Newton's Second Law of Motion

by
Nada Saab, Ph.D.

P3.4 Forces and Acceleration

The change of speed and/or direction (acceleration) of an object is proportional to the net force and inversely proportional to the mass of the object. The acceleration and net force are always in the same direction.

P3.4A Predict the change in motion of an object acted on by several forces.

P3.4C Solve problems involving force, mass, an

Newton's Second Law

When a net external force acts on an object of mass **m**, the acceleration that results is directly proportional to the net force and has a magnitude that is inversely proportional to the mass. The direction of the acceleration is the same as the direction of the net force.

In other words:

The acceleration of an object increases when the net external force increases. The acceleration decreases when the mass of the object increases.

Acceleration = Net Force / Mass

So

Net Force = Mass x Acceleration

SI Unit for Force

$$(\mathrm{kg})\left(\frac{\mathrm{m}}{\mathrm{s}^2}\right) = \frac{\mathrm{kg}\cdot\mathrm{m}}{\mathrm{s}^2}$$

This combination of units is called a newton (N).

Newton's Second Law of Motions

Net Force = Mass x Acceleration

$$\vec{F}\,net = m \times \vec{a}$$

F net: net external Force in Newton (N). It is the sum of all the external forces acting on the object.

m represents the Mass. The unit of mass is kilogram (kg).

a represents Acceleration. The unit of acceleration is m/s^2

Newton's Second Law of Motions

Acceleration = Net Force / Mass

$$\vec{a} = \vec{F}\,\text{net} / m$$

F net: net external Force in Newton (N). It is the sum of all the external forces acting on the object.

m represents the Mass. The unit of mass is kilogram (kg).

a represents Acceleration. The unit of acceleration is m/s^2

A Mathematical Symbol of the Net Force

Mathematically, the net force is written as

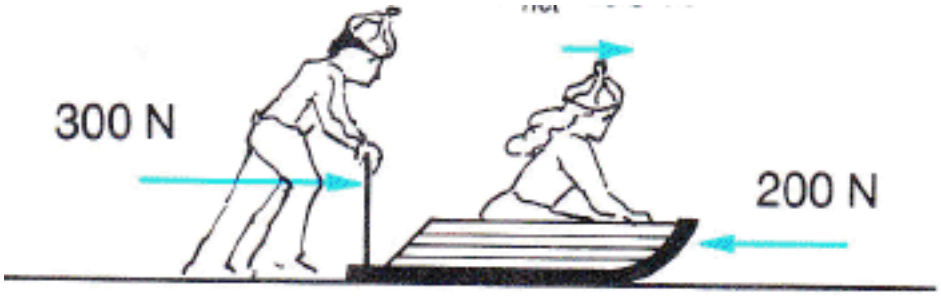
$$\sum \vec{\mathbf{F}}$$

where the Greek letter sigma denotes the vector sum.

Practice Problem: A boy gives his sister a ride on a sled by exerting a force of 300 N [east]. Frictional resistance exert a force of 200 N [west]. The sister and the sled have a combined mass of 50 kg.

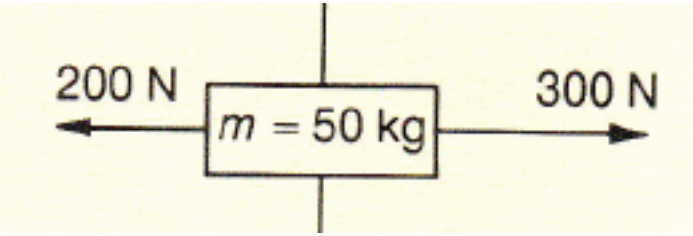
a) Find the net force. Assume that the east direction is positive.

a) Find the sled's acceleration.



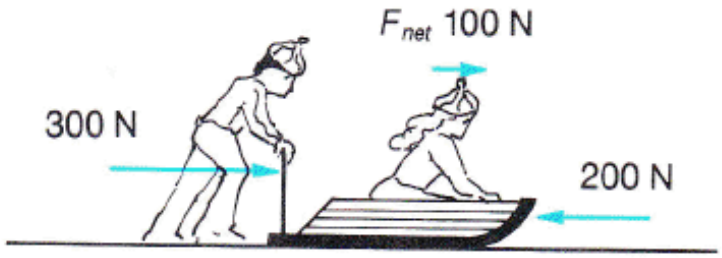
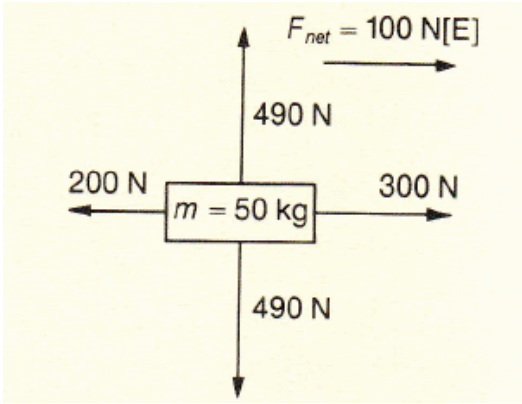
A free-body diagram will help in the solution.

A *free-body-diagram* is a diagram that represents the object and the forces that act on it. Below is the free-body diagram of the problem.



a) F net = 300 N - 200 N = 100 N [east]

So the problem can be represented like this:

Sketch	Free-body diagram
	

So a net force of 100 N is pushing the sled forward toward the east direction.

A force of 490 N is created by the mass of the sled and the girl. It is directed toward the center of the earth. It is canceled by another force in the opposite direction exerted by the earth on the sled and girl.

b) According to Newton's Second Law of Motion;

Acceleration = Net Force / Mass

$$\vec{a} = \vec{F}\,\text{net} / m$$

= 100 / 50 = 2.0 m/s^2

The sled accelerates at 2.0 m/s^2 [east]

Practice Problems;

Answer questions **1** and **2**.

1. Two people are pushing a stalled car, as shown below.

Assume that the east direction is the positive direction.

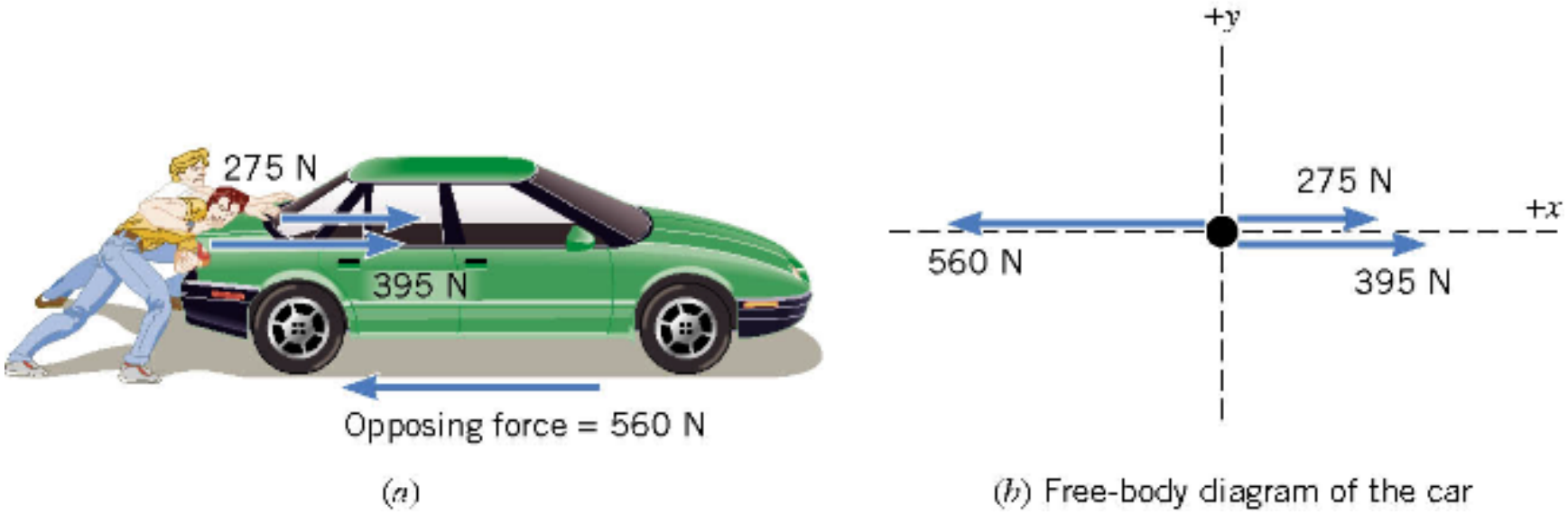


Figure (a) Two people push a stalled car. One person pushes with a force of 275 N. The other pushes with a force of 395 N. A third force of 560 N in opposing direction acts on the car. The cause of the third force is the friction and the

pavement opposing the motion of the tires. The mass of the car is 1850 kg.

Figure (b): a free-body diagram that shows the horizontal forces acting on the car. In the diagram, the car is represented as a black dot, and its motion is along the +x axis. Assume that the east direction is the positive direction.

Find:

a) The net force acting on the car.

b) The acceleration of the car.

2. Search to find a practice problem for Newton's Second Law of Motion. You need to show the sketch and the free-body diagram. Solution of the problem is not required, but recommended.