## Techniques to Engage Students in Mechanics:
## 1.    A silent poster

## INTRODUCTION TO FORCE

### Getting Started: Poster Activity

What do you understand by Force?

The word force is often used in an everyday sense, but has a more precise scientific meaning. What do you understand by the word force?

- Write down your 'definition' of the word force.

Answer the questions below using your understanding of the word force.

- If you drop a ball, gravity exerts a downward force on the ball. What happens to the ball? What is the effect of this force?

- You apply the brakes on a bicycle that you are riding. This result of this action is a backward force. What is the effect of this force?

- A tennis ball is travelling towards you, and you hit it with a racquet. The racquet exerts a force on the ball. What is the effect of this force?

- You are travelling on a well-oiled skateboard on a level surface. What happens to your speed? Why? In a perfect environment how far would the skateboard move before stopping?

### Summary

A force is defined as a physical quantity that causes a **CHANGE** in motion.

Forces can

- Start motion

- Stop motion

- Make objects move faster or slower

- Change the direction of motion

Force is a vector quantity with magnitude and direction.

The unit of force is the **Newton**

# Techniques to Engage Students in Mechanics:
## 2.    Concept Questions

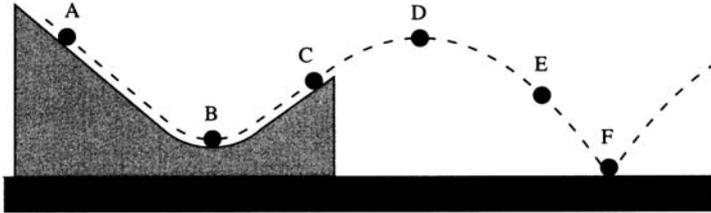**Direction of Resultant Forces**

1.    A ball is thrown vertically upwards and its path is shown in the diagram.
      The ball rises up through the point A until it reaches its highest point B. It then falls
      vertically downwards through the point C.
      Mark on the diagram, at each position, an arrow indicating the direction of the force
      acting on the ball.

●   B                at rest

●   C                ball going down

●   A                ball going up

2.    A ball rolls along the track and then moves through the air, following the path shown in the diagram.



Draw arrows to indicate the direction of the resultant force at each position.
(The track is straight except for the lowest part where it is circular.)

# Techniques to Engage Students in Mechanics:
## 3.    A 'Gallery Walk'

### Force Diagrams: Gallery Walk Activity: Group A tasks

For each situation illustrated below, draw a diagram to show the force of gravity, normal reactions, tensions and friction forces that are acting on each object that has been underlined and is in italics:
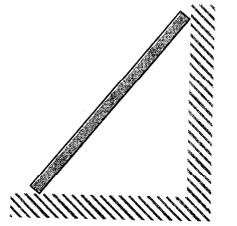
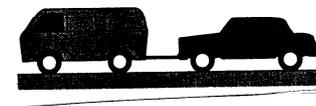A *plank* resting on two concrete blocks:

A *skier* travelling down a slope:

A *plank* leaning against a wall:

A *pole* stuck between two bars of a climbing frame:

A *van* of mass 1100 kg is towing a *car* of mass 750 kg.
There is a resistance force of 300 N on the car and 500N on the van.

# Force Diagrams: Gallery Walk Activity: Group B tasks

For each situation illustrated below, draw a diagram to show the force of gravity, normal reactions, tensions and friction forces that are acting on each object that has been underlined and is in italics:
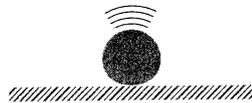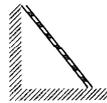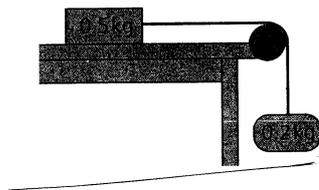
A *box* on a table.
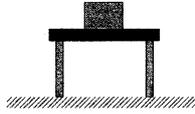
A *sledge* moving on a slope.

A *ball* as it hits the ground.

A *ladder* resting against a wall.

A *block* on a rough horizontal surface attached to an *object* by a string.

| Techniques to Engage Students in Mechanics: |
| 4.  'Fascinating' links |

## Newton's Law of Universal Gravitation

There is always a force of gravitational attraction between any two objects. For example there will be gravitational attraction between any two people in this room, but fortunately the magnitude of this attraction is small enough to be insignificant. There are strong gravitational forces between the sun and other planets in the solar system. Without these forces the plants would not continue in their orbits.

Newton formulated a **Law of Universal Gravitation**, based on his observations of the motion of planets. The law states that the force of attraction between any two objects is:

$\dfrac{GmM}{d^2}$ where $m$ and $M$ are the masses of the objects, in kilograms, $d$ is the distance between

their centres, in metres, and $G$ is a constant which has the value
$6.67 \times 10^{-11}$ kg$^{-1}$ m$^3$ s$^{-2}$.
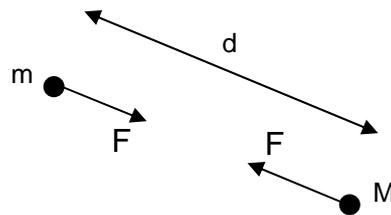


$$F = \frac{GmM}{d^2}$$

$$G = 6.67 \times 10^{-11} kg^{-1} m^3 s^{-1}$$

Note that the forces act on both objects and both have the same magnitude.

### Exercise: The Universal Law of Gravitation

Assume that the earth is a sphere with:
mass of the earth $= 5.98 \times 10^{24}$ kg and
radius of the earth $= 6.37 \times 10^6$ m

1. What is your mass?
2. What is the gravitational force exerted on you by the earth?

# The Force of Gravity on a object on (or near to) the earth's surface

The properties of the universal law of Gravity for an object close to the earth's surface can be drawn together to provide a law:

Every object on or near the Earth's surface is pulled vertically downwards by the force of gravity. The size or magnitude of the force on an object of mass $M$ (where $M$ is in kilograms) is $Mg$ newtons where $g$ is a constant whose value is approximately 9.8.
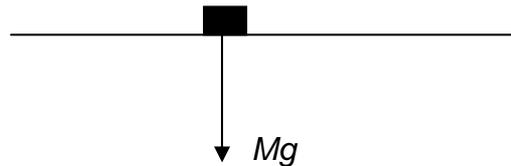


## Weight

In mechanics, the word **weight** means the force of gravity acting on an object. This different from everyday life where it is used to mean mass. For example, when a greengrocer says that the weight of a bag of apples is 1 kg this is a concise way of saying that its weight is that of a 1 kg mass.
To be mathematically correct he would say that the bag of apples had a mass of 1 kg. The weight is really 9.8 newtons. The word weight should be used with care, to avoid confusion.

## Force of Gravity and $\pi$

Work out the value of $\pi^2$ and compare its value with $g$.

What would the radius of the earth be if $\pi^2 = g$?

What would the mass of the earth be if $\pi^2 = g$?