Forces
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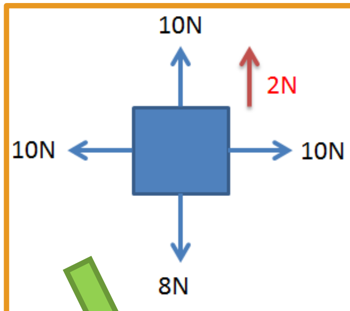
Resultant force examples:
The objects are shown here with the individual forces (blue) and the resultant force.



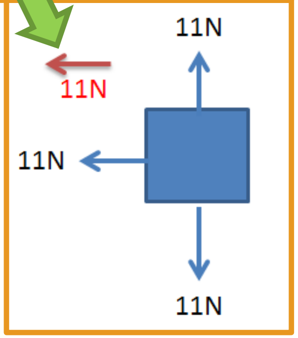


Figure 5 shows a tug-of-war in which the pull force of each team is represented by a vector. A scale of 10 mm to 200 N is used. Team A pulls with a force of 1000 N, and team B pulls with a force of 800 N. So the resultant force is 200 N in team A's direction.

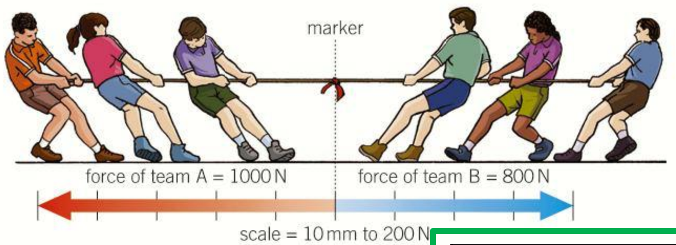


Figure 5 *A tug-of-war*

Resultant force is a single force that has the same effect as all the forces acting on the object. (The overall force acting on an object)

Zero resultant force: when two forces act on an object are opposite and balanced.

If there is a resultant force the object will speed up or slow down.

If there is no resultant force the object will stay at the same speed.

Vector Physical quantity with direction and magnitude	**Scalar** Physical quantity with just magnitude
Displacement, velocity, acceleration, force, momentum, weight and gravity.	Speed, distance, mass, time, energy and power.

Contact forces when two objects MUST touch each other to interact	**Non-contact forces** when two objects do not have to touch each other to interact
friction, air resistance, stretching, push, and pull.	Magnetism, electrostatic force and gravity.

Key Words:

Acceleration - change in velocity per second.
Braking distance - the distance travelled by a vehicle during the time it takes for it's brakes to act.
Deceleration - change of velocity per second when an object slows down.
Displacement - distance in a given direction
Elastic - A material is elastic if it is able to regain is shape after it has been squashed or stretched.
Extension - the increase in length of a spring (or a strip of material) from its given length.
Force - A force (in newtons N) can change the motion of an object.
Gravitational field strength (g) - the force of gravity of an object (of mass 1kg (in N/kg). It is also the acceleration of free fall.
Hooke's law - the extension of a spring is directly proportional to the force applied, as long as its limit of proportionality is not exceeded.
Magnitude - the size or amount of a physical quantity.
Parallelogram of forces - a geometrical method used to find the resultant of two forces that do not act along the same line.
Resolution of forces - the way of considering a force in terms of two perpendicular parts, which together have the same effect on an object as the force.
Resultant force - a single force that has the same effect as all the forces acting on the object.
Scalar - A physical quantity that has magnitude only e.g. mass.
Speed (m/s) - of an object is it's distance/time
Spring constant - Force per unit extension of a spring.
Stopping distance - the distance travelled by a vehicle in the time it takes for the driver to think and brake.
Terminal velocity - The velocity reached by an object when the drag force on the object is equal and opposite to the force making it move.
Thinking distance - the distance travelled by the vehicle in the time is takes the driver to react.
Vector - A vector is a physical quantity that has magnitude and direction (e.g. velocity).
Velocity - Speed in a given direction m/s)

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A method to calculate the resultant forces on an object where the forces are not acting on the same line.

Worked example

A tow rope is attached to a car at two points 0.80 m apart. The two sections of rope joined to the car are the same length and are at 30° to each other (Figure 5). The pull on each attachment should not exceed 3000 N. Use the parallelogram of forces to determine the maximum tension in the main tow rope.

Solution

The maximum tension *T* in the main tow rope is the resultant force of the two 3000 N forces at 30° to each other.

Drawing the parallelogram of forces as shown in Figure 5 gives:

$T = 5800\text{ N}$

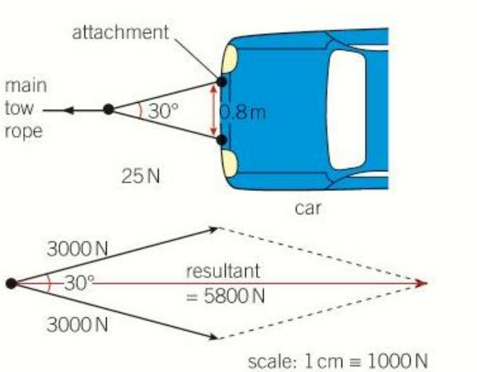


Figure 5 *Using the parallelogram of forces*

Gravity:
Gravity acts on **all objects**.
The bigger the mass, the stronger the force of gravity.
The closer together the objects, the stronger the force of gravity.

The force gravity causes is **weight** measured in **Newtons**.

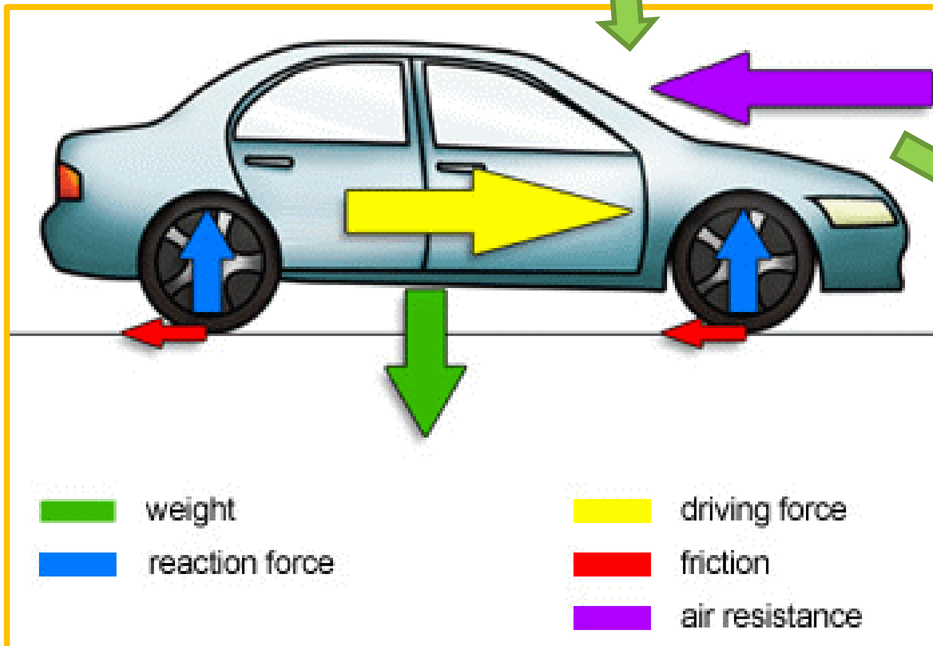
$$F = m \times g$$
$$Force\ (weight) = mass \times strength\ of\ gravity$$

The strength of gravity is 10N/kg on Earth

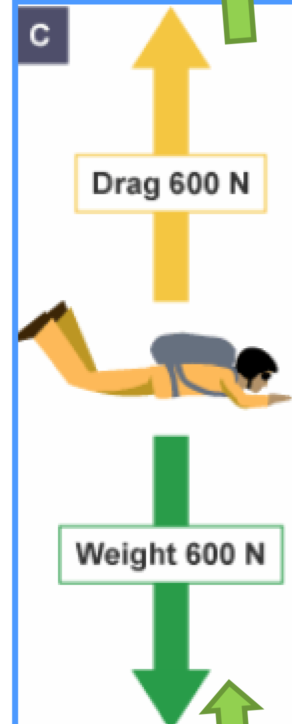
Mass and weight are different things.

Mass is how much material makes up an object, measured in kilograms (kg).
Weight is the force due to gravity in Newtons (N).

Your mass is the same everywhere in the universe, but if gravity is different then your weight will be different.



End of P2



Terminal velocity:
When the resultant force on an object is 0N it continues travelling at a constant speed/velocity. This is called **terminal velocity**.

E.g. when the forces of weight and air resistance on a skydiver are equal they will be travelling at constant speed: they're at terminal velocity.

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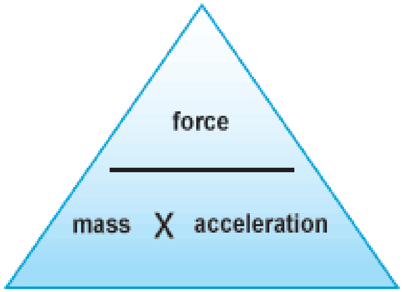
$F = m \times a$

Force (N) Mass (kg) Acceleration (m/s^2)



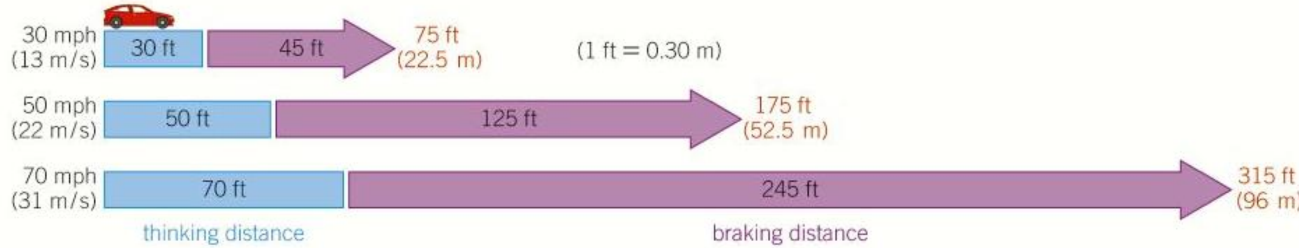
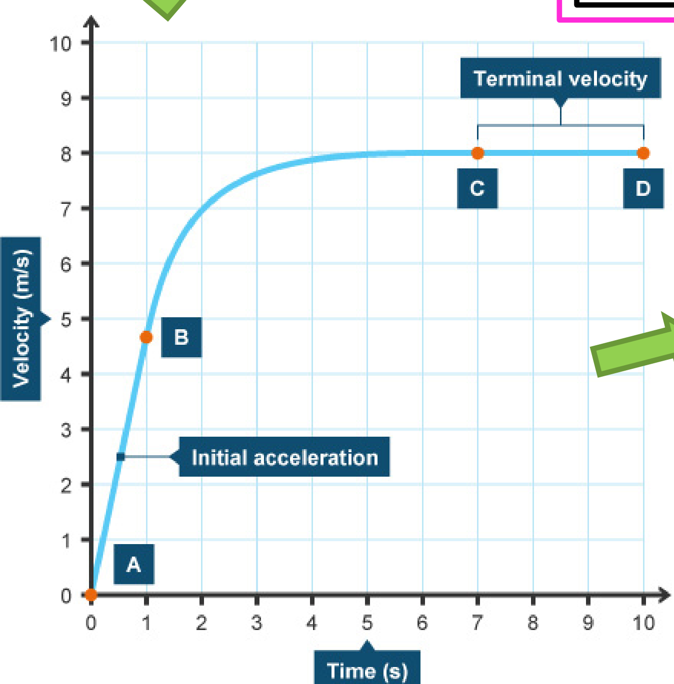


Figure 2 *Stopping distances*

Reaction time: The time taken to respond to a stimulus. Tiredness, alcohol, and drugs affect the brain and increase reaction time. All these factors increase reaction time (thinking distance = speed x reaction time).

Braking distance: Adverse road conditions (wet or ice roads increase the braking distance (less friction) as does a poorly maintained car (worn brakes and tyres; decreased friction).

Stopping distances
Equal to the total of the thinking and braking distance.
Thinking distance: the distance travelled by the vehicle in the time it takes the driver to react (the driver's reaction time)
Braking distance: the distance travelled by the vehicle during the time the braking force acts.



Between A and B
The object accelerates at first because of the force of gravity. Its speed increases. The resultant force acts downwards because frictional force acting against it is less than the weight of the object.

Between B and C
The object is still accelerating but its acceleration decreases as time goes by. Its speed still increases but by a smaller amount as time goes by. The resultant force still acts downwards but is decreasing. This is because frictional force acting against it is increasing as the speed increases, but is still less than the weight of the object.

Between C and D
The object is not accelerating any more. It has reached its terminal velocity and is falling at a steady speed. The resultant force is zero because the frictional force acting against it is now the same as the weight of the object.
Take care: the object does not stop falling once its resultant force is zero (unless it has hit the ground!).

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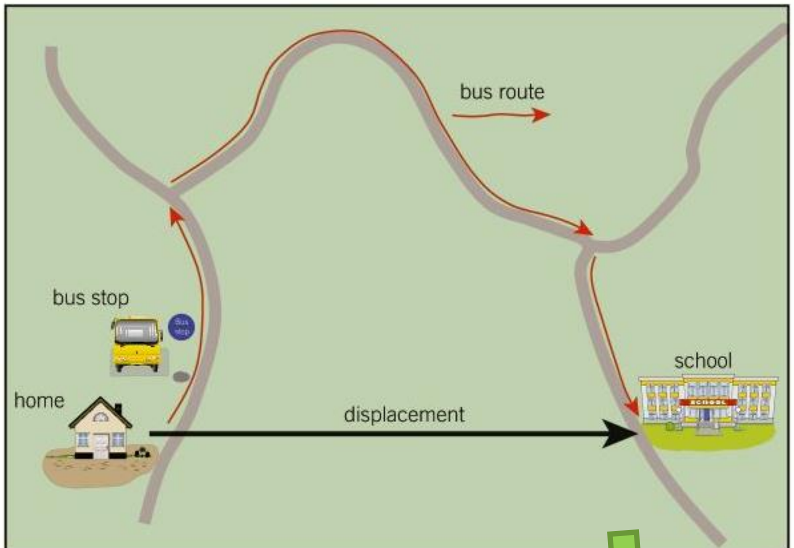
Distance and displacement

Distance is scalar (the journey below) and displacement is a vector (distance in a certain direction)



Speed and velocity

Velocity is speed in a certain direction. A car travelling north at 30 mph has a different velocity that a car travelling south at 30 mph

An object moving in a circle has the direction of motion that continuously changes as it goes round. So its velocity is not constant even if it's speed it as it changes direction.

$$a = \frac{\text{change in velocity}}{\text{time}}$$

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

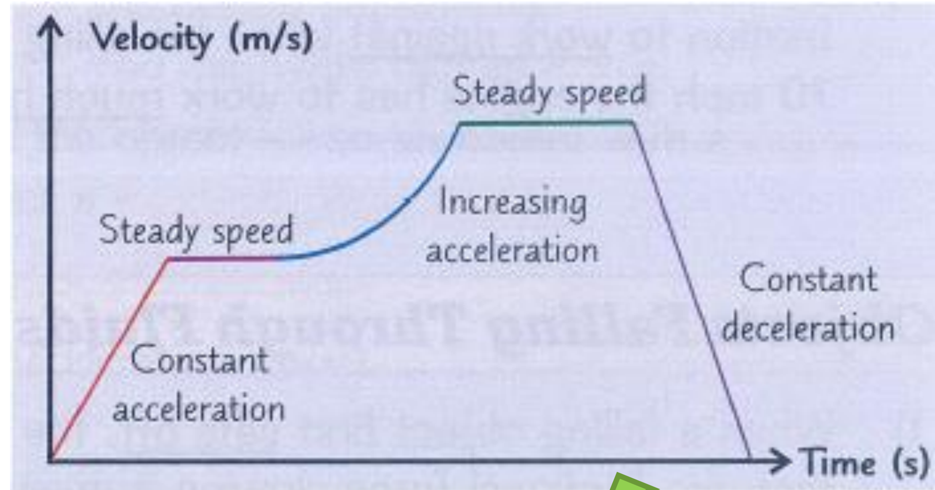
v= final velocity u= initial velocity

Velocity Time Graphs

Gradient = acceleration.

Flat sections are where the object is at a steady speed.

A curve means a change in acceleration.

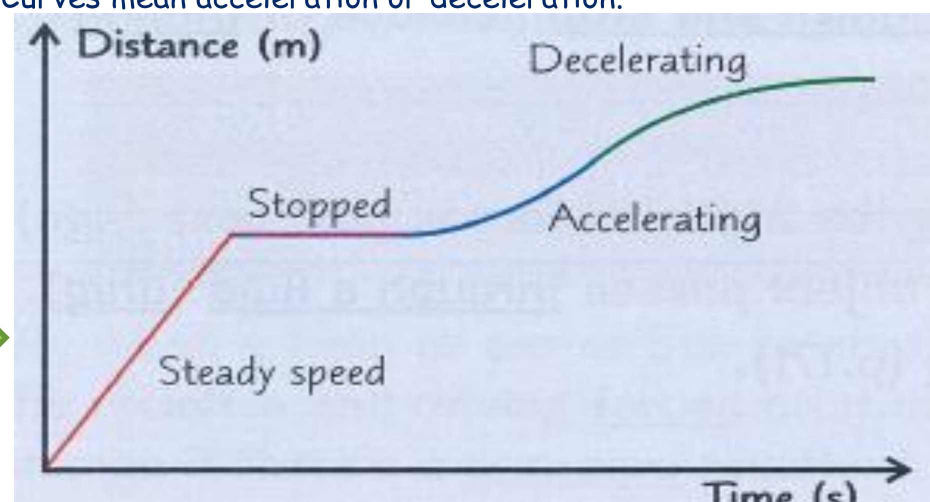


Distance Time Graphs

Gradient = speed (The steeper the line, the faster the object).

Flat sections are where the object has stopped.

Curves mean acceleration or deceleration.



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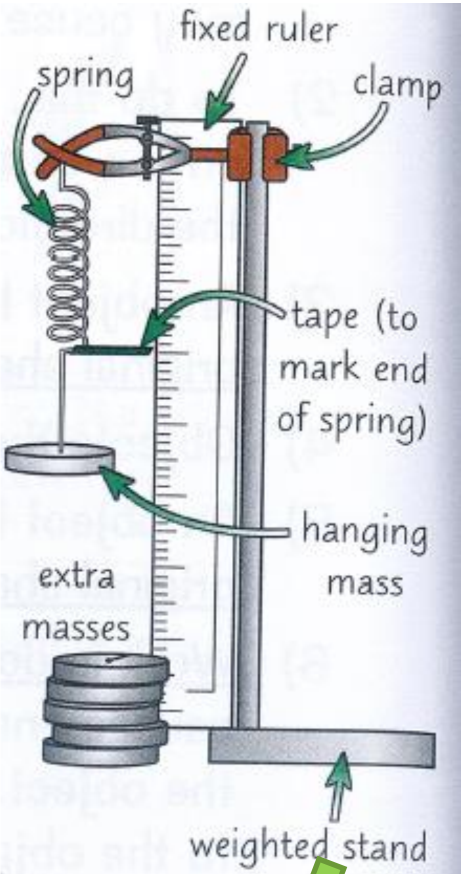
Elastic energy: some objects store elastic potential energy because when stretched they return to their original shape; elastic band and squash ball.
To change the shape two forces need to applied in opposite directions.



Investigating elasticity

1. Setup apparatus as diagram

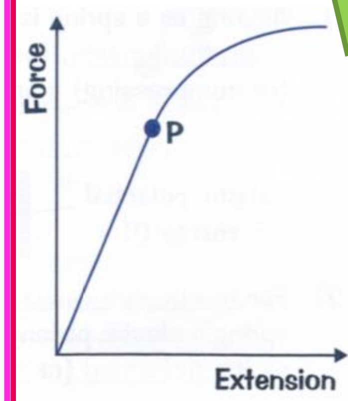
2. measure natural length of spring (with no load) using mm ruler

3. Add one mass at a time, allow spring to come to rest and measure extension (CHANGE IN LENGTH from original to stretched)

4. Do this seven times for enough measurements

5. Repeat experiment for reliability and calculate average value for each weight

FINISH



Elastic behaviour is shown by the straight line. Plastic (inelastic) behaviour is shown by the curve. P is the limit of proportionality (elastic limit).

Elastic behaviour is when an object returns to normal when the forces are removed (like a spring). Plastic (or inelastic) behaviour is when an object doesn't return to normal (like a broken spring or Play-Doh).

Hooke's law
The extension of a spring is directly proportional to the force applied, as long as its limit of proportionality's not exceeded.

$$F = kx$$

F = Force applied on the spring
k = spring constant
x = extention of the spring

$$W = F \times d$$

W is the work done in joules, J
F is the force applied in newtons, N
d is the distance moved, m

Energy transfers take place during work.
For example, the work done in lifting an object causes an increase in gravitational potential energy.

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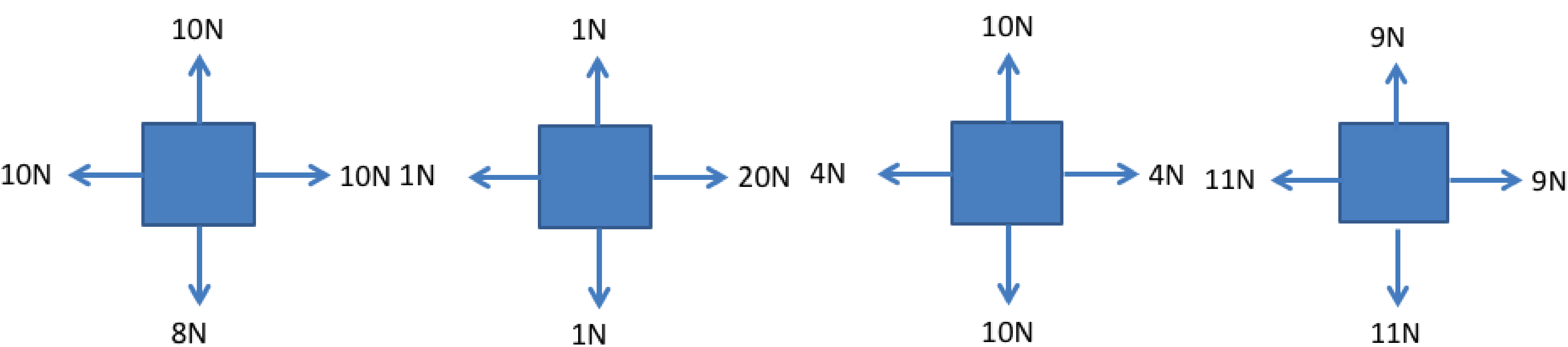
1. Draw a force diagram of a moving car which is:
   a) Accelerating
   b) Decelerating
   c) At terminal velocity.
2. Name 3 vector quantities and 3 scalar quantities. How do you know which is which?

3. Which 2 things make up a car's stopping distance?

4. Why does drinking alcohol affect stopping distance?

5. Draw the direction each of the following objects will move.
   (Higher level: Resolve the forces using the parallelogram method to find the resultant forces)



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6. For each of the following sketch a force diagram and explain what will happen to the object's speed.

   a) A skydiver has jumped out of a plane. The skydiver's weight is 750N and the force due to air resistance is 45N.

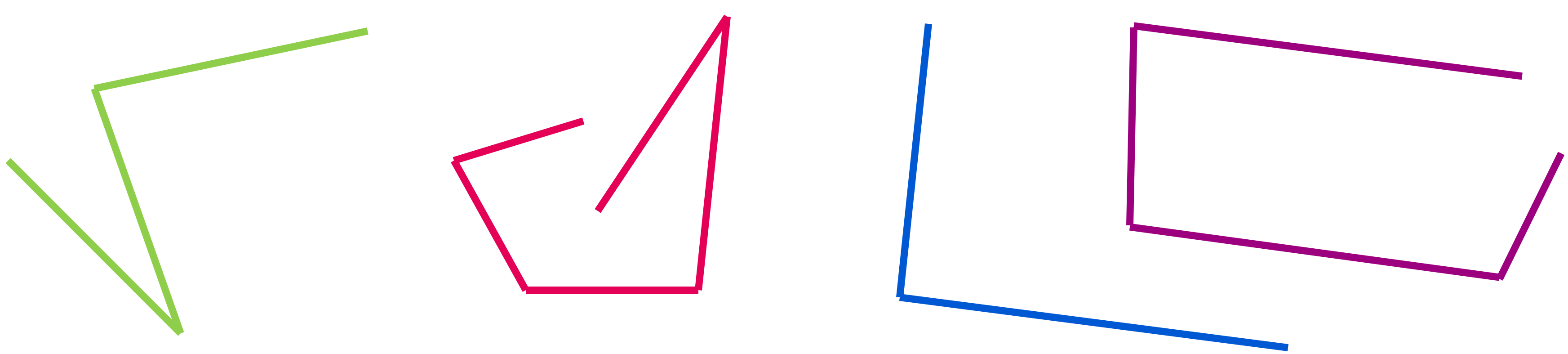
   b) The skydiver has been falling for a while. Their weight is still 750N but air resistance has now increased to 750N.

   c) The skydiver opens their parachute. Air resistance increases to 1250N while their weight remains the same.

7. What is the difference between distance and displacement?

8. For each of the following lines, measure (using a ruler in cm) what the distance travelled is and what the displacement is.

   (Hint: Distance is the measurement along the lines. Displacement is just the measurement from one end to the other ignoring the shape of the line).



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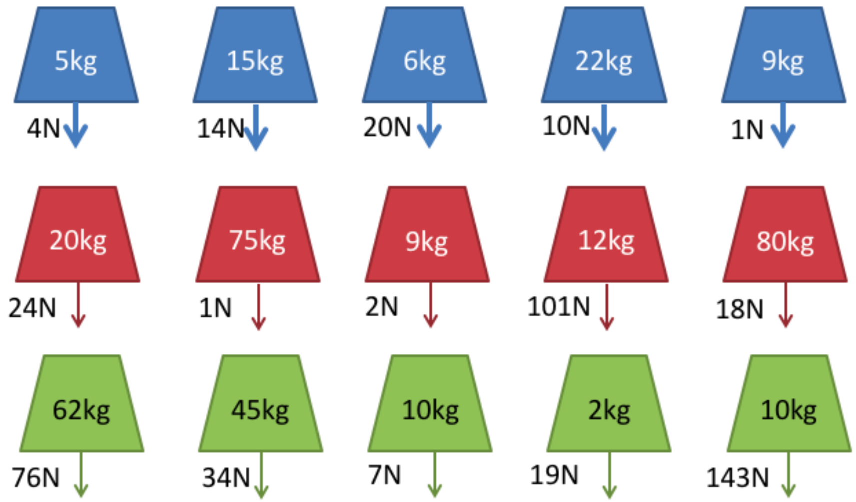
9. Some blocks have been places on different planets where they experience different forces of gravity.

For each of the rows of blocks below:

a) Which block has the largest mass?

b) Which block has the largest weight?



10. Use the equation linking mass, weight and gravitational strength for these questions:

a) How much will a 40kg dog weigh on Earth?

b) How much will the same dog weigh on the Moon (g=1.6N/kg)?

c) What is the gravitational strength if a 200kg object weighs 3000N?

d) Why can an object's weight change at different places in the universe while mass remains unchanged?

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11. Sketch a distance time graph for a journey of your choice. Include periods of; acceleration, constant speed, deceleration, not moving.

12. Sketch a velocity time graph for the same journey as you used in question 11.

13. How does a speed camera use 2 photographs and the lines on the road to measure the speed of a moving vehicle?

14. What units do we use for:
    - a) Speed/velocity?
    - b) Acceleration/deceleration?
    - c) Time?
    - d) Weight?
    - e) Distance?
    - f) Mass?

15. How fast is a horse running which travels 40m in 2.2s?

16. How far does a rocket travel in 20s if its velocity is 540m/s?

17. Write a method on how you would measure a person's walking speed.

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11. What is elastic deformation?

12. What is inelastic deformation?

13. What is Hooke's Law?

14. Sketch a graph of a spring's extension, including both elastic and inelastic deformation. (Extension on the y-axis and mass added on a the x-axis).

15. What force is needed to extend a spring by 0.3m if its spring constant is 2N/m?

16. Write a risk assessment for the extension of a spring practical.

17. Name 3 control variables for the extension of a spring practical.

18. What is elastic potential energy?