $a = \frac{v-u}{t},\ a = \frac{18-6}{10} = 1.2\ ms^{-2}$

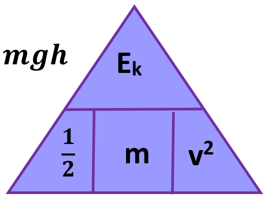
Energy equations



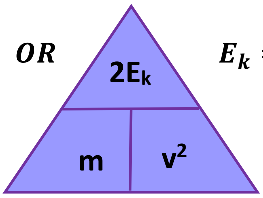
$E_w = Fd$



$E_p = mgh$



OR

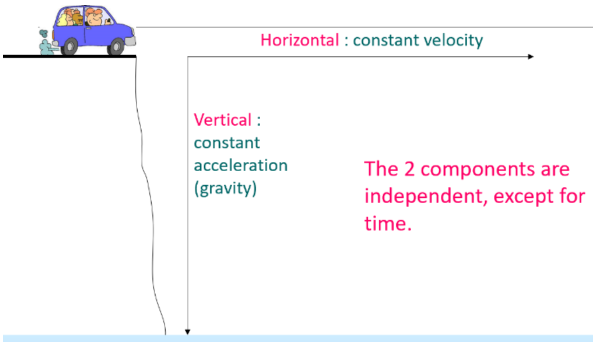


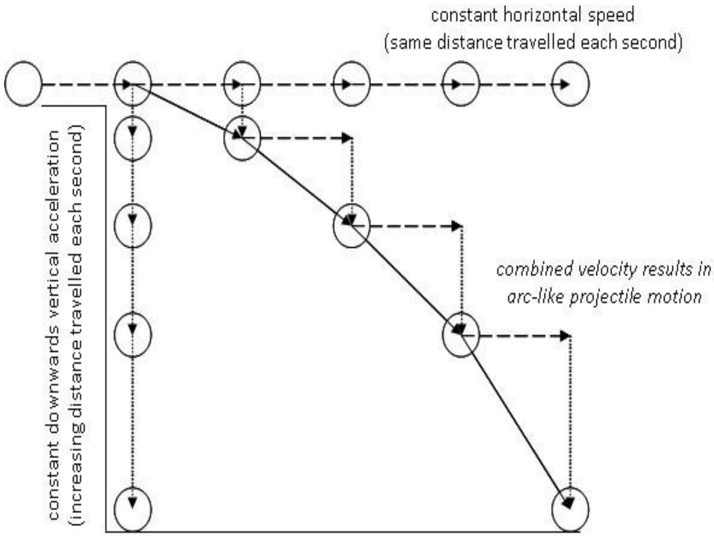
$E_k = \frac{1}{2}mv^2$

E, E_w, E_p, E_k = Energy (J) m = mass (kg) v = velocity (ms^{-1})
F = Force (N) g = gravitational field strength (N/kg) on Earth g = 9.8 N kg^{-1}
d = distance (m)

Projectiles

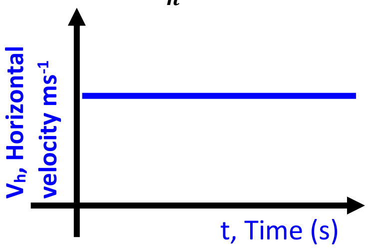
Projectile motion occurs when an object has both a constant horizontal velocity and a constant vertical acceleration
To calculate horizontal velocity, use: v = dt
To calculate vertical velocity, use: v = u + at





Horizontal motion – constant velocity

Horizontal distance (range) can be found using area under graph (equivalent to $d_h = v_h t$)
Just need $d = v_h t$

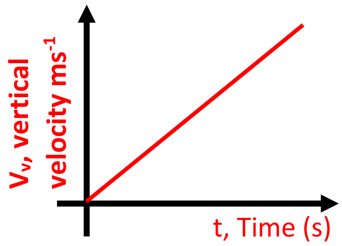


Vertical motion – constant acceleration, increasing velocity

on Earth acceleration and hence gradient = 9.8 ms^{-2}

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

$$v = u + at$$



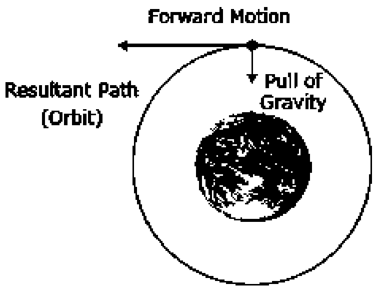
but u = 0 ms^{-1}
distance = area under v-t graph or distance (height) = average speed x time

$$average\ speed = \frac{v+u}{2}$$

or ½ vt (if u is 0)

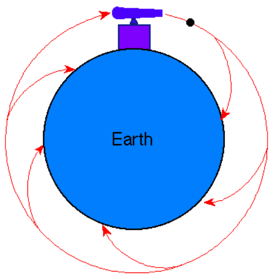
Explain how gravity keeps a satellite in orbit.
The force of gravity provides the force needed to maintain the stable orbit of both planets around a star and also of moons and artificial satellites around a planet. For an object to remain in a steady, circular orbit it must be travelling at the right speed.

Too slow and it will spiral to earth, to high and it will leave the orbit.



Explain why a satellite needs a horizontal motion and a vertical motion to stay in orbit.

Newton's cannon - thought experiment

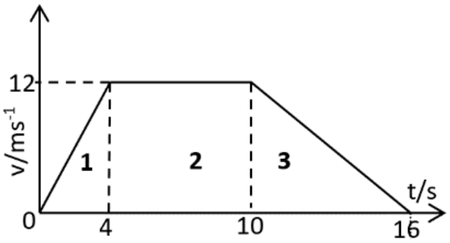


If a projectile has enough speed, it will move through space constantly falling towards the Earth in free fall. With the high constant horizontal speed the projectile falls around the curvature of the Earth.

Without a horizontal speed the satellite would fall to Earth.

Without the vertical motion (constant acceleration) the satellite would move away from the Earth at constant speed, leaving the gravitational field.

Distance/displacement from v-t graph is the area under v-t graph



Distance travelled = area 1 + area 2 + area 3

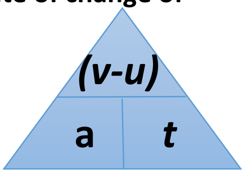
Distance travelled = (½ × 12 × 4) + (12 × 6) + (½× 6 ×12)

Distance travelled =24 + 72 + 36 = 132 m

Acceleration: the rate of change of velocity

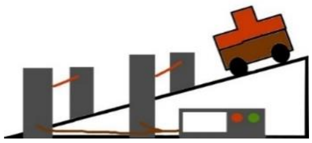
$$a = \frac{v-u}{t} = \frac{\Delta v}{t}$$

$$\Delta v = v - u$$

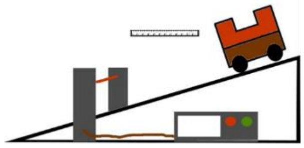


Acceleration experiments

Method 1: Single mask, double light gate



Method 2: Double mask, single light gate



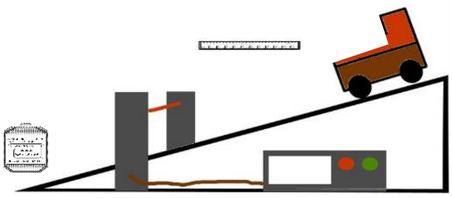
a = acceleration (ms^{-2})

v = final velocity (ms^{-1})

u = initial velocity (ms^{-1})

t = time (s)

Method 3: If u= 0 ms^{-1}, then measure v at the bottom of the slope and a stopwatch to time it takes for the vehicle to start and the mask reach the end of the light gate.

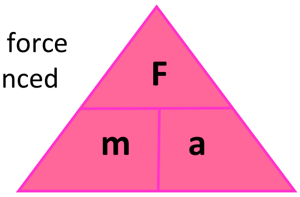


Newton's Laws

I: An object will remain at rest or same speed/direction unless acted on by an unbalanced force

II: If mass remains constant, an object's acceleration is directly proportional to the unbalanced force applied F=ma

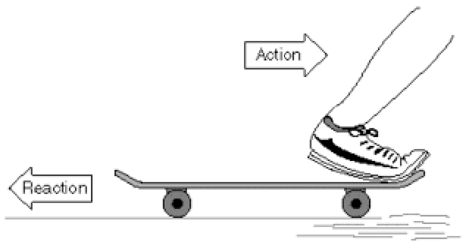
III: Every action has an equal and opposite reaction



Newtons 3rd Law

A person sits on a chair which rests on the Earth. The person exerts a downward force on the chair. The reaction force is the chair exerts an upwards force on the person.

Newtons 3rd Law - Skateboard moving



F = unbalanced force (N)

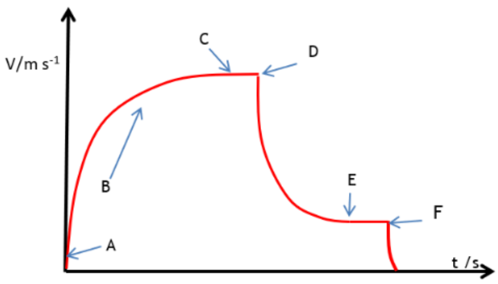
m = mass (kg)

a = acceleration (ms^{-2})

$W = mg$ is a form of this equation

Free fall/Terminal velocity

Terminal velocity is the velocity something will travel at when **forces acting upon it are balanced** (e.g. Weight and air resistance for a being in a parachute).



Point	Forces and Motion
A	Initial velocity in the vertical direction is zero, the object accelerates under the force of gravity at $9.8ms^{-2}$. Initially no drag force.
B	As vertical speed increases air resistance acting against the parachutist increases. At B weight is greater than drag so the skydiver accelerates with a reduced acceleration than at the start.
C	At B Weight = drag so the skydiver falls at constant speed, terminal velocity.
D	The parachute is opened. At E drag forces are much greater than the weight (the parachute has been opened) so there is a high deceleration (or negative acceleration)
E	At E Weight = drag so the skydiver falls at constant speed, terminal velocity
F	The parachutists touches the ground large forces cause a great negative acceleration (slowing down)

Balanced forces are Equal forces but acting in opposite directions Forces are always balanced if an object is travelling at constant height or at constant speed in a straight line.