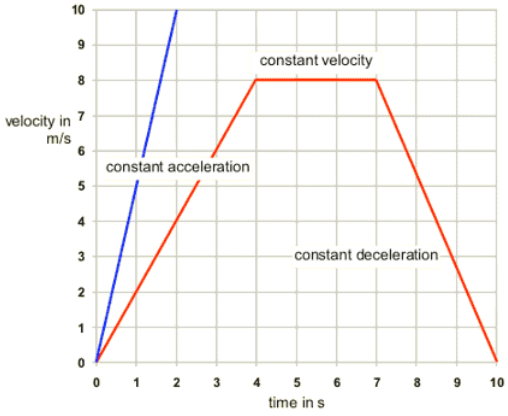
Motion

Equations of motion

1. Velocity means speed in a straight line or given direction
2. **minus or - 10m/s** means going the opposite way
3. The area under a velocity time graph tells you the distance covered
4. Area under red graph



Total distance travelled = area under red line
Shape can be divided into 2 triangles plus a rectangle
Triangle one (first 4s) = _ x 8 x 4 = 16m
Rectangle (4 to 7s) = 3 x 8 = 24m
Triangle two (7 to 10s) = _ x 3 x 8 = 12 m

Total distance travelled = 16 + 24 + 12 = 52m

5. Equations of motion (BOLD FOR HIGHER)

$v=u+at$ $\quad\quad$ $\mathbf{x = ut + \frac{1}{2} at^2}$

$x = \frac{(u + v)}{2} t$ $\quad\quad$ $\mathbf{v^2 = u^2 + 2ax}$

6. Use

Where x is distance in m
u is starting velocity in m/s
v is final velocity in m/s
a is acceleration in m/s^2
t is time in s

7. Example
   Write down x, u, v, a, t. Look at the question, find which values they have given you and add them to your list.

A car starts from the lights and accelerates at 4 m/s^2 for 5s, what is its velocity?

x
u = 0
v
a = 4 m/s^2
t = 5s

Which value is the question asking you to find? Add a ? to the list

x
u = 0
v = ?
a = 4 m/s^2
t = 5s

Look at your list of equations for one that links u, v, a and t

Use v = u + at

Now replace letters with their values

V = 0 + 4 x 5
V = 20 m/s **don't forget to add the unit!**

Momentum

1. momentum (kgm/s) = mass (kg) x velocity (m/s)
2. Example
   A mass of 2kg travelling at 10m/s has a momentum of 20kgm/s
3. Crumple zones, air bags – the change in momentum of a crashing car equal to force acting on it multiplied by the time the force acts for. If the time is made greater then the force becomes less for the same change in momentum.
   Eg., change in momentum is 100kgm/s for a force of 20N acting for 5s (20 x 5 = 100). If time is doubled to 10s then force halves to 10N (10 x 10 = 100)

HIGHER PAPER ONLY

4. Law of conservation of momentum

Total momentum before = total momentum after

5. Eg., Truck A mass 60kg moves with velocity 3m/s collides with stationary truck B of mass 30kg. They stick together and move off. What will the velocity be?

Total momentum before = Momentum A + Momentum B

A 60 x 3 = 180 kgm/s B 30 x 0 = 0

A + B = 180 + 0 = 180

Total momentum after = (60+30) x ? = 90?

Total momentum before = total momentum after

180 = 90?

$$\frac{180}{90} = ?$$

2m/s = ?

The combined trucks move off at 2m/s

6. **kinetic energy before and after can be calculated using**

$$\text{kinetic energy (KE)} = \frac{mv^2}{2}$$

7. **Force (N) = $\frac{\text{change in momentum (kgm/s)}}{\text{Time (s)}}$**

Eg., a mass 3kg accelerates from 4m/s to 8m/s when a force acts for 2s.

Momentum before force acts = 3 x 4 = 12kgm/s

Momentum after force acts = 3 x 8 = 24kgm/s

Change in Momentum = 24 – 12 = 12kgm/s

$$\text{Force} = \frac{12}{2} = 6\text{N}$$

8. **Circular motion – for an object to go round in a circle at a constant speed there must be a force acting inwards towards the centre of the circle.**

9. Sling-shot orbits

Potential energy PE and kinetic energy KE

- **At point of take off rocket has 100% KE and 0% PE**
- **The KE is converted to PE as rocket gains height**
- **The total energy at a given point = KE + PE**
- **The higher the rocket the greater the PE an the smaller theKE**
- **Knowing the KE of the rocket you can find its velocity using**

$$\text{kinetic energy (KE)} = \frac{mv^2}{2}$$

- **Once beyond Earth's gravitational pull, you need energy to escape the pull of the Sun's gravity if you are to travel further out of the Solar system eg., towards Jupiter etc**

Saving energy (steal it from a planet)

SPEEDING UP

- **Rocket passes behind a planet but just miss it**
- **Approach speed of rocket= 20km/s**
- **Planet orbits at 15km/s**
- **Rocket departs at = 20 + 15 + 15 = 50km/s**
- **Double speed of planet and add to rocket.**
- **Rocket's speed has increased; planet's has decreased slightly**

SLOWING DOWN

- **Rocket passes in front of planet**
- **Speed of rocket is 40km/s**
- **Planet orbits at 15km/s**
- **Rocket departs at = 40 – 15 – 15 = 10km/s**
- **Rocket's speed has decreased; planet's has increased**

FROM THE SIDE

- **Passing a planet from the side (instead of head on) has the same effect only it gains less energy so smaller gain in speed.**