

## FORCES IN EQUILIBRIUM

18 FEBRUARY 2014



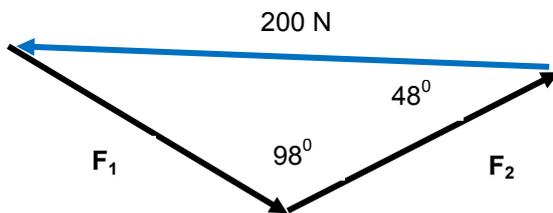
### Lesson Description

In this lesson we:

- Explain forces in equilibrium
- Define the equilibrant
- Show the relationship between the equilibrant and the resultant force
- Explain the triangle of forces



### Challenge Question



Three forces in equilibrium are indicated by the triangle of forces above. Calculate the magnitude of  $F_1$  and  $F_2$ .



### Summary

A number of forces acting on an object are in equilibrium if their vector sum (resultant) is equal to zero. The single force that brings about balance to a number of forces acting on an object is called the equilibrant. The equilibrant is equal in magnitude to the resultant force but acts in the opposite direction.

Examples:

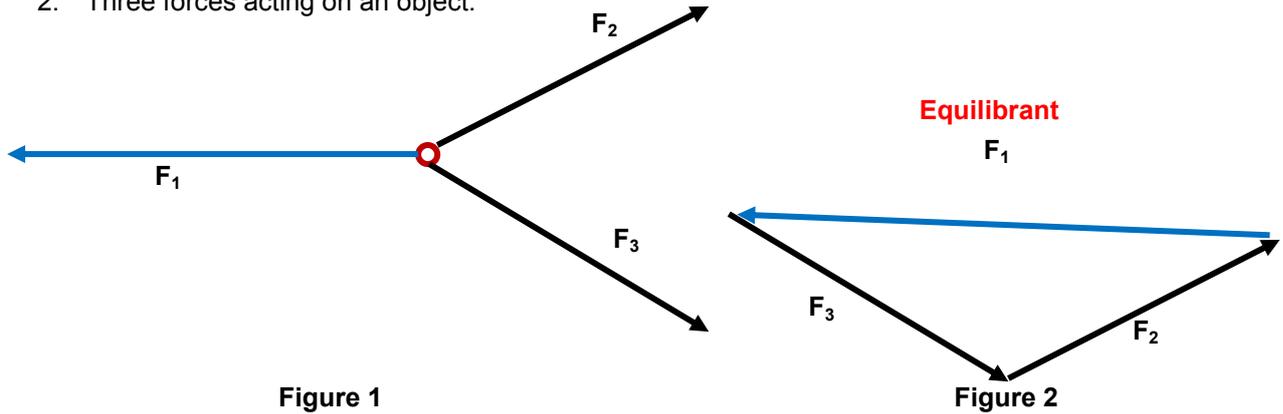
1. Two forces,  $F_1$  and  $F_2$  of equal magnitudes act on an object in opposite directions.



The two forces are in equilibrium since their resultant is zero.  $F_1$  is an equilibrant of  $F_2$  and vice versa.

notes for...

2. Three forces acting on an object.



The three forces are in equilibrium if their resultant is equal to zero. Therefore if the object was at rest, it will remain at rest. Or if it was moving, it would continue to move in the same direction at constant velocity. The force,  $F_1$  is the **equilibrant** of  $F_2$  and  $F_3$ . It is equal in magnitude to the resultant of  $F_2$  and  $F_3$  but acts in the opposite direction. An **equilibrant** is a single force that brings about **balance** (a state of equilibrium) to a number of forces acting together. When three or more forces in equilibrium are arranged tail-to-head, a closed figure is formed. For three forces, as shown in figure 2 above, a triangle of forces will be formed. When three forces acting on an object are in equilibrium, their magnitude and direction can be represented by the three sides of a triangle. This is known as the **law of the triangle of forces**.



## Test Yourself

### Question 1

When a number of forces acting on an object are in equilibrium, the magnitude of the equilibrant is ...

- A. Greater than that of the resultant
- B. Less than that of the resultant
- C. Equal to that of the resultant
- D. Equal to zero

### Question 2

In a practical investigation, two forces act on an object. An equilibrant is introduced so as to bring the forces to a state of equilibrium. What will happen to the equilibrant when the angle between the two forces is increased?

- A. Increases
- B. Decreases
- C. Remains the same
- D. Change direction

### Question 3

Equilibrium can be established ...

- A. Only for objects at rest
- B. Only for objects in motion
- C. For objects at rest and in motion
- D. Only when one force is acting on an object

**Question 4**

A metal sphere of mass 10 kg is at a stationary position suspended by a rope. The equilibrant to the weight of the metal sphere is ...

- A. 98 N to the right
- B. 98 N to the left
- C. 98 N downwards
- D. 98 N upwards

**Question 5**

Two forces act on an object at right angle to each other.  $F_1 = 40$  N and  $F_2$  is 30 N. an equilibrant is introduced to bring about balance to the two forces. Find the magnitude of the equilibrant of the two forces.

- A. 50 N
- B. 10 N
- C. 70 N
- D. 0 N

**Question 6**

Three forces act on an object. A non-closed figure is obtained when the three forces are arranged tail-to-head graphically. Which of the following is correct?

- A. The three forces are in equilibrium
- B. The resultant of the three forces is zero
- C. None of the three forces is an equilibrant.
- D. There shall be no change in the object's state of motion

**Question 7**

A student chooses to use a scale of 10 mm to represent 2 N. How many millimetres will be needed to represent a 12 N force?

- A. 20 mm
- B. 12 mm
- C. 24 mm
- D. 60 mm

**Question 8**

Give one word or phrase for the following:

- (a) A single force with the same effect as a number of forces acting together.
- (b) A single force that brings about balance to a number of forces acting together.
- (c) Three forces in equilibrium can be represented successively in magnitude and direction by the three sides of a triangle.

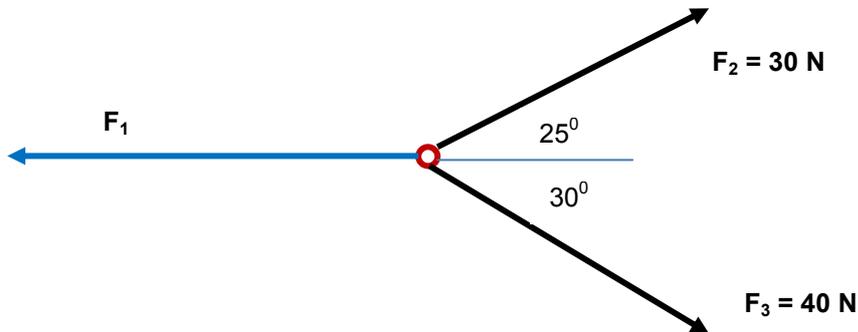
**Improve your Skills****Question 1**

An object of mass 2 kg hangs from a cable. A man pulls the object horizontally with a force of 16 N so that the cable makes an angle of  $45^\circ$  with the vertical.

notes for...

- 1.1 Draw a free body diagram showing all the forces acting on the object.
- 1.2 Calculate the weight of the object.
- 1.3 Find the magnitude of the equilibrant.

**Question 2**



A free body diagram showing three forces in equilibrium is shown above.

Find the magnitude of  $F_1$  by means of construction.