Newton's Third Law of Motion

by

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P3.3 Newton's Third Law

Whenever one object exerts a force on another object, a force equal in magnitude and opposite in direction is exerted back on the first object.

P3.3A Identify the action and reaction force from examples of forces in everyday situations (e.g., book on a table, walking across the floor, pushing open a door).

P3.4B Identify forces acting on objects moving with constant velocity (e.g., cars on a highway).

Items:

1. Newton's Third Law of Motion.

2. Normal Force (F_N).

3. Equilibrium Relationship to F_{net} and Acceleration.

Newton's Third Law of Motion

All forces come in pairs.

Whenever one body exerts a force on a second body, the second body exerts an oppositely directed force of equal magnitude on the first body.

The two forces are called interaction pairs. They are called sometimes Action-Reaction pairs of forces.

Definitions

Normal Force or Support Force: The normal force F_N is one component of the force that is perpendicular to the surface in contact.

Equilibrium: An object is in equilibrium when it has zero acceleration. The F net acting on it is zero. The object is either motionless or moving at a constant speed over a period of time.

If F net = 0 N, then the system is in equilibrium.

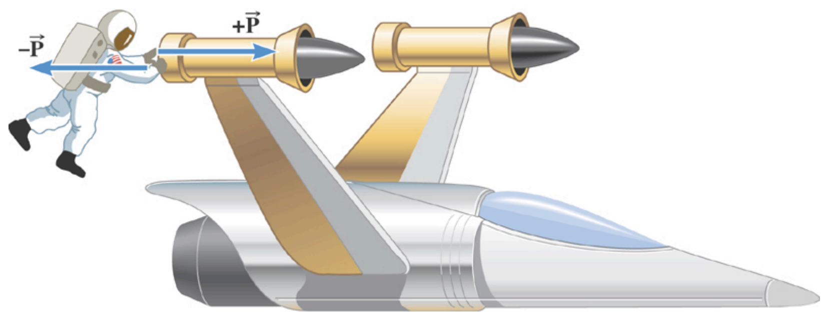
If acceleration = 0, then the system is in equilibrium.

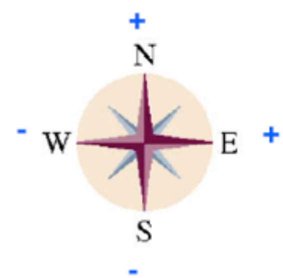
An object accelerates when its speed changes over a period of time, whether speeding up or slowing down.

Weight: is the earth's gravitational force on the object.

Example 1: *An Astronaut Pushing a Spacecraft.*

An Astronaut pushes a spacecraft in equilibrium is an example of Action-Reaction pairs of forces.





Action Force: An astronaut pushes on the spacecraft with some force **P**.

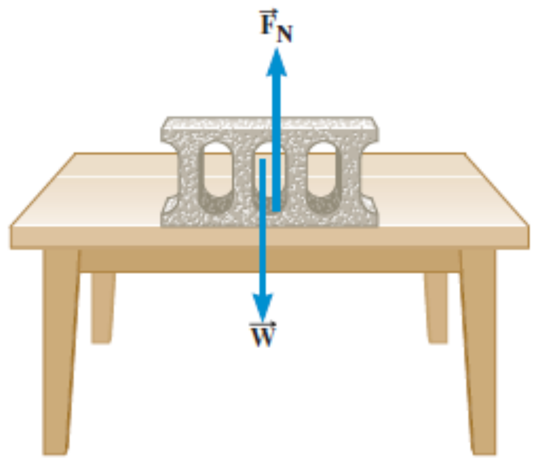
Reaction Force: The spacecraft pushes back on the astronaut with the same force **P** in the opposite direction.

So, if the astronaut pushes with a force P = 38 N, the space craft pushes back with a force P = -38 N.

Normal (Support) Force and Equilibrium

Normal Force or Support Force: The normal force F_N is one component of the force that is perpendicular to the surface in contact.

This is block resting on a table is an example of Action-Reaction pair of forces.



There are two forces act on the block:

1) Action Force: Its weight that pushes down on the table with a force = W.
2) Reaction Force: The surface of the table pushes up with an equal force called the normal force F_N in the opposite direction (up).

Action Force = Reaction Force, so the block is in equilibrium

Suppose the upward direction is the positive direction.

$$F_N = -W$$

If the weight W of the block = -10N (Action Force), then, the normal force F_N = 10N (Reaction Force).

Net force = sum of all the forces

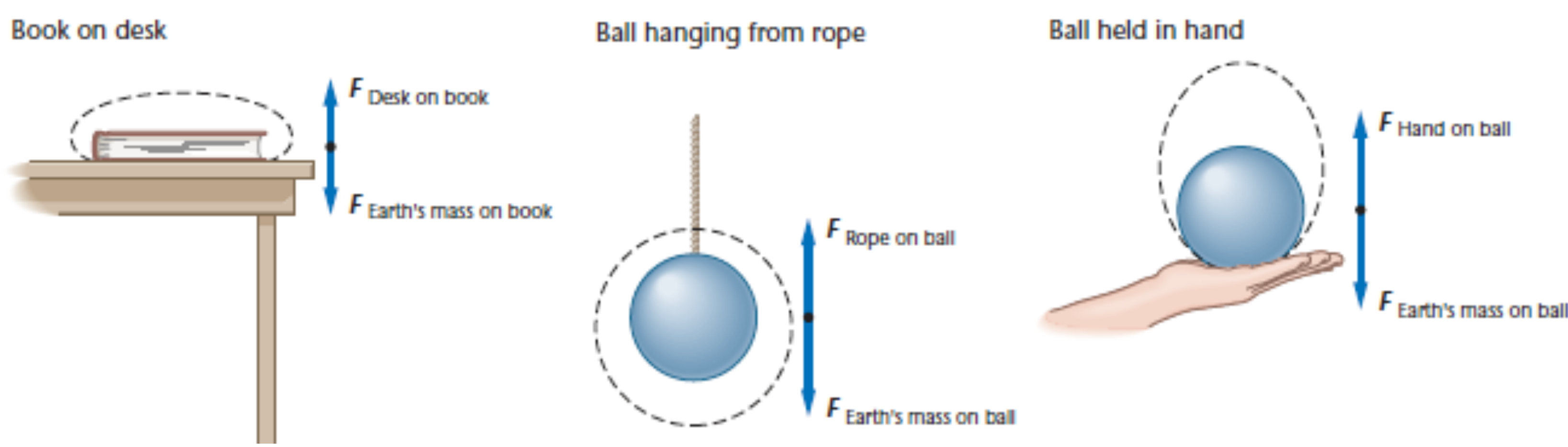
F net = F_N + W = 10-10 = 0 N.

Acceleration = 0 m/s^2

The block is in equilibrium and resting on the table because: Action forces = Reaction forces. So, Fnet acting on the block is zero and the acceleration is zero.

Example 2: *Action Reaction Pairs of Forces*

The book on desk, the ball hanging from rope, the ball held in hand are in **equilibrium**.



Example 3: *Changing The Motion of a Water Skier.*

The figure below shows a water skier at four different moments a, b, c, and d:

(a) (b) (c) (d)

Moment (a): The skier is floating motionless in the water.

Moment (b): The skier is being pulled out of the water and up onto the skis, and its speed is increasing.

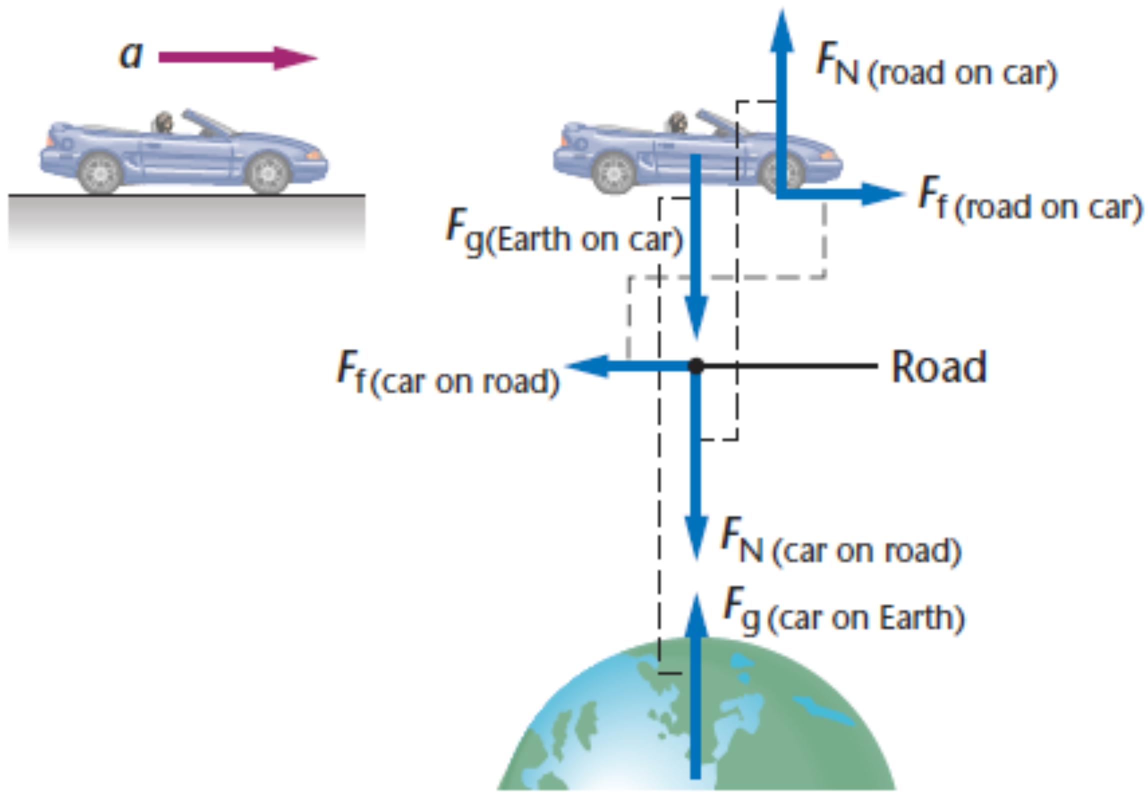
Moment (c): The skier is moving at a constant speed along a straight line.

Moment (d): The skier has let go the tow rope and its speed is slowing down.

Discuss whether there is equilibrium or not in each moment.

Example 4: *Forces Acting on a Car that Accelerates on the Highway.*

The Newton Third Law of Motion explain how a car accelerates on the highway. In the diagram, there are three interaction, Action- Reaction pairs of forces. Each pair is connected with a dashed line. One of them is responsible for moving the car.



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2) Cutnell, J. D. & Johnson, K. W. (1998). *Cutnell & Johnson Physics, Fourth Edition*. New York: John Wiley & Sons, Inc.

The edition was dedicated to the memory of Stella Kupferberg, Director of the Photo Department: "We miss you, Stella, and shall always remember that a well-chosen photograph should speak for itself, without the need for a lengthy explanation"

3) Martindale, D. G. & Heath, R. W. & Konrad, W. W. & Macnaughton, R. R. & Carle, M. A. (1992). *Heath Physics.* Lexington: D.C. Heath and Company

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