4.1.2 Balanced forces

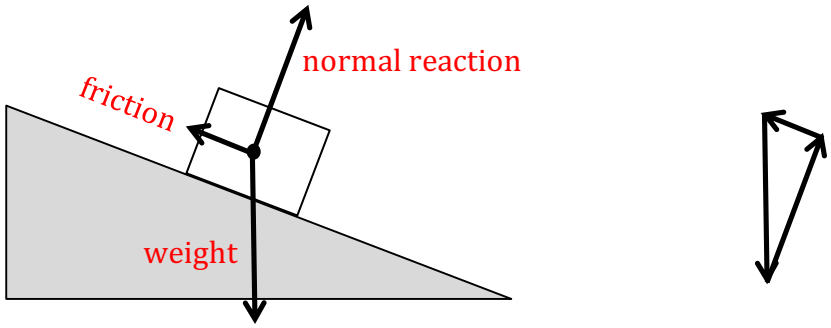
Forces acting on an object are said to be balanced if they add together to produce no resultant force. If we add the force vectors together the tip of the last vector arrow should return to the tail of the first arrow.

If the forces acting on an object are balanced the object will remain at rest or continue moving at a constant speed in a straight line. This is Newton's 1st law of motion.

Objects at rest

In situations where an object is at rest, we can conclude that the forces acting on the object are balanced.

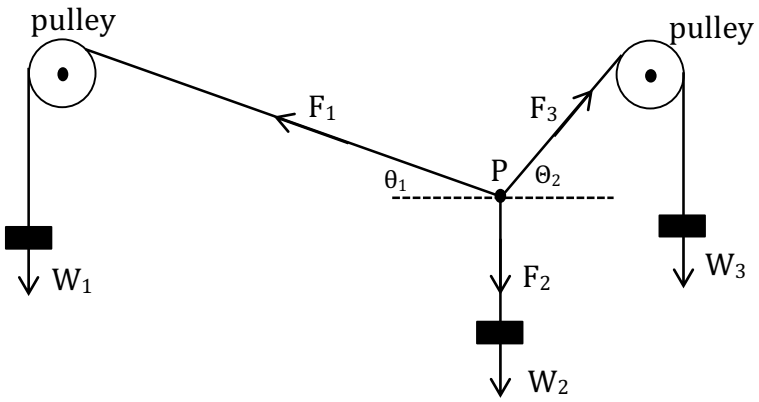
Consider the following situation:



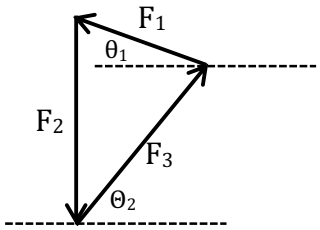
A block is at rest on a slope. This means that the forces acting on the body are balanced. The 3 forces acting on the block are shown. When they are added together (tip-to-tail) they produce no resultant force.

(1) Label the three forces on the diagram.

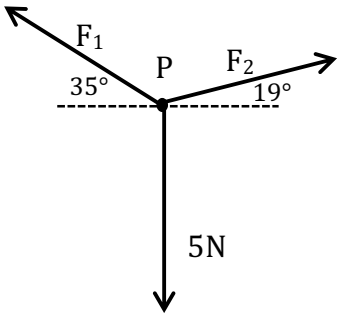
One way to demonstrate forces in equilibrium is shown below:

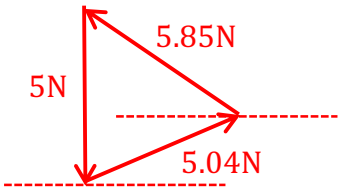


When 3 weights (W_1, W_2, W_3) are suspended, point P comes to rest when the three forces (F_1, F_2, F_3) acting on point P are balanced. If we measure the 2 angles we can draw a scale diagram to find how the 3 forces compare in magnitude:



(2) Use a scale diagram to work out the forces F_1 and F_2 in the following situation (Note: The diagram is not drawn accurately - just use the values given). Point P is stationary. You will need to use a ruler and protractor.





(3) What values would the weights W_1, W_2 and W_3 have for this situation?
5.85N, 5N, 5.04N

Another way to solve the problem above is to resolve forces into horizontal and vertical components. Horizontal components of force (F_h) should balance and vertical components of force (F_v) should balance.

Resolving horizontally:

$$F_2 \cos(19°) - F_1 \cos(35°) = 0$$

Resolving vertically:

$$F_1 \sin(35°) + F_2 \sin(19°) = 5$$

We end up with two simultaneous equations and 2 unknowns - which can be solved.

(4) Use the method above and compare your answers with those obtained from your scale diagram.
From first equation:

$$F_2 \cos(19°) = F_1 \cos(35°)$$

$$\therefore F_2 = F_1\left[\frac{\cos(35°)}{\cos(19°)}\right] = 0.866F_1$$

Substitute into the second equation:

$$F_1\sin(35°) + 0.866F_1\sin(19°) = 5$$
$$\therefore F_1(0.574 + 0.866\times0.326) = 5$$
$$\therefore F_1 = 5.84N$$

$$F_2 = 0.866F_1 = 0.866\times5.84 = 5.06N$$