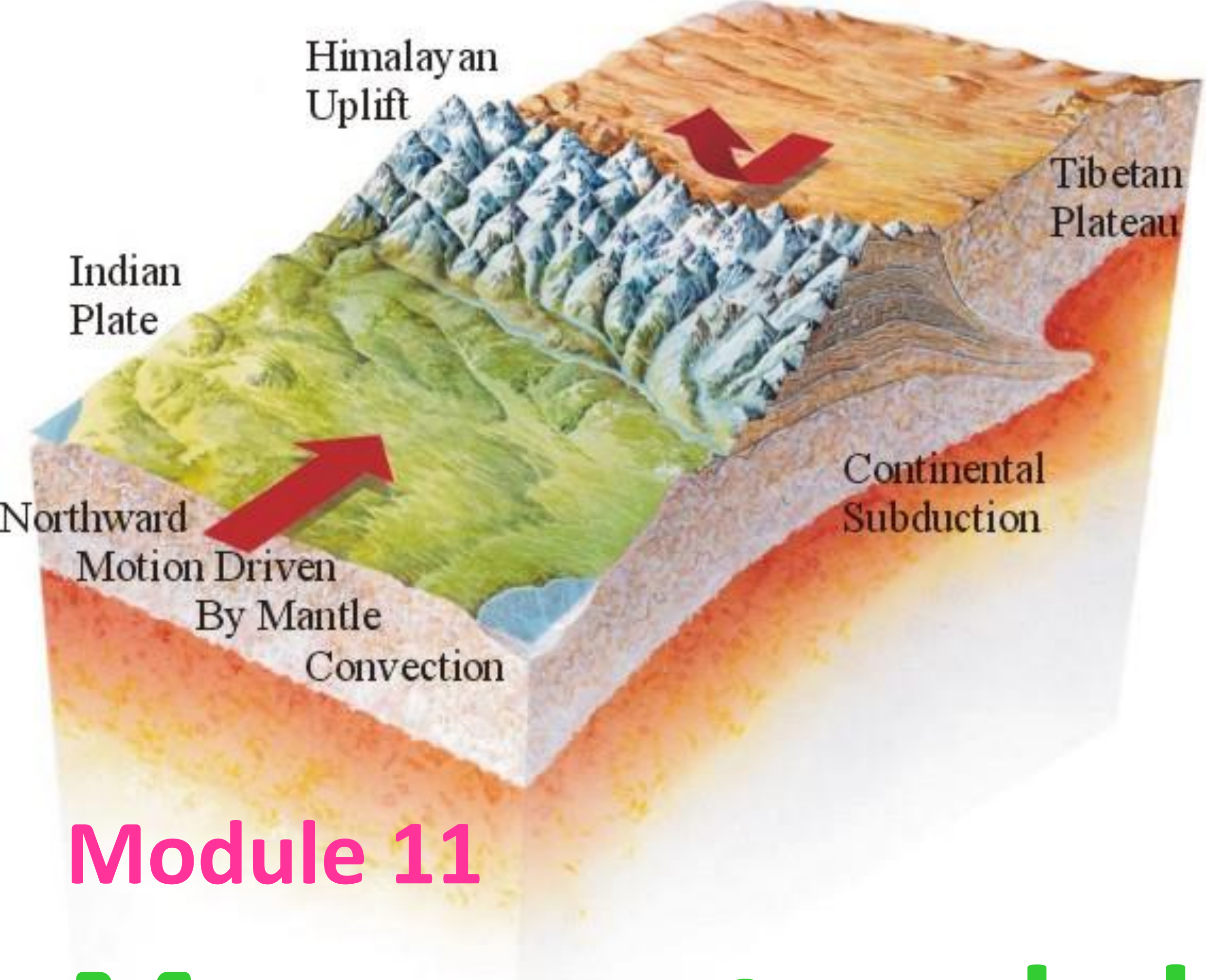


Module 11

Movement and change

Lesson 1

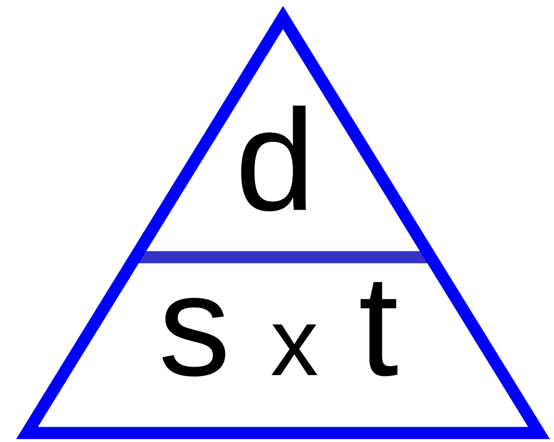
Speed

What is speed?

Speed is the rate at which an object moves. To measure the speed of an object you need to know the:

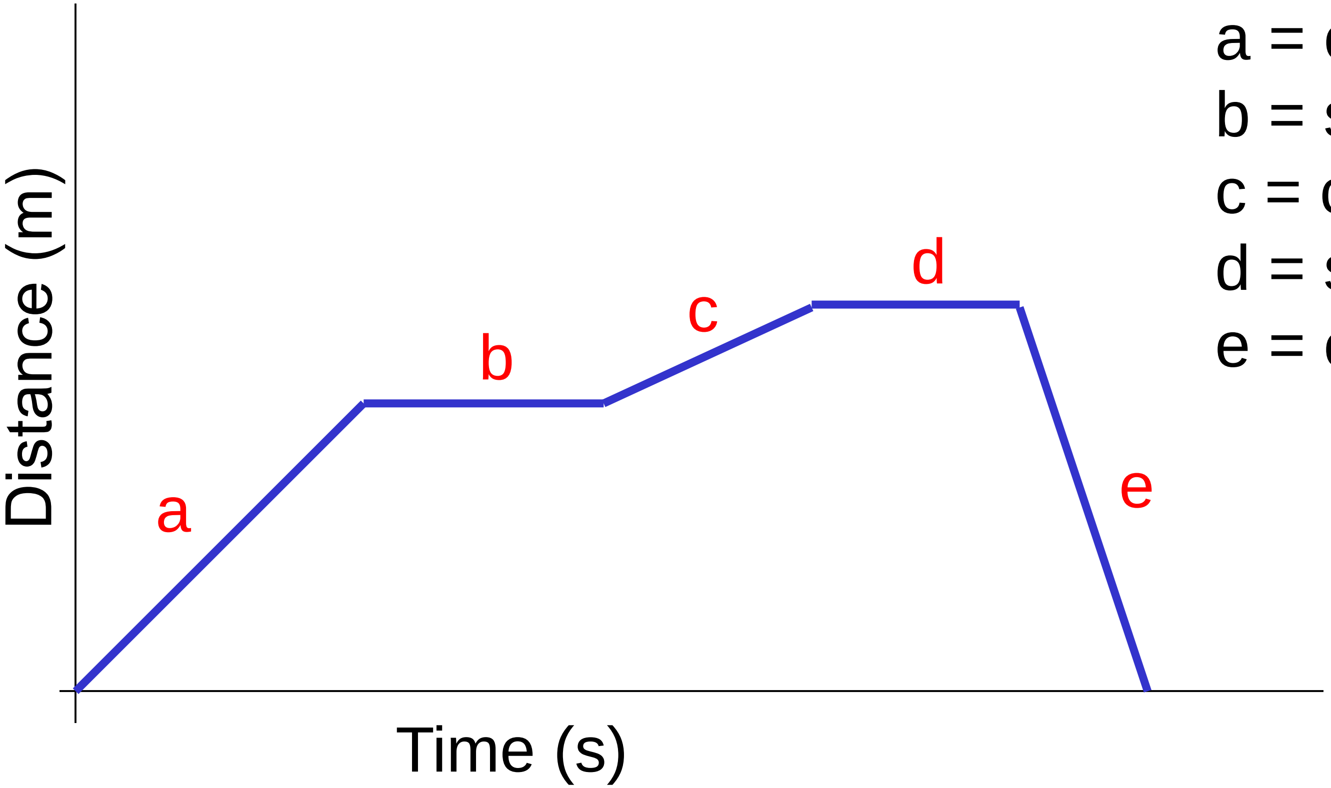
Distance the object moved (m)
How long it took (s)

$$\text{Speed (m/s)} = \frac{\text{Distance (m)}}{\text{Time (s)}}$$



If speed is given a direction then it is called VELOCITY.
Velocity is speed in a certain direction.

Distance - time graphs



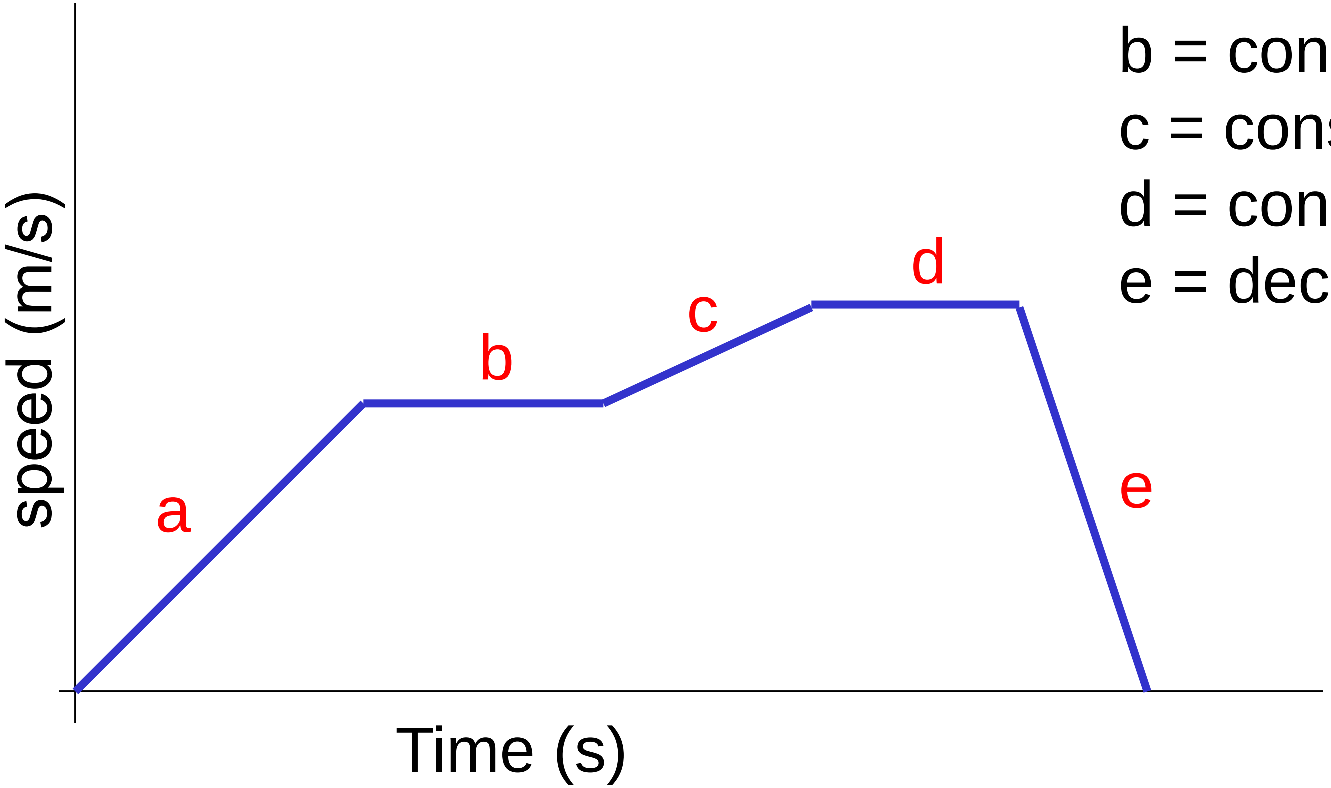
a = constant speed
b = stationary
c = constant speed
d = stationary
e = constant speed

1. What can you say about the speed at ‘a’ and ‘c’?
2. What does ‘e’ show?

Lesson 2

Acceleration

Speed-time graphs

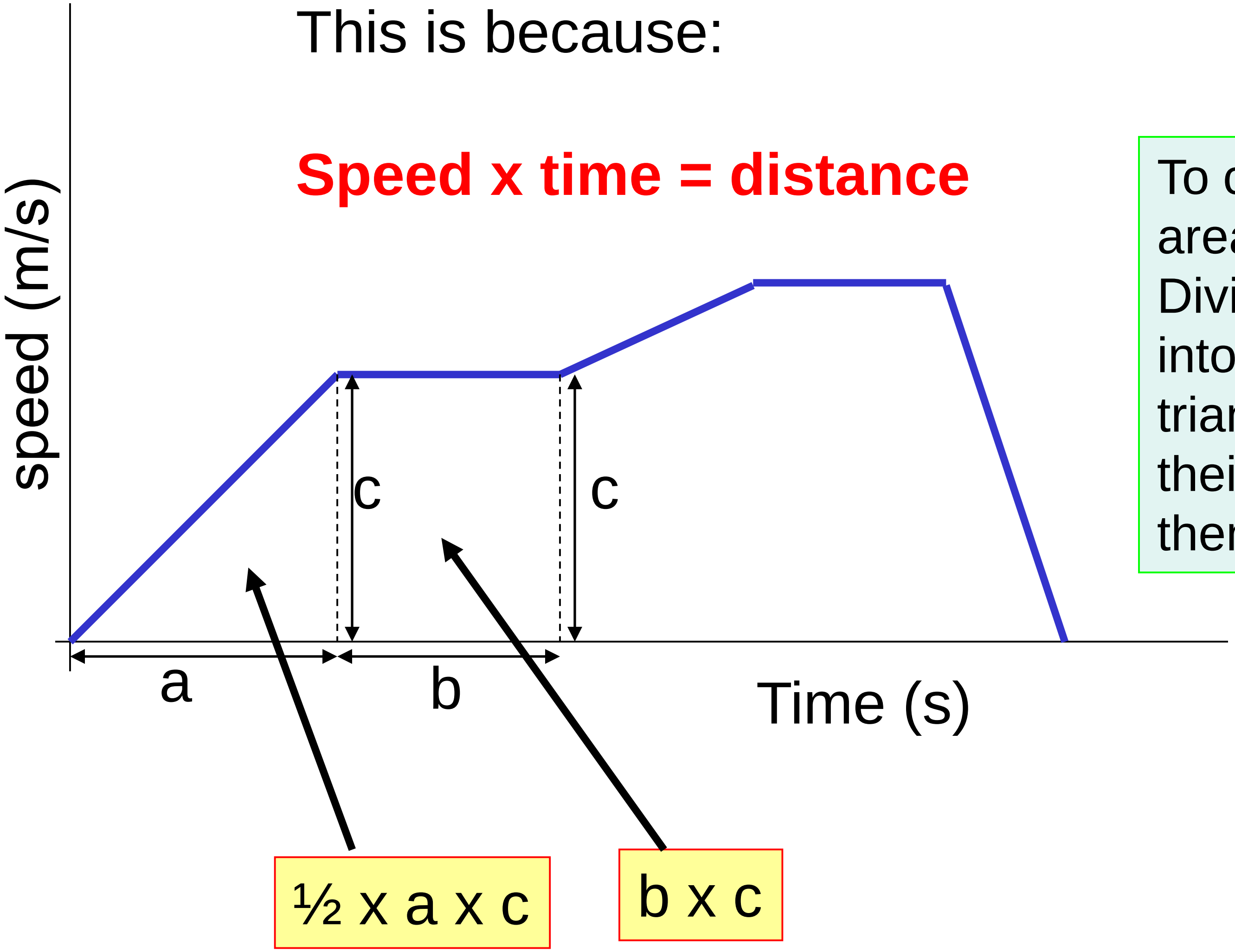


a = constant acceleration
b = constant speed
c = constant acceleration
d = constant speed
e = deceleration

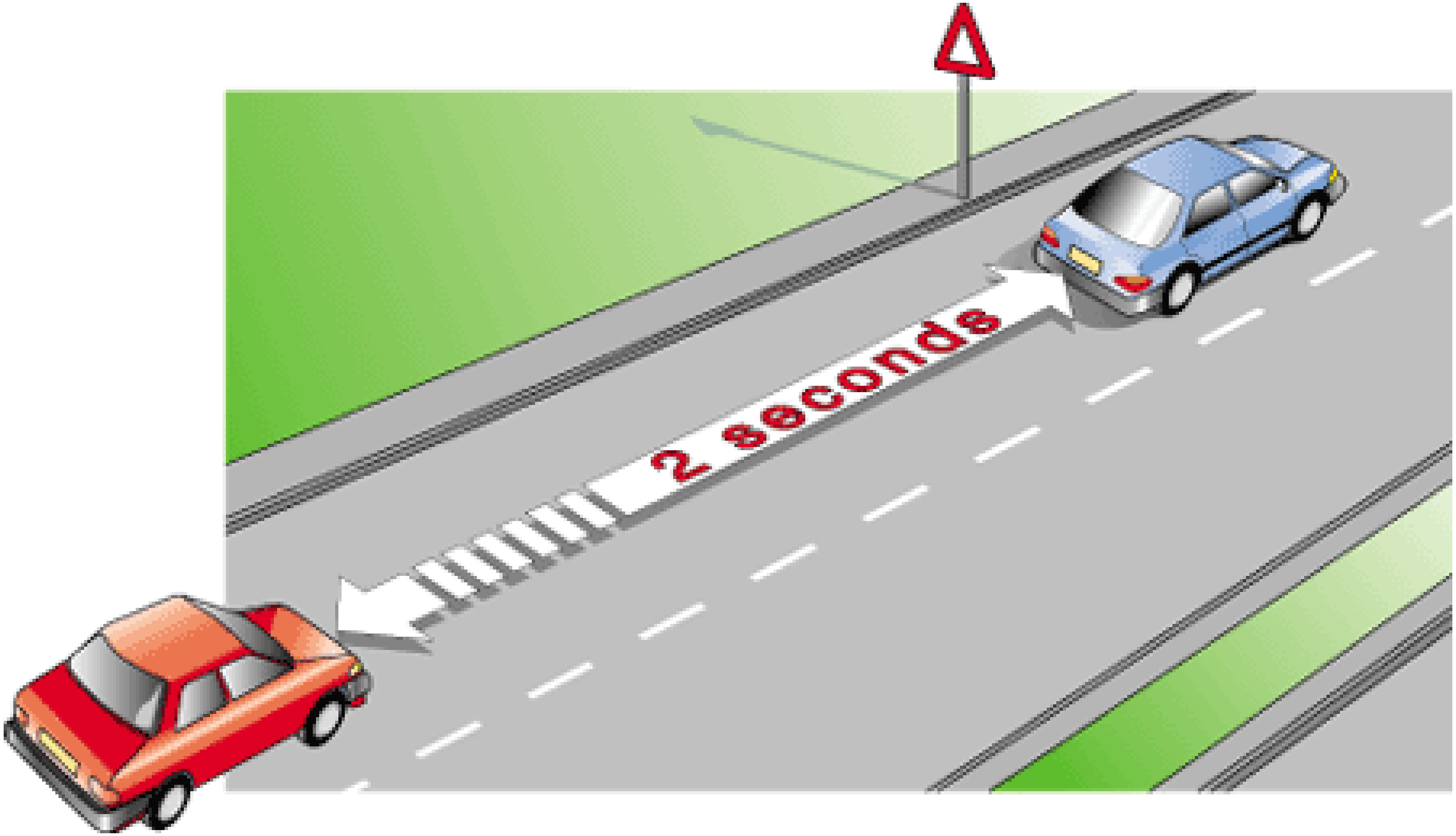
Speed-time graphs and the area under the graph

The area under the graph is the distance travelled.
This is because:

Speed x time = distance



To calculate the total area under the graph: Divide the graph up into rectangles and triangles. Calculate their areas and add them up.



Lesson 3

Car stopping distance

NO
STOPPING
ANY
TIME
34

How to stop a car?

How quickly a car stops depends upon **you** and the **car**.

The distance needed to stop a car completely is called the STOPPING DISTANCE.

Stopping distance = thinking distance + braking distance

Thinking distance = the distance travelled while you decide to put your foot on the brake.

Braking distance = the distance travelled by the car from the moment the brakes are applied to when the car stops completely.

Factors that affect stopping distance

Thinking distance

At 90 miles per hour (90 mph) a car will cover 40 metres every second. Even if your reaction time is as short as 0.5 s you will travel 20 m before you even hit the brakes! This is your **thinking distance**.

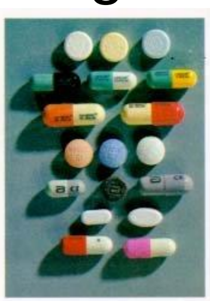
Alcohol

tiredness

Thinking distance

eyesight

drugs



Distractions (posters, people)

Factors that affect stopping distance

Braking distance

The braking distance depends on the car and road conditions.

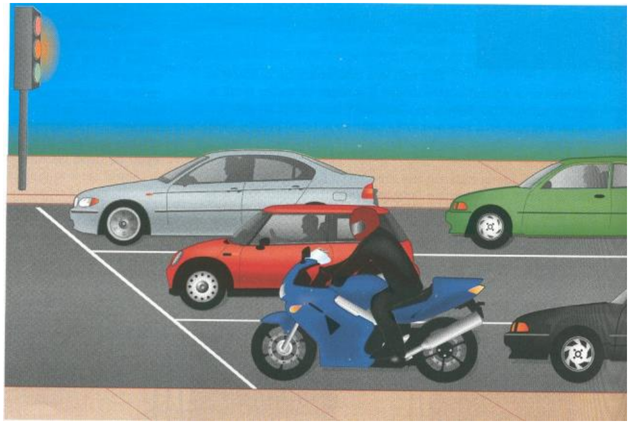
Weather conditions

Road surface conditions

Braking force

braking distance

Mass of car

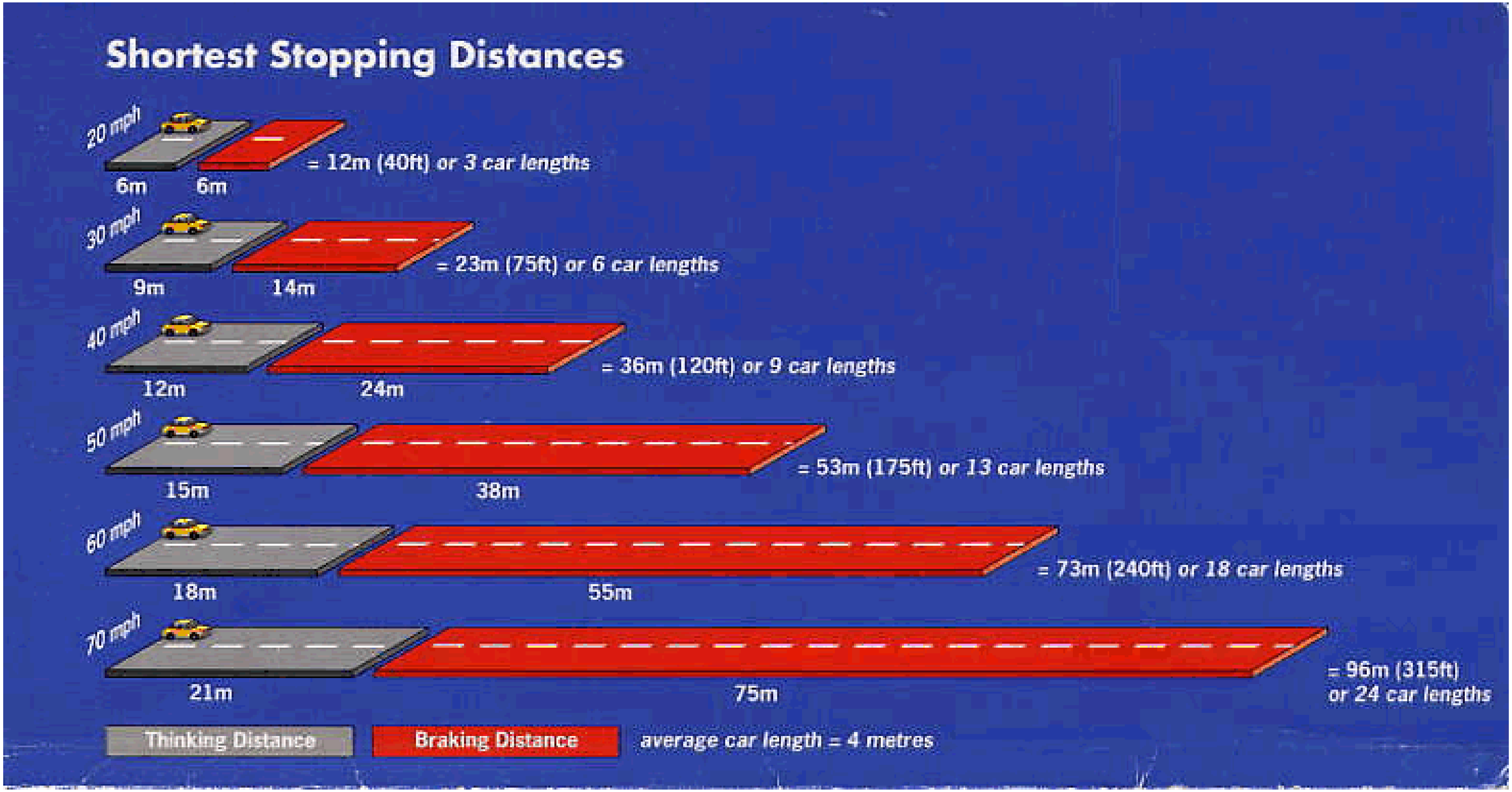


Speed of car

Tyre grip

Recommended stopping distances

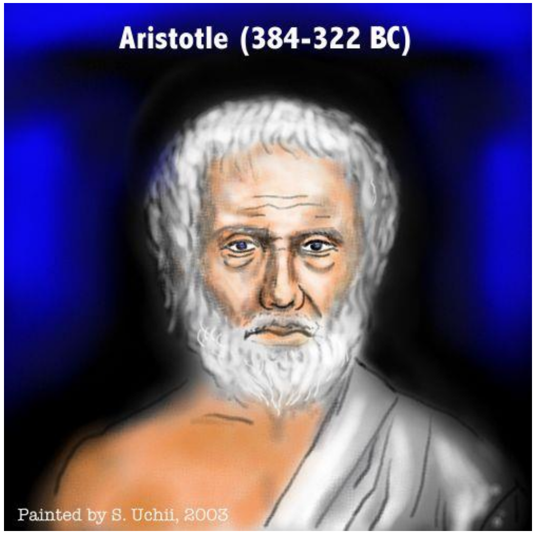
The stopping distances below are ‘ideal’ – they will increase if affected by the factors we have mentioned before.



Lesson 4

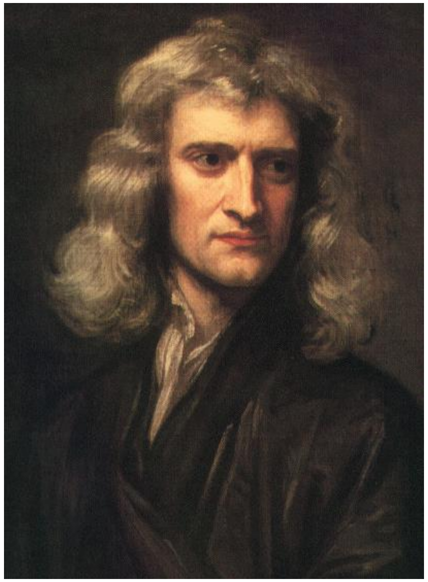
Forces

A brief history of forces



Aristotle (384-322 BC)
The Greek View

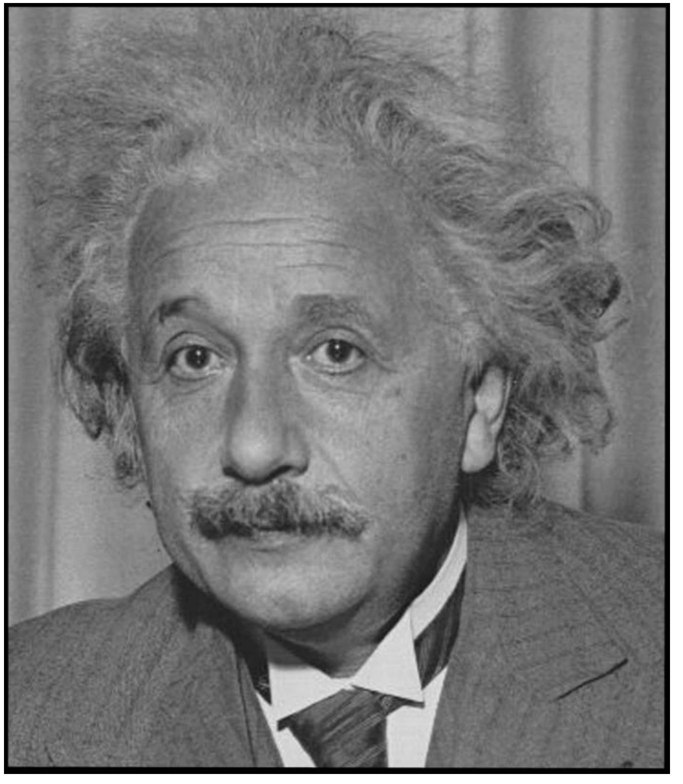
Galileo Galilei (1564-1642)
The modern view



Newton (1642 -1727)
The modern view

The Greeks believed that if an object was moved using a force then the object would stop moving if the pushing force was taken away. The Greeks did not know about friction being that stopped the object. Galileo and Newton changed these views.

A brief history of forces



Albert Einstein (1879 - 1955) had even more to say about forces and motion.

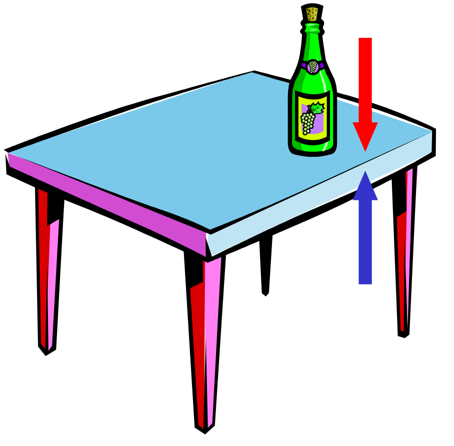
Newton's Laws of Force and Motion

Newton's 1st Law.

Balanced and unbalanced forces.

Newton's 3rd Law.

Opposite and equal forces



Newton's 2nd Law.

Force = mass x acceleration

$$F = ma$$

Newton's 1st Law

Resistive force

Friction and air resistance

Driving force

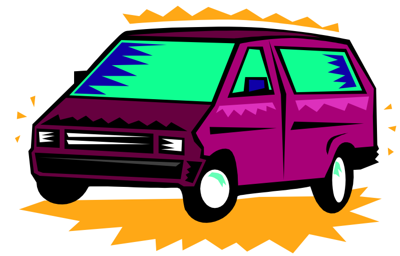
Forces act in pairs. The driving force moves the vehicle forward and the resistive force slows down the vehicle.

If the driving force is equal to the resistive force then the overall force is **balanced**. But, if one of the forces is greater than the other then the overall force is **unbalanced**.

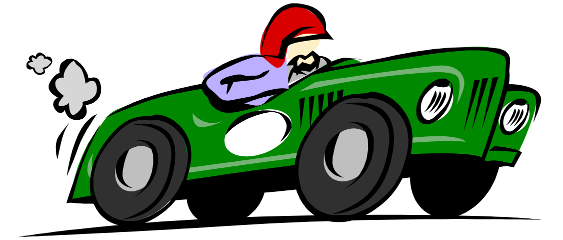
Newton's 1st Law

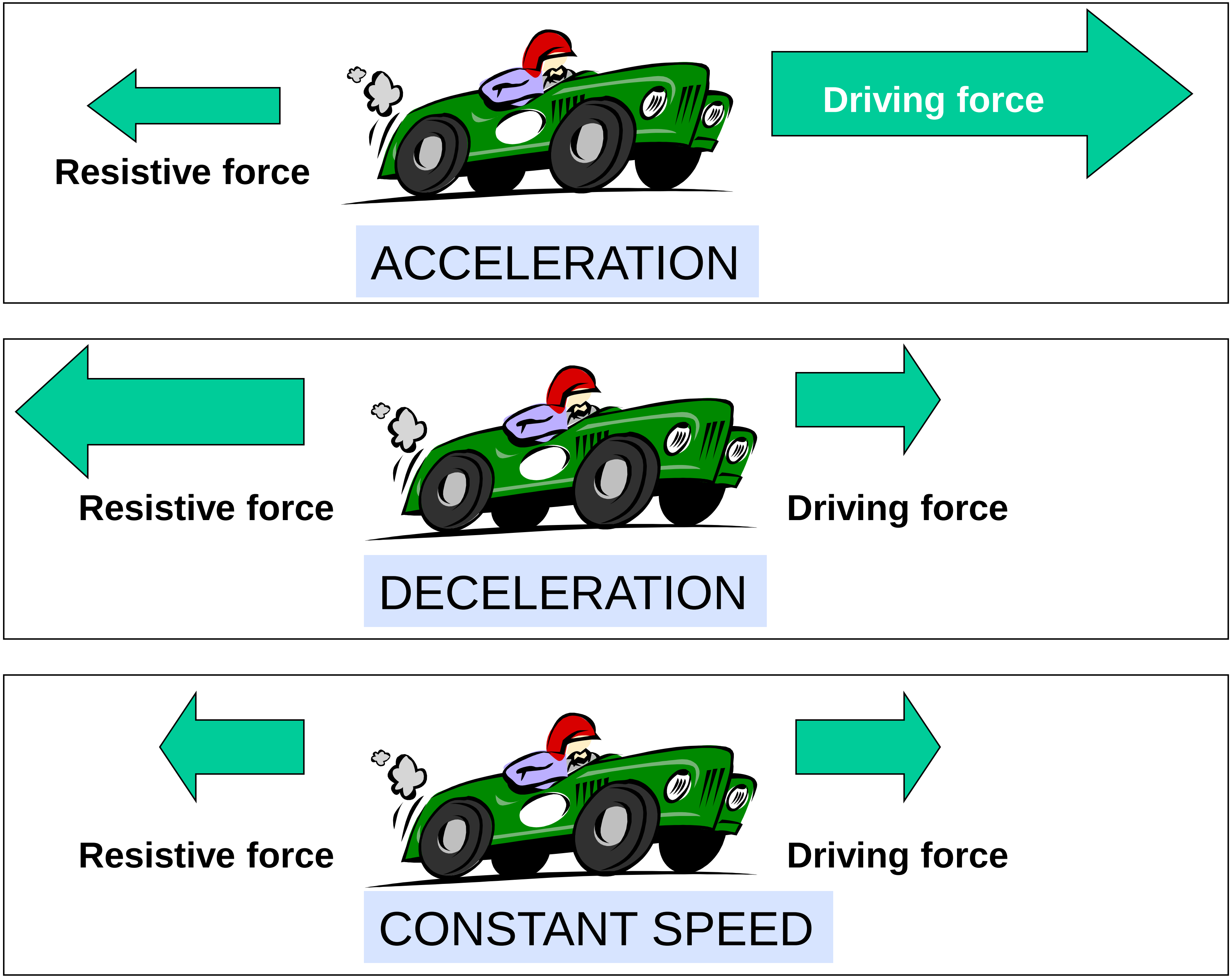
Forces are balanced

A stationary object will stay stationary

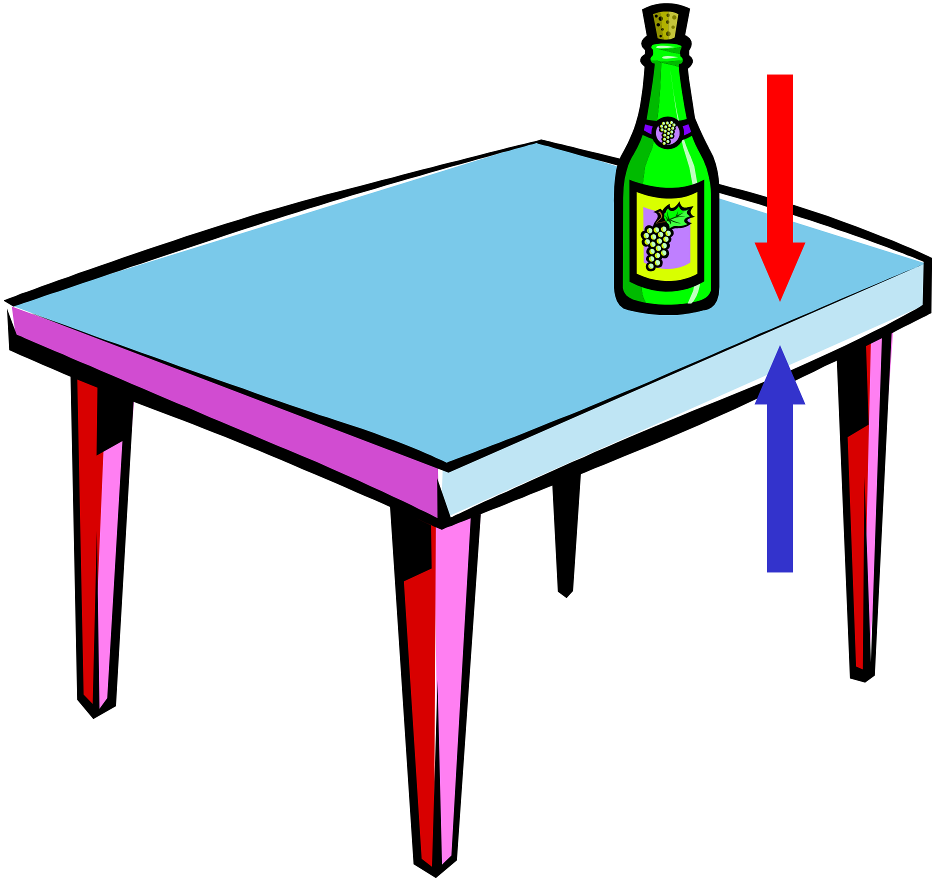


A moving object will move at constant speed.

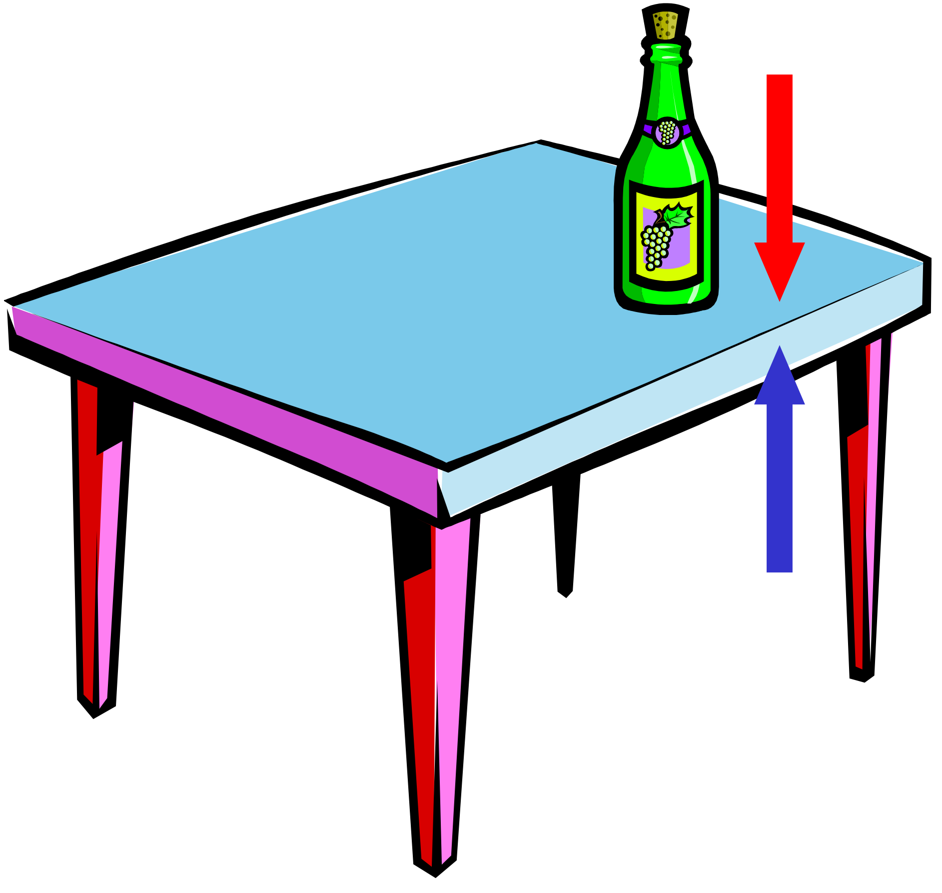



Resistive force
Driving force
ACCELERATION
Resistive force
Driving force
DECELERATION
Resistive force
Driving force
CONSTANT SPEED

Newton's 3rd Law



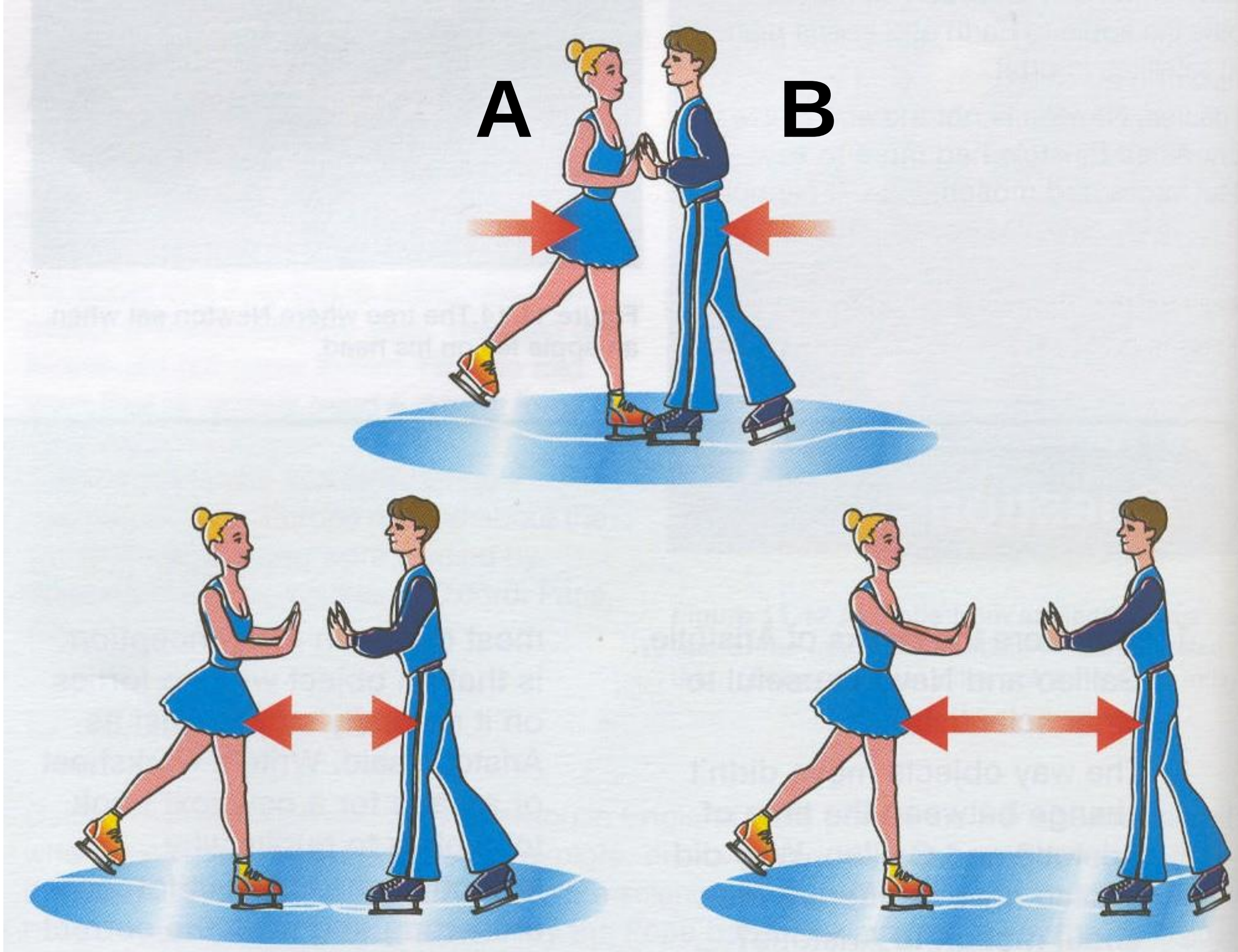
Newton's 3rd Law



The bottle has a downward force on the table. The table has an upward force on the bottle.

The forces are the same in size but opposite in direction.

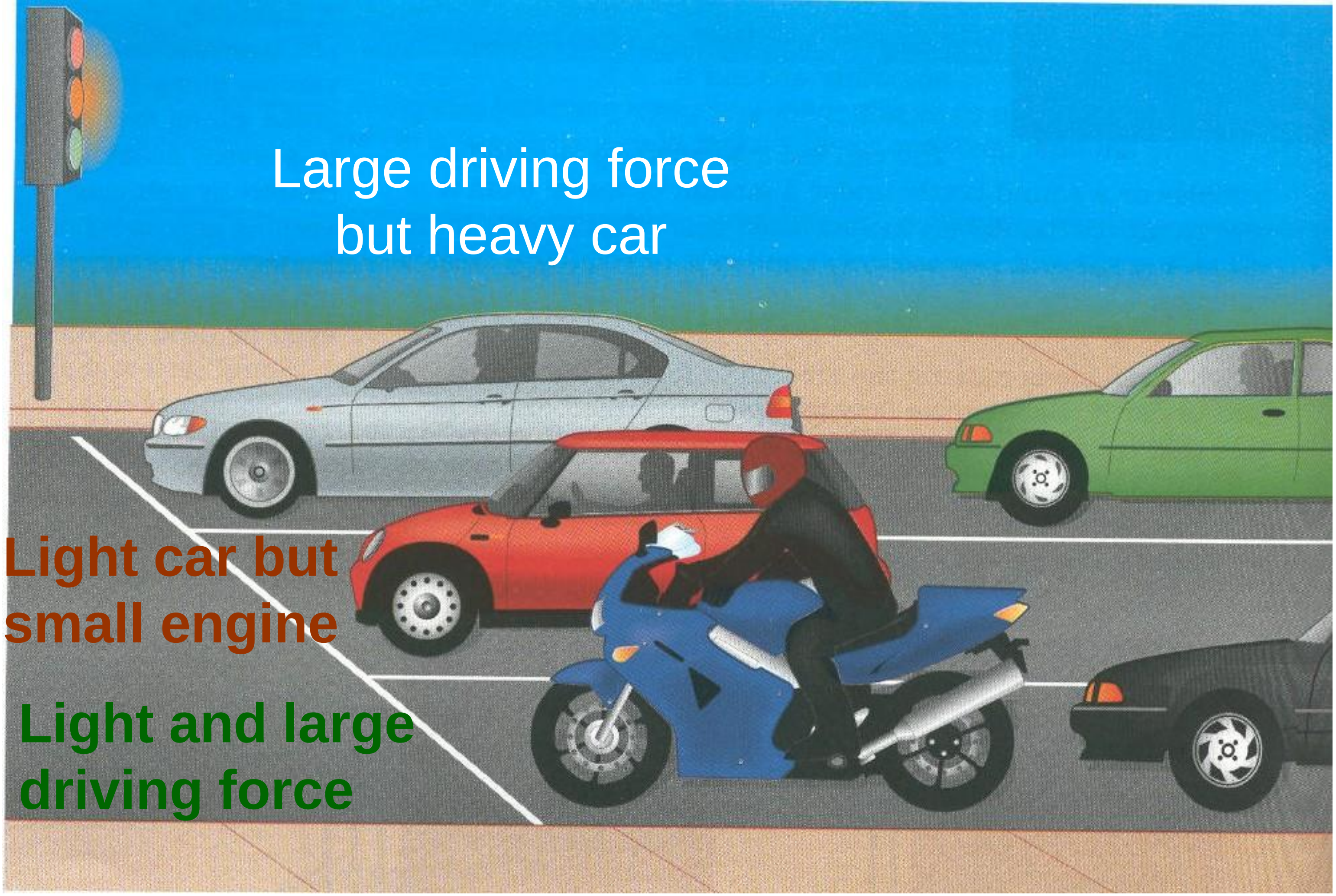
If the forces become unbalanced then either the bottle will fall through the table or the bottle will fly up in the air.



When object ‘A’ pulls or pushes on object ‘B’, then object ‘B’ pulls or pushes object ‘A’ with a force that is **equal in size and opposite in direction**.

Newton's 2nd Law

$$F = ma$$



Who will speed off first at the traffic lights?

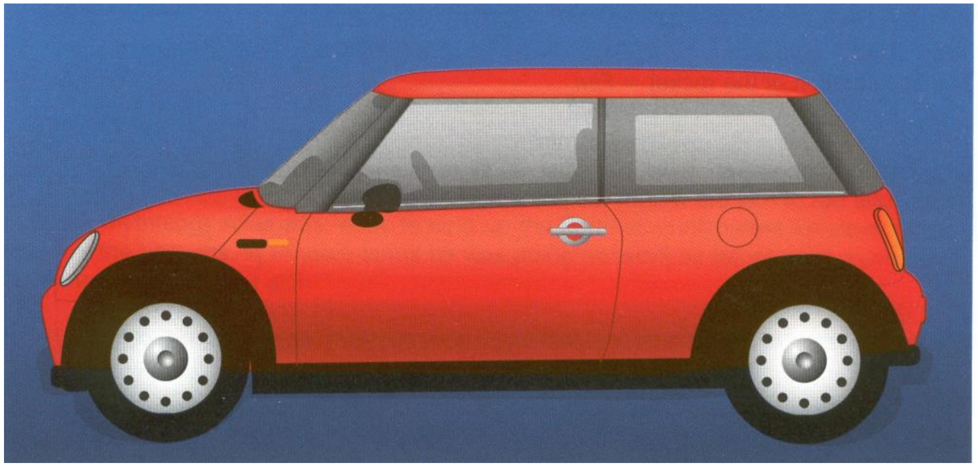
Newton's 2nd Law

To accelerate you need unbalanced forces. For maximum **acceleration** you need the largest unbalanced **force** (the difference between the driving force and the resistive force must big!) and the lightest **mass**.

The force you need can be calculated using the formula:

Force	**=**	**mass**	**x**	**acceleration**
F	=	m	x	a
Newton		kg		m/s^2

Using F=ma



The mini has a mass of 1000 kg and accelerates at 2 m/s^2. What is the net driving force?

$F = 1000\ kg \times 2\ m/s^2$

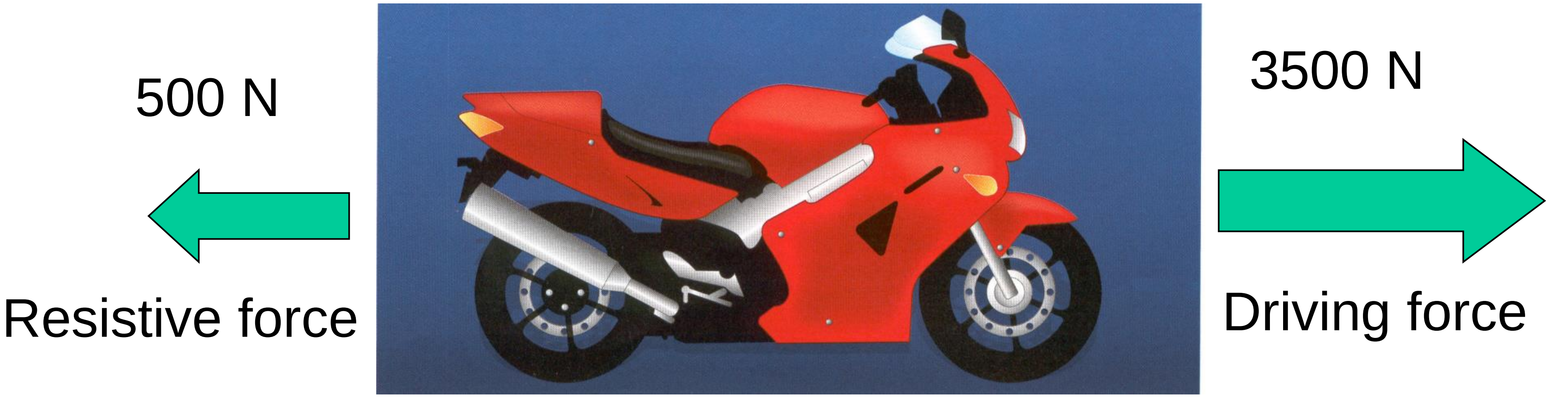
F = **2000 N**

The motorbike has a mass of 500 kg and a driving force of 2000 N. What is its acceleration?

$a = F/m$

a = 2000 N/500 kg = **4 m/s^2**

Using F=ma

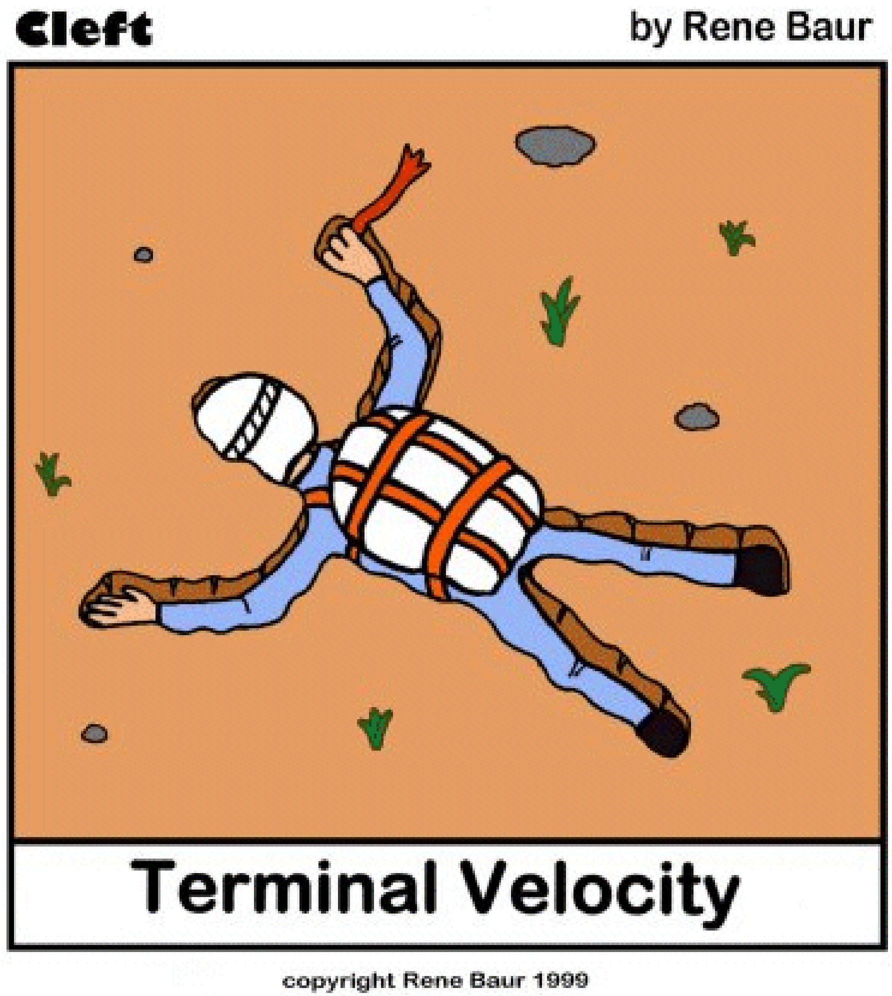


What is the acceleration of the motorbike if it has a mass of 500 kg?

1. Calculate the ‘resultant’ force: 3500 – 500 = 3000 N.
2. a = F/m

   a = 3000/500

   a = **6 m/s²**



Lesson 5

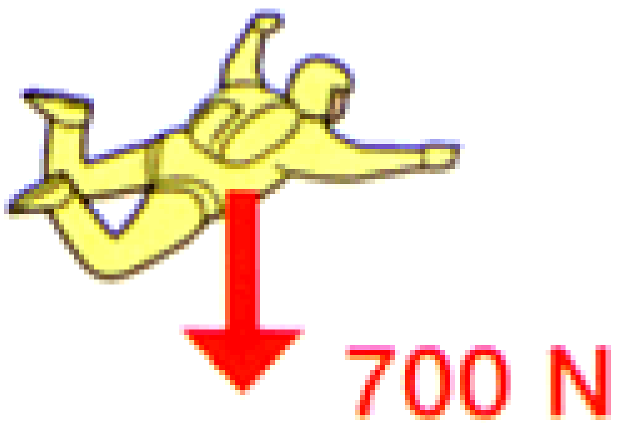
Falling and terminal velocity

Falling

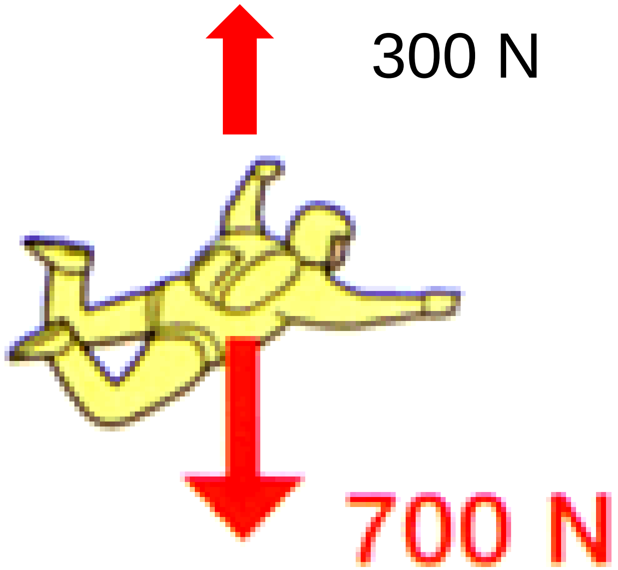
What goes up must come down! Why?

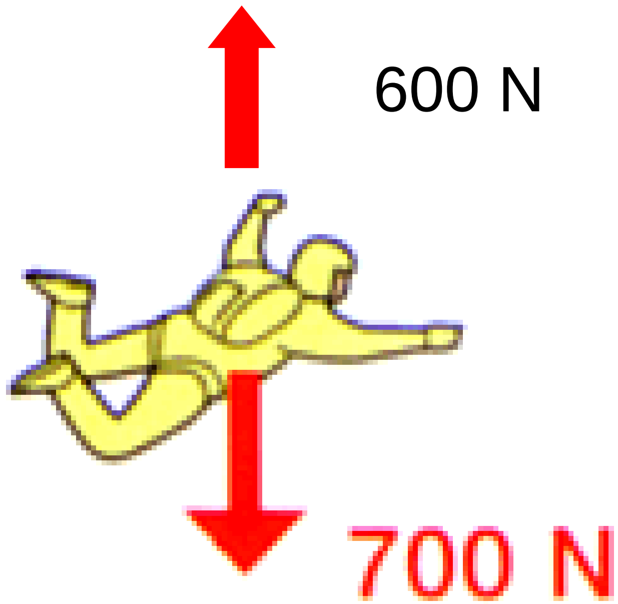
Gravity

When a skydiver falls out of a plane, the greatest force on her would be **gravity**.

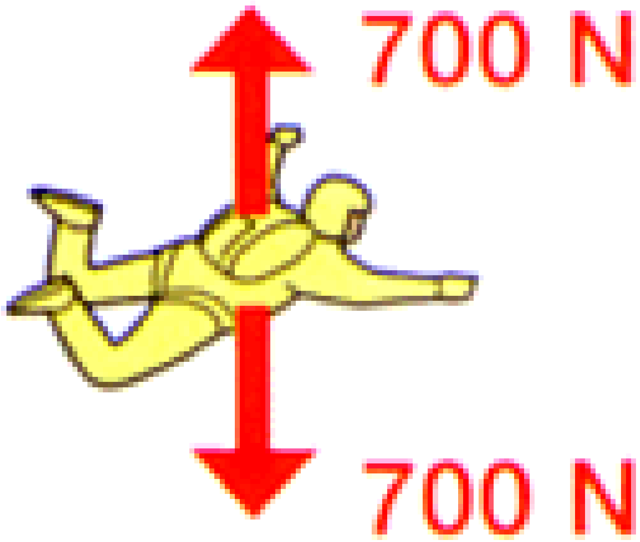


As the skydiver continues falling the force of air resistance starts to increase. But gravity is always , the greatest force on her would be **gravity**.



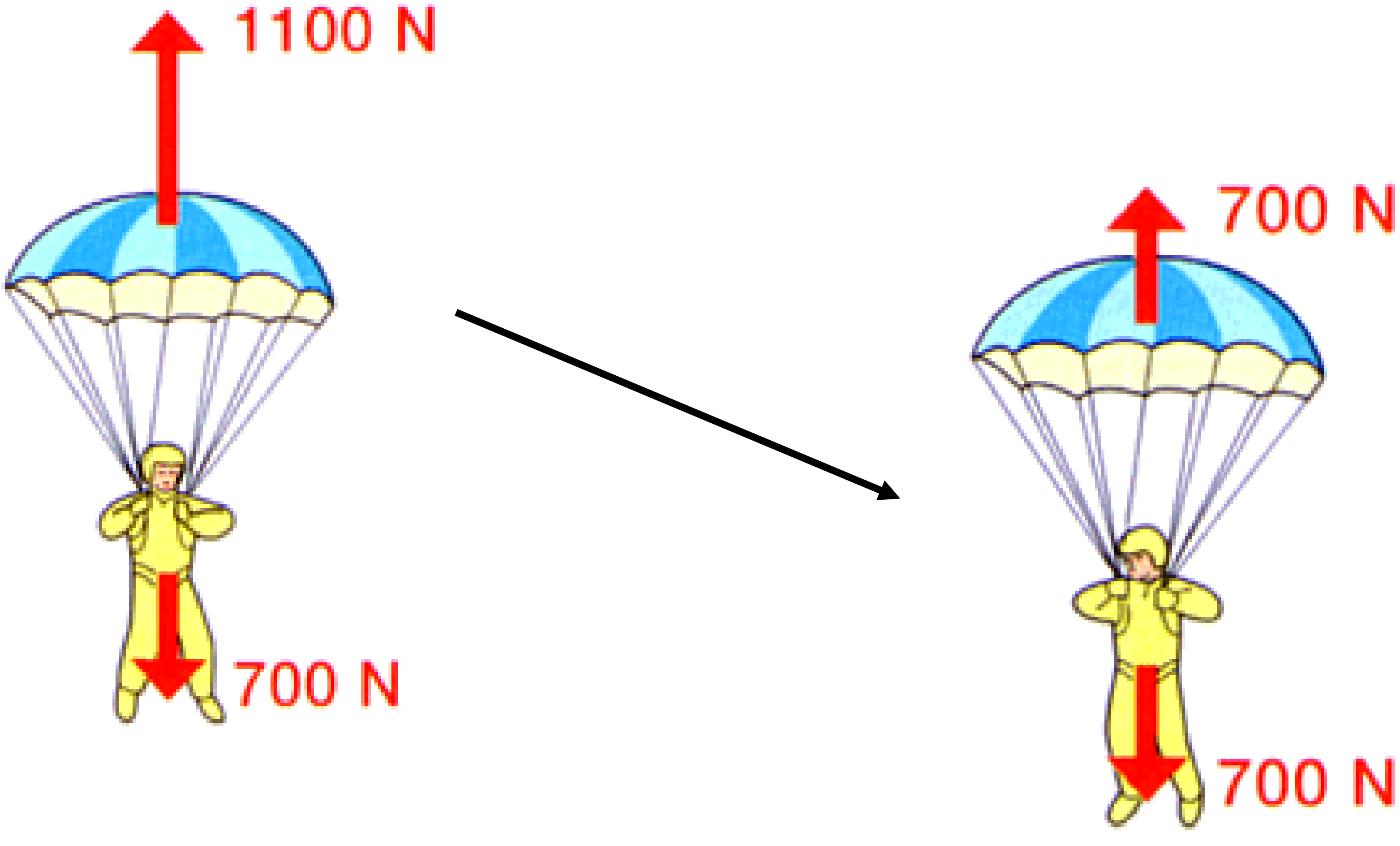


When the force of air resistance equals the force of gravity (forces are balanced), the skydiver reaches a maximum constant speed. This is called TERMINAL VELOCITY..

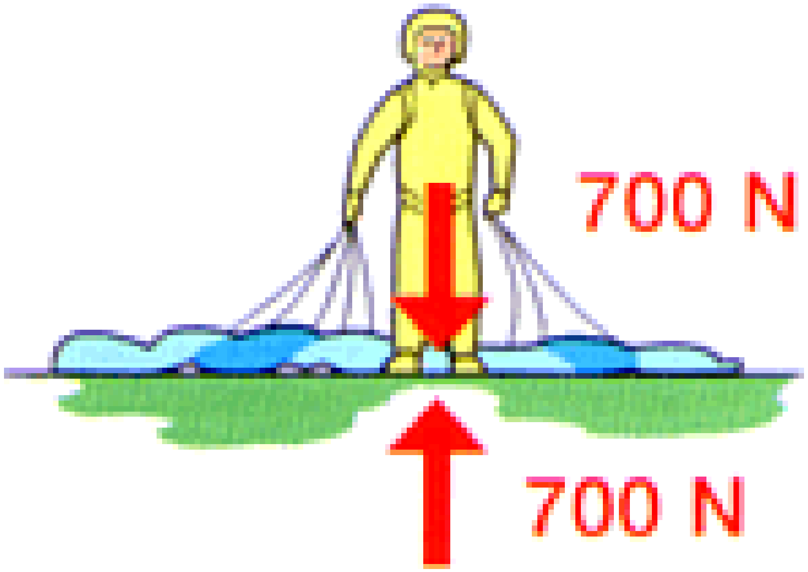


Forces balanced –
terminal velocity

When the skydiver opens her parachute then the force of air resistance is greater than the force of gravity. This slows down the diver. The forces will then balance again and the diver will reach a new terminal velocity.

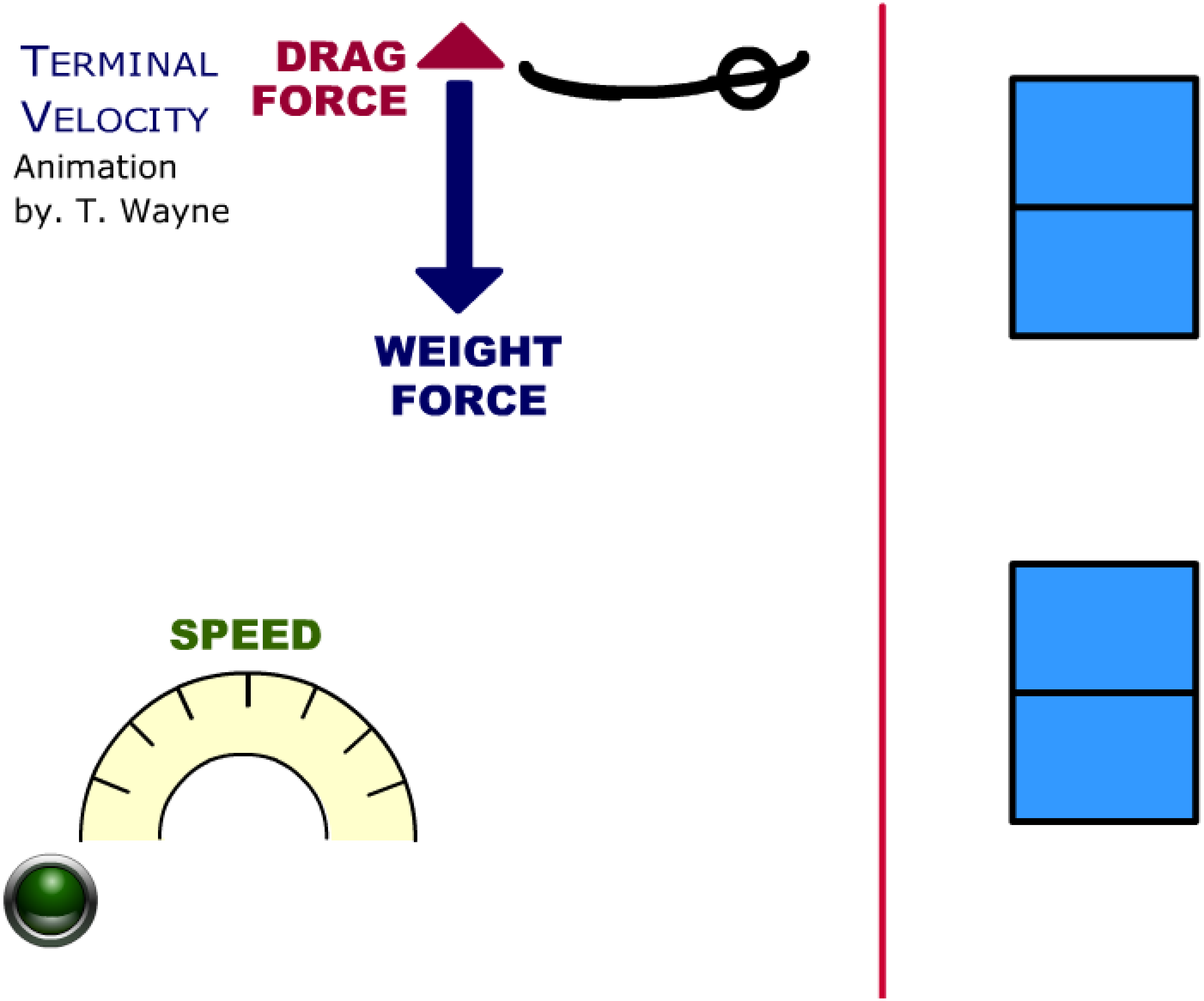


The skydiver then lands.



Terminal velocity - summary

1. When an object starts to fall through the air, the force of gravity is the only force.
2. The force of gravity does not change in size at all.
3. The force of air resistance starts to increase.
4. When the forces are balanced the object reaches constant maximum speed, called **Terminal Velocity**.


TERMINAL
VELOCITY
Animation
by. T. Wayne
DRAG
FORCE
WEIGHT
FORCE
SPEED

Lesson 6

Work done

Learning objectives

To use the **word equation** for ‘Work done’.

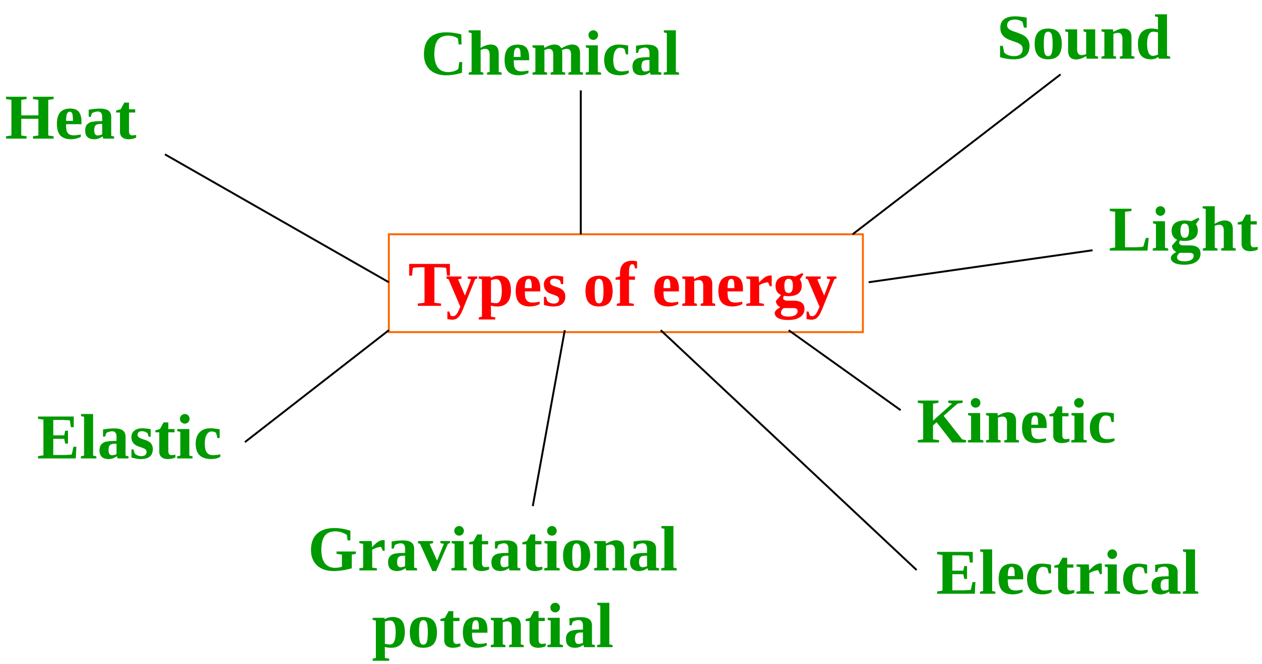
Recognise that work done is the same as energy transferred.

What I must learn

Energy is measured in **JOULES (J)**

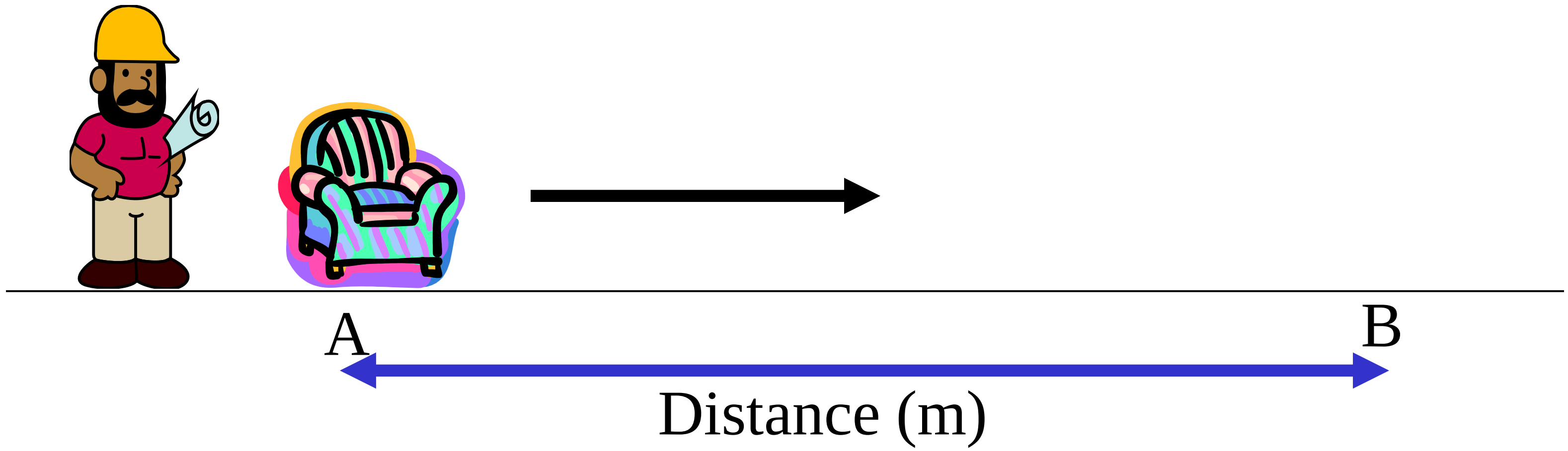
KJ = kiloJoules. J ÷ 1000 = KJ and KJ x 1000 = J

Energy cannot be created or destroyed. It is transferred from one form to another.



Measuring work done on a flat surface

Work done (J) = Force (N) x Distance moved (m)



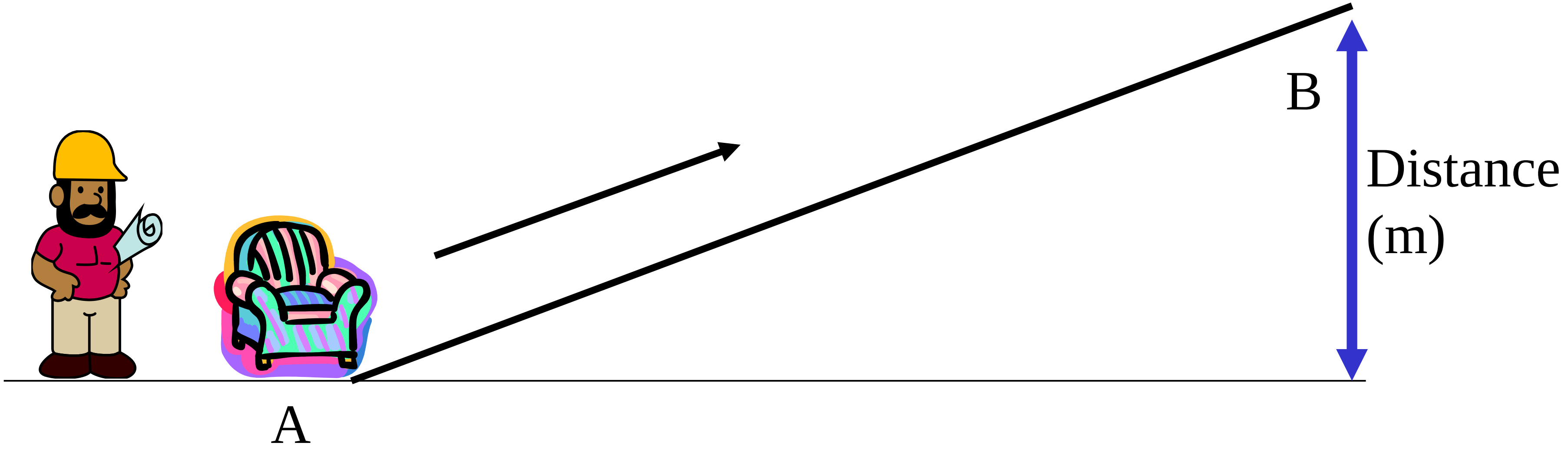
The sofa is pushed with a force measured in Newtons. The distance the sofa is pushed is measured in metres.

e.g., Calculate work done (J) if the sofa is pushed 10 m with a force of 30 N?

Work done (J) = 30 x 10 = 300 J

Measuring work done up a hill

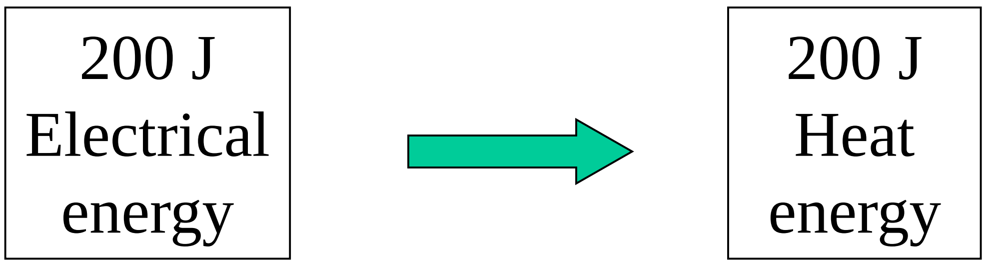
Work done (J) = Force (N) x Distance moved (m)



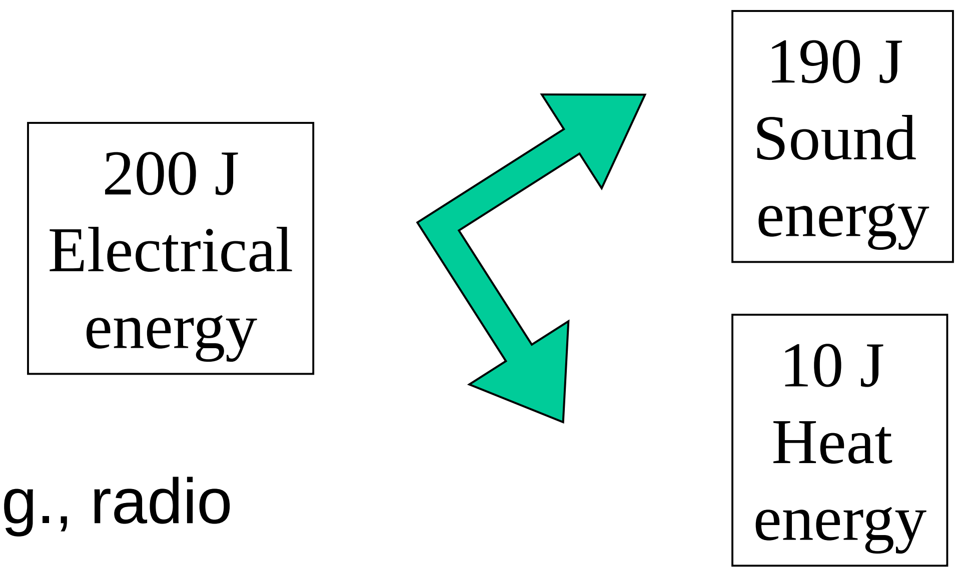
When the object is pushed up a hill, **the vertical height** is taken as the distance moved.

Energy transferred (J) = work done (J)

When work is done, energy must be transferred. The amount of work that can be done depends on the amount of energy transferred. Therefore, energy transferred = work done.



e.g., heater



e.g., radio

These diagrams show the energy transferred and the work done using this energy.

Lesson 7

Power

Power

Learning objectives

To explain that power is a measure of how fast energy is transferred.

To use the Power equation.

Remember the equation for Work Done….

Work done (J) = Force (N) x Distance moved (m)

This equation shows how much energy is transferred when work is done. However, the equation does not tell us how quickly the work is done. To calculate how fast work is done we use the equation for **Power**.

$$\text{Power (W)} = \frac{\text{Work done (J)}}{\text{Time taken (s)}}$$

Power is measured in Watts (W)

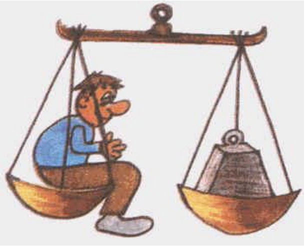
and…..

Since work done is equal to energy transferred the Power equation can also be written as:

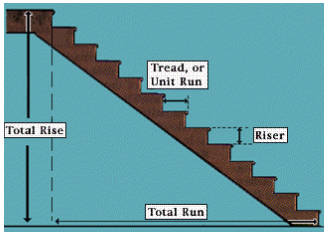
$$\text{Power (W)} = \frac{\text{Energy transferred (J)}}{\text{Time taken (s)}}$$

The faster you work, the more energy is transferred, the more powerful you are!

Measuring your own personal power



1. Measure your mass in kg and work out your weight in Newtons (mass x 10).



2. Measure height of stairs in metres.
3. Calculate 'work done' (use formula).

4. Measure time taken to run upstairs in seconds.

5. Calculate Power in Watts using power equation.

Example calculation of personal power

Mass of person = 50 kg

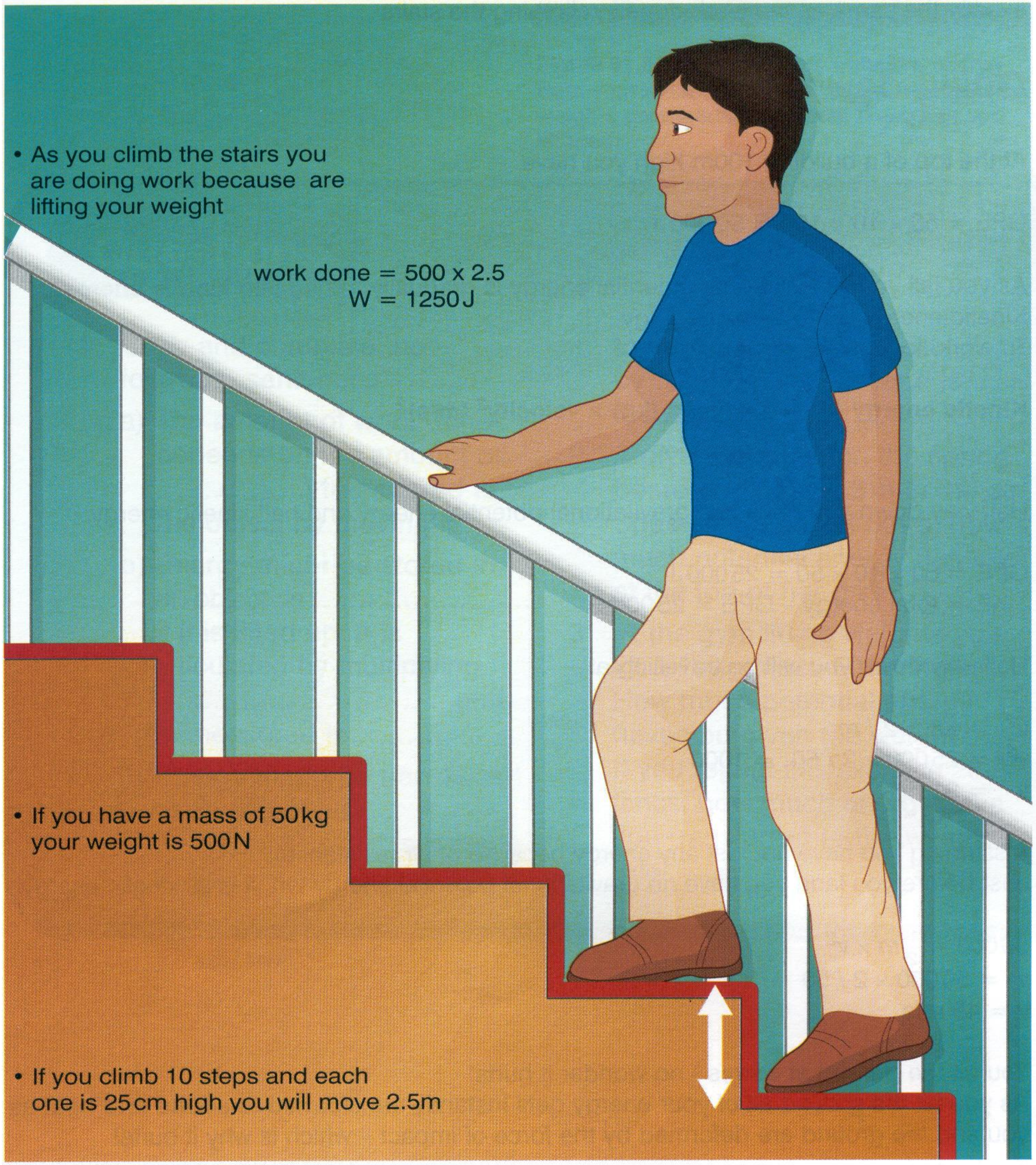
Weight =

Height of stairs = 2.5 metres

Work done (J) =

Time taken to run up stairs = 10 seconds

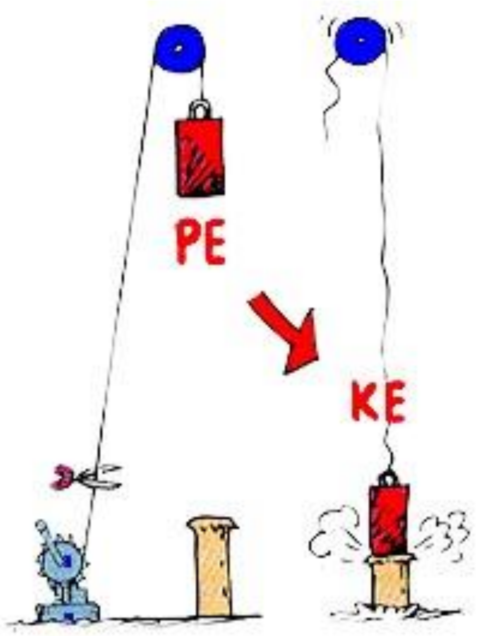
Power (W) =



Measure your mass.

Calculate force.

Time how long it takes.



Lesson 8

Gravitational Potential Energy and Kinetic Energy

Gravitational Potential and Kinetic energy

Learning objectives

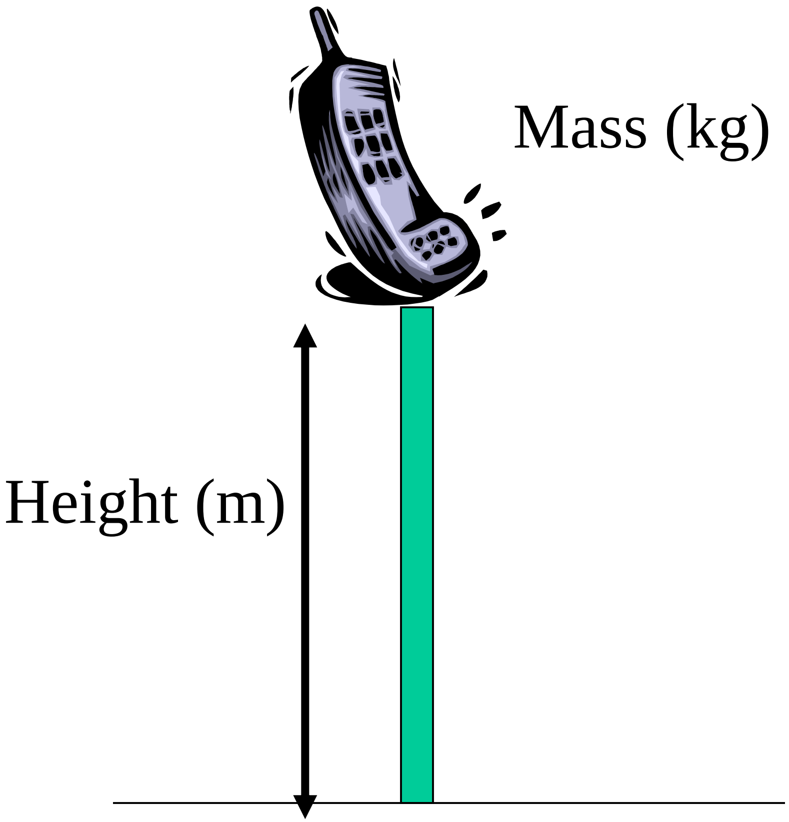
Define gravitational potential energy and kinetic energy.

Use a diagram to explain the link between GPE and KE.

Use the equations for GPE and KE.

What goes up.........

Gravitational Potential Energy (GPE) is defined as the energy an object has because of its position above the ground.

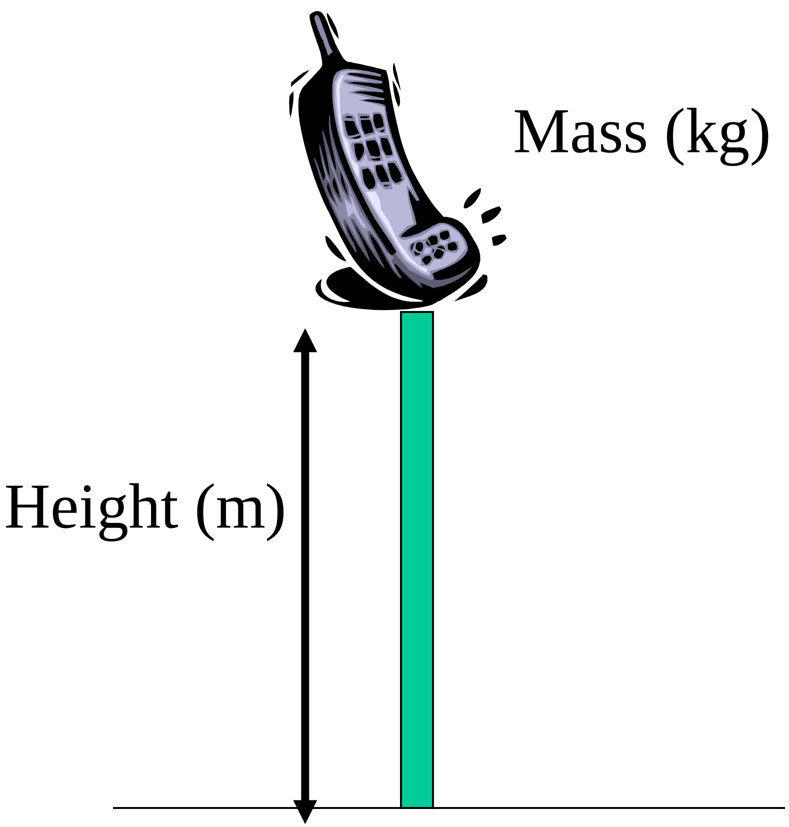


If the object is pushed then gravity will cause it to fall to the ground.

The amount of energy released depends on the **force** produced by the object and the **height** it falls from.

Calculating force

On Earth, 1 kg of mass has a force of 10 N.
This is called the gravitational field strength (*g*)



Once the force is known then the gravitational potential energy can be calculated.

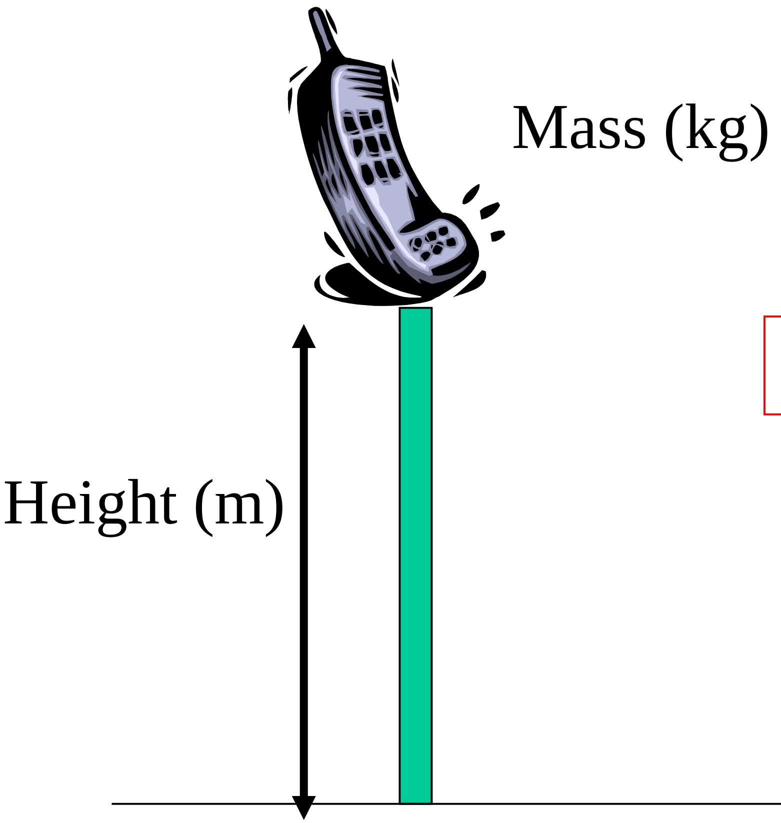
GPE (J) = mass (kg) × *g* × height (m)

or

GPE (J)= mass (kg) × 10 × height (m)

Gravitational Potential Energy

Gravitational Potential Energy (GPE) is defined as the energy an object has because of it position above the ground. It is stored energy.

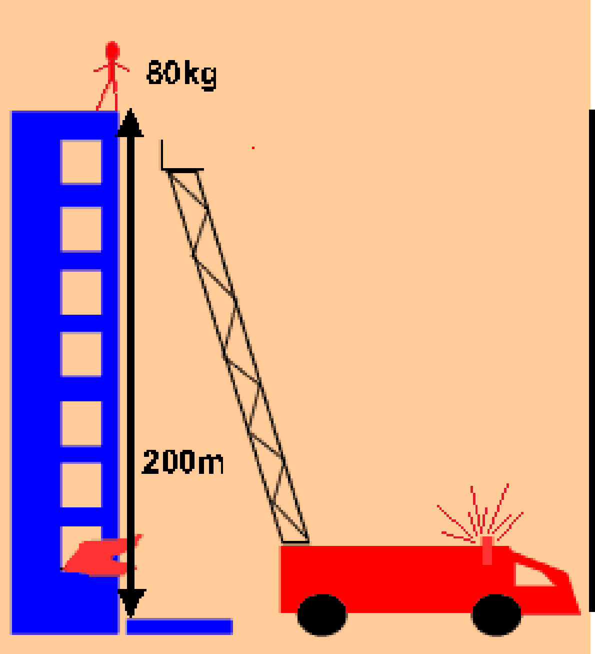


GPE (J) = mass (kg) × 10 × height (m)

GPE = mgh

What happens to the GPE when the object falls?

As the object is falling the GPE is transferred into Kinetic Energy (KE). Kinetic energy is the energy produced by movement.



Height (m)	GPE (J)	KE (J)
200	160000	0
100	80000	80000
>0	0	160000

When the person hits the mat all the energy is transferred into ….?

Heat and Sound

Kinetic Energy

Kinetic energy is movement energy.

$$KE\ (J) = \tfrac{1}{2} \times \text{mass (kg)} \times \text{velocity}^2\ (m/s)^2$$

$$KE\ (J) = \tfrac{1}{2} \times m \times v^2$$

The kinetic energy increases as the mass and/or speed of the object increases.

$$\textbf{GPE}\ (J) = \text{mass (kg)} \times 10 \times \text{height (m)}$$

$$\text{GPE} = mgh$$

$$\text{KE (J)} = \tfrac{1}{2} \times \text{mass (kg)} \times \text{velocity}^2\ (\text{m/s})^2$$

$$\text{KE (J)} = \tfrac{1}{2} \times m \times \text{v}^2$$