Resultant force

Physics

09

9.1 The resultant of several forces

Figure 9.1 shows a motor car stalled on the road due to a mechanical fault being pushed by one person in the forward direction. Since the force exerted was not sufficient to move the vehicle, it did not move. Figure 9.2 shows two people trying to push the car. The motor car did not move in this attempt either. In Figure 9.3, three people are shown to push the motor car. In this attempt, the car has moved.

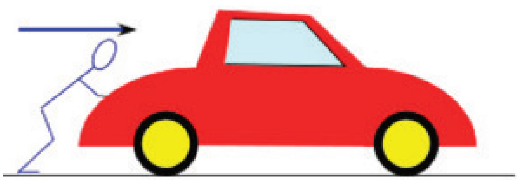


Figure 9.1 – One person pushing a car

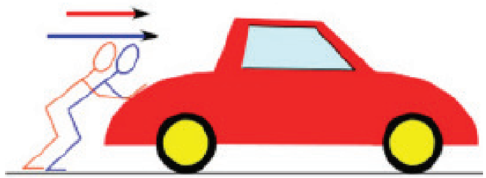


Figure 9.2 – Two persons pushing the car

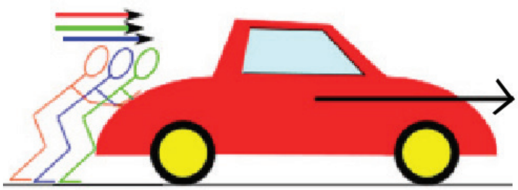


Figure 9.3 – Three persons pushing the car

In order to move the car all the forces have to be applied in the direction that the car needs to be moved.

If many people take part in pushing the car insted of just one person, all the individual forces combine to form a larger force in the same direction and the task becomes easier.

The result of many people exerting forces in the same direction is that all the forces add up to give a larger single force.

When more than one force is applied, the single force that gives the same result as that of all the contributing forces is known as the resultant force of the individual contributing forces.

Forces applied on objects can have various directions. In this lesson will discuss about,

(i) the resultant of two collinear forces (forces having the same 'line of action') and

(ii) the resultant of two parallel forces (forces having parallel but different 'line of action')

9.2 Resultant of two collinear forces

Resultant of two collinear forces acting along the same direction

When pulling on fishing nets, the task can be accomplished more easily if a large group of people take part in pulling the net in the same direction. Because all the forces act in the same direction, the fishing net can be successfully pulled. Here, all the forces are applied in the same direction and along the same line.

Figure 9.4 – A group of people pulling a fishing net

Now let us investigate a way of finding the resultant of two collinear forces acting along the same direction.

Activity 1

Items required : a trolley, three Newton balances, two pulleys, a ring

Place the trolley on a table and fix the ring to one side of the trolley and attach two strong strings to the ring as shown in Figure 9.5. Pass the two strings over the two pulleys and connect the two Newton balances *B* and *C* to the other ends of the strings. Fix the other end of the trolley to a wall through the third Newton balance *A*.

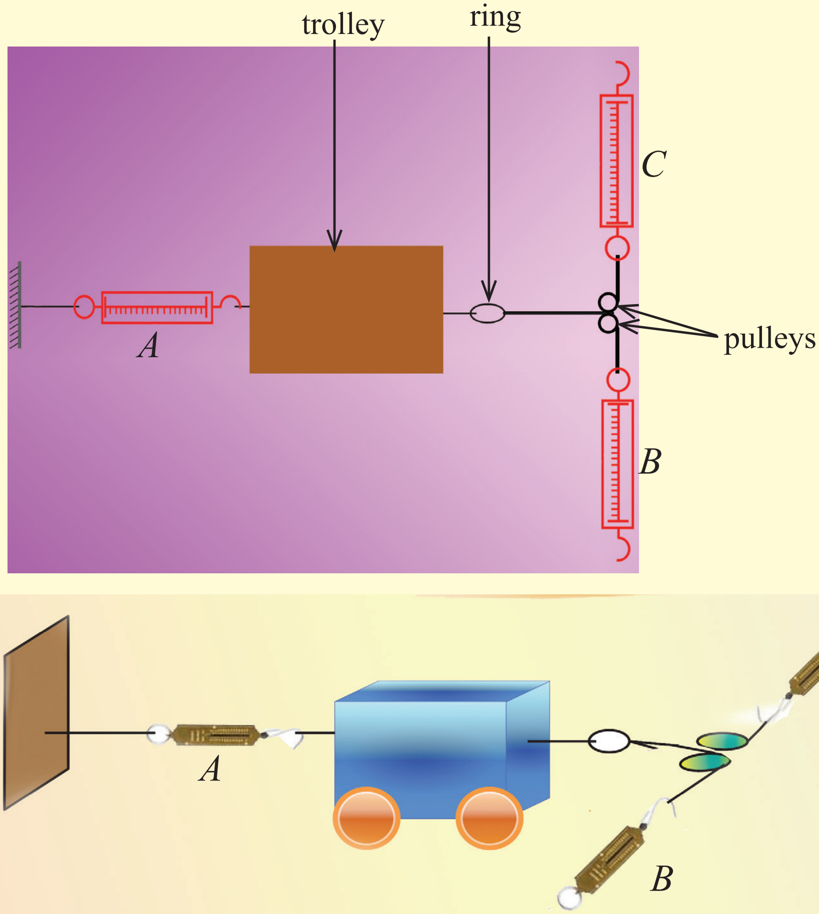


Figure 9.5 - Two forces acting on the trolley in the same direction

- Apply two forces from the two Newton balances *B* and *C*. Record the readings of the balances.
- Record also, the reading of the balance *A*.

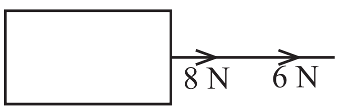
- Find a relationship between the reading on the balance *A* and the readings recorded from *B* and *C* balances.
- Applying different forces from the *B* and *C*, repeat the activity several times and find the relationship between the measurements.

You will observe that the sum of the readings of *B* and *C* is equal to the reading of *A*.

That is, when two collinear forces act along the same direction, the resultant of the two forces is equal to the sum of the two individual forces.

Example 1

Two children are pulling a thread connected to a box placed on a table in the same direction. The force applied by one child is 8 N while that of the other child is 6 N. What is the resultant force with which the children are pulling the box?



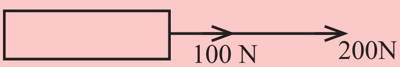
The resultant force applied by both children $= 8 \text{ N} + 6 \text{ N}$

$= 14 \text{ N}$

Exercise 9.1

(1) Find the resultant force in each of following situations.

(i)



(ii)

(2) A child is pushing an object placed on a table with a force of 5 N in a certain derection while another child is pulling it in the same direction with a force of 7 N. What is the resultant of these two forces?

Resultant of two collinear forces acting along opposite directions

Have you seen the national sport of pulling ropes during the Sinhala new year season? The participants of such competitions form two groups and pull a rope in two directions. The rope will be dragged in the direction of the resultant force which lies in the direction of the larger force.

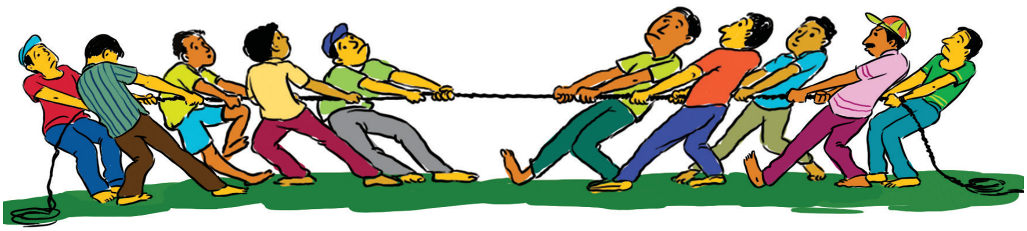


Figure 9.6 – Pulling a rope

When we want to pull an object along a certain direction, the resultant force or the net force of forces applied along that direction is given by the summation of the forces.

The result of applying forces in various directions is a nonutilization of the forces productively.

It is possible to obtain a large net force only if all the contributing forces are applied in the same direction.

It is an experience that in order to drag a heavy object along the floor easily, the object should be pushed from behind and pulled from the front.

Go carts used to carry children can be pulled from the front or pushed from the back in order to move it. If both a pull from the front and a push from the back are given to the go cart, moving the cart would be easier as a large resultant will operate on the cart.

Now let us find the resultant of two collinear forces acting in opposite directions. In order to do it, let us engage in the following activity.

Activity 2

Items required : a trolley, two Newton balances, two smooth pulleys, measuring weights

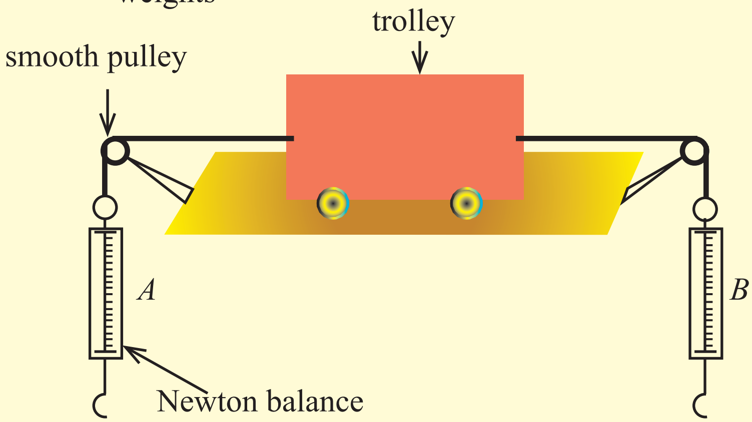


Figure 9.7 - Forces acting in opposite directions on a trolley

- Place the trolley on a table as shown in Figure 9.7 and fix two pieces of string to the two ends of the trolley. Allow the other ends of the pieces of string to pass over the two pulleys and attach two Newton balances *A* and *B*.
- Record your observations on the motion of the trolley after applying a 4 N force on each balance.
- Record your observations on the motion of the trolley after applying a 4 N force on the balance *A* and a 6 N force on balance *B*.
- Repeat the above step applying a 6 N force on the balance *B* and a 6 N force on the balance *A*.

You will observe that the trolley does not move in the first case. The trolley remains in equilibrium under the action of the two equal forces acting on it in opposite directions.

In the second instance, the trolley moves in the direction of the Newton balance *B*. Here, there are two inequal forces acting on the trolley in opposite directions and the trolley moves in the direction of the larger force. The extra force which is applied in the direction of *A* than in the direction of *B* is 2 N. That is, in this instance the resultant is 2 N in the direction of *B*.

In the third instance, the trolley does not move. Here, the resultant is zero since the two forces acting in the opposite directions become equal.

When two collinear forces are exerted on an object in opposite directions, the resultant is given by their difference, with a direction in the direction of the larger force.

Example 1

What is the magnitude and the direction of the resultant of a force of 5 N pulling an object placed on a table in a certain direction and another force of 2 N pulling it in the opposite dirction?

$$\text{Resultant force} = (5\text{ N}) + (-2\text{N})$$
$$= 3\text{ N}$$

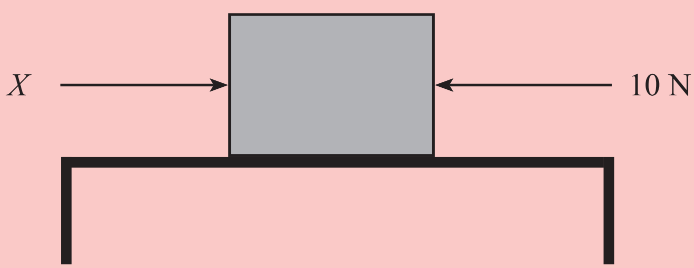
The object will be pulled by a force of 3 N in the direction of the 5 N force.

Exercise 9.2

(1) The forces applied by two children in order to push a box resting on a horizontal plane is shown in the figure.

Find the resultant of the two forces.

(2) A force of 10 N is applied towards the West, on an object placed on a table. If the object is drawn towards the West with a force of magnitude 5 N, what is the magnitude of the force *X*?



9.3 Resultant of two parallel forces

Let us now investigate instances where two parallel forces which are not collinear are in action, and how to find the resultant of these two parallel forces.

Let us consider this example.

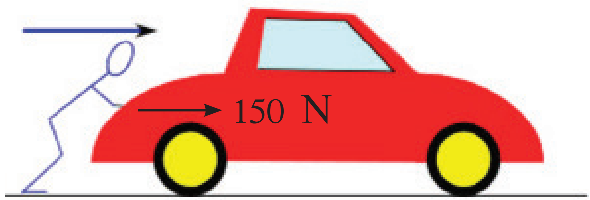


Figure 9.8 – One person trying to push a motor car

One person is trying to push a motor car with a force of 150 N in the direction as shown in Figure 9.8, but it has not moved.

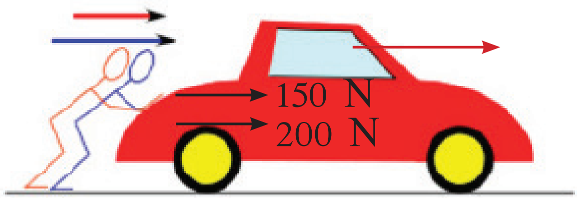


Figure 9.9 – Two persons pushing the car

However, when the assistance of another person pushing the car with a force of 200 N was obtained and the car was pushed by both persons, in the direction shown the car moved. It was because the resultant of the two forces is sufficient for the motion of the car.

Although both these forces were applied in the same dirction, they are not collinear. They are two parallel forces acting on two different points of the motor car. However, that when two forces act along the same direction the resultant is the sum of the two forces.

Resultant of the two forces = 150 N + 200 N (since both forces act in the same direction)

= 350 N

To experimentally check that the resultant of two parallel forces are equal to their sum, let us do the following activity.

Activity 3

Items required : a strip of wood with three holes drilled as shwon in the figure, three Newton balances

- Drill three holes *X*, *Y* and *Z* on the strip of wood as shown in the figure below and attach the three Newton balances *A*,*B* and *C*. Pull the three balances keeping the strip of wood to be in a rest position. (Always keep the strip perpendicular to the Newton balances. you may need to apply equal forces on the *A* and *B* balances)

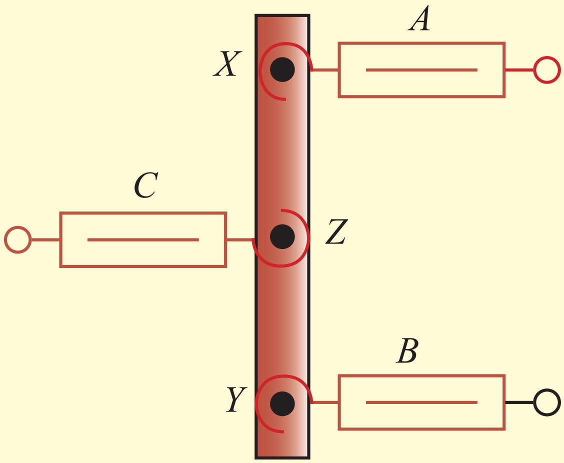


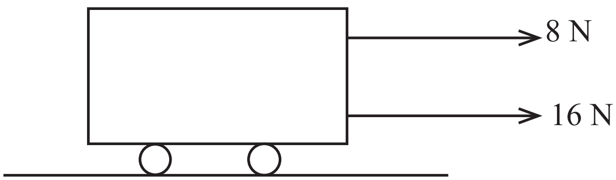
Figure 9.10 - Finding the resultant of two parallel forces

- When the strip of wood is at rest, you would observe that the sum of the readings of the Newton balances *A* and *B* is equal to that of the Newton balance *C*. What is the reason for this? It is because the resultant of the two forces on *A* and *B* is equal to the magnitude of the force on *C*.

In order to find the resultant of two parllel forces acitng along the same direction, the two forces must be added.

One of the best uses we can get from a knowledge of resultant force is to make use of a large number of small forces in place of a single large force effectively.

Example 1



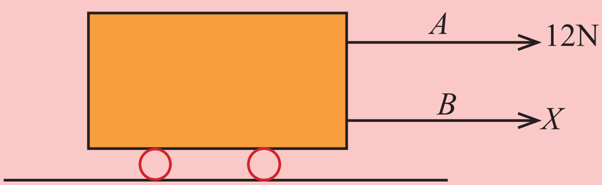
Two strong strings attached to a trolley is pulled by a force of 8 N on one string and a force of 16 N on the other string keeping the two strings parallel. Find the resultant of these two forces.

Resultant of the two forces $= 8\text{ N} + 16\text{ N}$

$= \underline{\underline{24\text{ N}}}$

Exercise 9.3

(1) When a trolley placed on a table is pulled by two strings attached to it keeping the two strings parallel to each other, the resultant force is 20 N.



The force exerted on the string A is 12 N. Find the force exerted by the string B.

9.4 Resultant of two inclined forces

Let us now investigate how to find the resultant of two inclined forces.

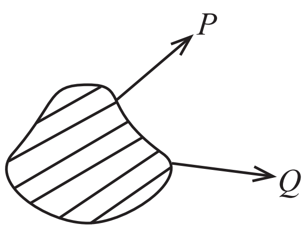
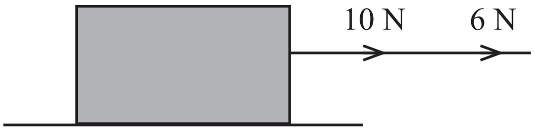


Figure 9.11 – Two inclined forces acting on an object

Two forces P and Q that act with their lines of action inclined to one another is shown in Figure 9.11. When two such forces are applied on an object, the object does not move in either of the directions of P or Q. In such an instance, the direction of motion of the object lies in a direction between the two forces.

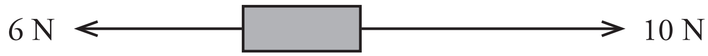
Miscellaneous exercises

(1) (i)



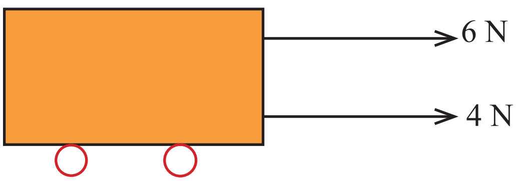
If an object is pulled by two forces 10 N and 6 N along the same direction, what is the resultant of the two forces?

(ii)



If the two forces are applied along two opposite directions, what would be the resultant?

(2) (i) What is the resultant of the two parallel forces shown below?



(ii) (a) What is the force that can be applied in the opposite direction so as to make the resultant zero.

(b) Illustrate it using a figure.

(3) One bull out of a pair of bulls tied to a plough for ploughing a paddy field, exerts a force of 100 N while the other bull exerts a force of 80 N. What is the resultant force that the plough is pulled with?

(4) When an object is held by a Newton balance, the reading was 80 N. If another object of mass 500 g was attached to the Newton balance, what would be the resultant force in Newtons?

(5) If a trolley is being pulled by two forces, one with a magnitude of 20 N along the East and the other with a magnitude of 15 N along the West, in which direction would it move? What is the resultant?

Summary

- The single force acting in place of many forces (the single force that gives the same result as many forces) is known as the resultant force.
- The magnitude of the resultant of two forces acting in the same direction is the sum of the two forces. Direction of the resultant is the direction of an individual forces.
- If the magnitudes of two collinear forces acting in opposite directions are different, then the magnitude of their resultant is equal to the difference between the two forces and acts in the direction of the larger force.
- The reslutant of two inclined forces act in a direction which lies between the two forces.

Technical terms		
Resultant force	සම්ප්‍රයුක්ත බලය	விளையுள் விசை
Newton balance	නිව්ටන් තුලාව	நியூற்றன் தராசு
Unbalanced force	අසංතුලිත බලය	சமநிலைப்படாத விசை
Opposite direction	විරුද්ධ දිශාව	எதிர்த் திசை