CHAPTER ONE

FORCE, WEIGHT AND THE CENTRE OF GRAVITY:

Force: This is defined as the agent which changes a body`s state of rest or uniform motion in a straight line. It denotes a push or a pull.

Effects of force:

- It can applied to stop a moving body.
- It can increase the speed of a moving object.
- It can cause a change in the direction of movement of a body.

Types of forces: There are different types of forces and some examples are:

(1) The force of gravity:

- This is the force which attracts us and other objects towards the centre of the earth.
- If an object is thrown into the sky, it is this force which pulls its back to the surface of the earth.

(2)Centripetal force:

- This is the force which is needed in order to enable a body move in a circular motion.
- It therefore acts on every object which moves in a circular motion.

(3)Tension force:

- This is the opposing force which tends to make a rubber contract when it is stretched.

(4)Magnetic force:

- This is the type of force which acts between two magnets or between a magnet and a magnetic material.

(5)Surface tension:

- This is the force which acts on the surface of a liquid and enable it acts as an elastic material.

(6)**Cohesive force:**

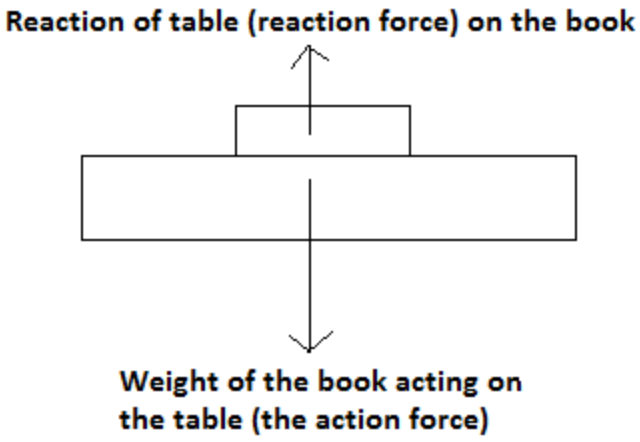
- This is the type of attractive force, which acts between the molecules of the same kind.
- It is this force which pulls small amounts of a liquid into droplets.

(7)**Adhesive force:**

- This is the type of attractive force, which acts between the molecules of a liquid and another material.

(8)**Action and reaction forces:**

- Whenever a force acts on a body, there must be an equal and opposite force or reaction acting on the same body.
- In short, action and reaction forces are equal but opposite.
- For example, if a book lies on a table and exerts a force which is equal to its weight on the surface of the table, then the table will exert an equal upward reaction force on the book.



(9)**Resultant force:**

- When two or more forces are acting at a point, it is always possible to find a single force which has the same effect as these forces.
- This force is called the resultant of these forces mentioned.

(10) **The equilibrant:**

- When two forces act on a body, they generally produce motion on the body.
- A third force introduced to restore the body in equilibrium, is referred to as the equilibrant of the first two forces.

(11) The total gravitational force:

- This is made up of the force of gravity and the centripetal force.

Weight and mass:

- The mass of a body is the amount of matter it contains.
- But the weight of a body is the force, which it exerts on anything which freely supports it.
- A body has weight because the force of gravity is pulling it towards the surface or the centre of the earth.
- This enables it to exert a force on its support which is referred to as its weight.

Differences between weight and mass:

(1) The weight of a body is the force which it exerts on its support, but the mass of a body refers to the amount of matter it contains.
(2) Mass is a scalar quantity but weight is a vector quantity.
(3) Weight is measured in kilogram force (kgf) or gram force (gf), but mass is measured in kilogram or grams.
(4) The mass of a body remains always constant, but the weight of a body changes from place to place.

Our weight and the total gravitational force:

The total gravitational force acts on everybody or item found on the surface of this earth. Since our earth is in a circular motion, then every object or person moves in a circular motion or path, and for this reason, centripetal force will be needed. Part of the

total gravitational force is therefore used to provide this needed centripetal force. The remaining part of the total gravitational force, called the force of gravity attracts us towards the centre of the earth, and so enables us to exert a force on our support, i.e. enables us to have weight. It must also be noted that the greater the speed of this circular motion, the greater will be the amount of centripetal force needed, and vice versa.

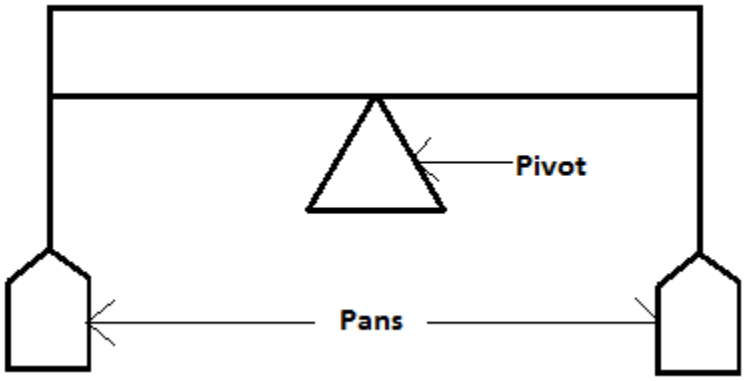
Weightlessness:

- Assuming we stand on a weighing machine, and that by certain means the speed of earth`s rotation can be increased, then more centripetal force will be needed to act on our bodies.
- Part of the force of gravity pulling us towards the surface of the earth, will therefore be converted in the extra needed centripetal force.
- Since the force of gravity acting on us has decreased, then our weight will also decrease.
- As the speed of rotation keeps on increasing, then more centripetal force will be needed and for this reason, our weight will keep on decreasing.
- At a particular speed, the centripetal force needed will just be equal to the total gravitational force and none will be available to provide gravity force, which enables us to have weight.
- The weighing machine will indicate a zero reading and we are said to have become weightless or experiencing weightlessness.

Measurement of weight:

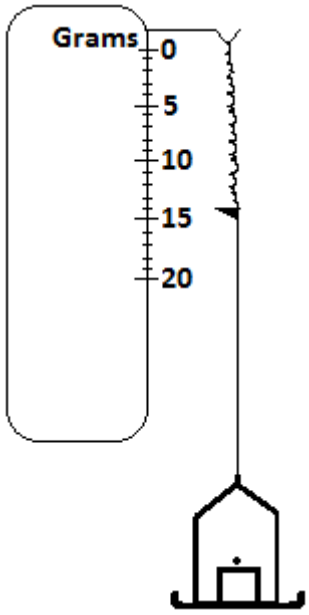
- Weight can be measured by using the lever balance (beam balance), or the spring balance.

Measurement of weight using the beam or the lever balance:



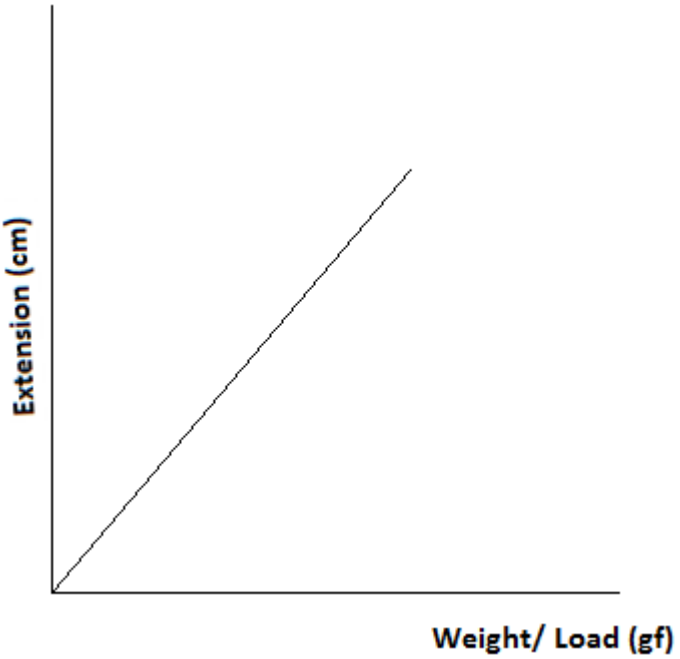
- The beam balance consists of a uniform rigid material such as a stick, which is pivoted at its centre, i.e. a pivot is placed at its centre.
- Found hanging at the two ends are two empty pans of equal weight.
- If these two pans are empty, the rigid material will be in equilibrium, i.e. in the horizontal position.
- With the aid of known weights, the beam balance can be used to determine the weight of an unknown item.
- These known weights are certain metallic solids, whose weights have been indicated or written on them.
- They come in the form of different weights such as 1 gram, 2 grams and 3 grams.
- In order to determine the weight of an unknown item, the item is placed in one of the pans.
- Some of the known weights are then placed into the other pan, until equilibrium is achieved.
- At equilibrium, the total weight of all those known weights placed into the pan, is equal to the weight of the unknown item.

Measurement of weight using a spring balance:



- Weight or mass can be measured by using a spring balance.

- In this method, one end of a spring is fixed to a point, and the unknown weight or mass is placed in a light pan or container, which is attached to the other end of the spring.
- The extension of the spring will be proportional to the applied force or weight.
- This extension produced causes a pointer to move over a scale to indicate the weight. -
- The principle underlying the spring balance was first investigated by Robert Hooke.
- He showed that when a spring is fixed at one end and a force is applied at the other end (i.e. a weight is hanged at the other end), then the extension produced in the spring will be proportional to the applied force, provided the elastic limit is not reached, (i.e the force not large enough to stretch the spring permanently).
- Hooke`s law states that, provided the elastic limit is not exceeded, the extension of a material is proportional to the applied force or weight.
- To verify Hooke`s law experimentally or by means of an experiment, a spiral spring with a scale pan and a pointer attached is held vertically by a clamp and a stand.
- Equal weights are then added to the pan, say 10gf at a time and in each case, the corresponding extension of the spring noted.
- By plotting a grapg of extension against force (weight), a straight line which passes through the origin is had.
- This shows that the extension produced is proportional to the applied force or weight.



The centre of gravity:

- The centre of gravity of a body is the position, through which the weight of the body is supposed to act.

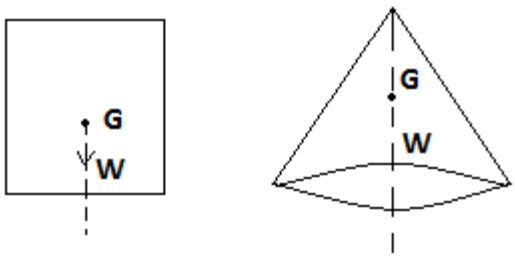
- Every body or object has small gravitational forces acting on it.
- All these small gravitational forces together act as a single force, at just one point.
- This point is called, the center of gravity of the body.

Types of equilibrium:

There are three types and these are:

(1) Stable equilibrium.
(2) Unstable equilibrium.
(3) Neutral equilibrium.

Stable equilibrium:



- An object is said to be in stable equilibrium, when the vertical line through which the centre of gravity acts, passes through the base of the object, i.e. the line of action of weight W passes through the base of the object.
- For stability, the vertical line through which the centre of gravity acts must pass through the base of the object.
- This is so for the objects shown in the diagrams drawn, and they are therefore in stable equilibrium state.