Force

NEWTON'S LAWS OF MOTION

First Law (Law of Inertia)

Every body continues in its state of rest or of uniform velocity in a straight line unless it is compelled to change that state by the application of some resultant external force.

In other words, there can be no acceleration (speed up, slow down, change directions) without a force.

Second Law

The acceleration of a body is directly proportional to the resultant force acting upon it and is inversely proportional to the mass of the body.

In other words, force equals mass times acceleration.

Third Law

Whenever one body exerts a force upon a second body, the second body exerts an equal and opposite force upon the first.

In other words, there is no action without reaction.

NEWTON'S LAW OF UNIVERSAL GRAVITATION

Between every two particles in the universe there is a force of gravitational attraction (F_G) which is proportional to the product of the masses of the two particles (m_1 and m_2, respectively) and inversely proportional to the square of the distance (r) between them.

In equation form:

$F_G = \frac{Gm_1m_2}{r^2}$, where G = the universal gravitational constant, $6.67 \times 10^{-11}\ N \cdot m^2/kg^2$

FORMULAS

$F = ma$ $F_g = mg$, where $g = 10\ m/s^2$ $(9.81\ m/s^2)$ $F = \frac{F_g a}{g}$

where "F" is force, "F_g" is force due to gravity (also known as weight), "m" is mass, "a" is acceleration, and "g" is acceleration due to gravity at the earth's surface. Note: "F" may also be referred to as the **net force**, the **unbalanced force** or the **resultant force**.

EXERCISES

A. A playing card is placed over the mouth of a glass of water. A coin is then placed on top of the card. With a quick flick of a finger, the card is knocked away so that the coin drops into the glass. Which of Newton's Laws of Motion best explains the action of the coin?

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B. A book rests on a table. Newton's Third Law applies to this situation.
   1) Explain what force the book exerts on the table.

   2) Explain what force the table exerts on the book.

C. A woman has a mass of 50 kg. Find her weight.

D. Find the unbalanced force required to give a 1000-kg automobile an acceleration of 2 $^{m}/_{s^2}$.

E. A body has a mass of 8.0 kg. If a resultant force of 12 N acts on the body, determine its acceleration.

F. When a net force of 2.0 N is applied to a "frictionless" cart, the acceleration is found to be 200 $^{cm}/_{s^2}$. Determine the mass of the cart.

G. A 1000-kg trailer is accelerated steadily from 10 $^{m}/_{s}$ to 20 $^{m}/_{s}$ in 5 s. If the trailer friction is 2000 N, find the force applied to the trailer through the trailer hitch.

H. If a force of 200 N accelerates a 20-kg sled at 8.0 $^{m}/_{s^2}$, find the friction.

I. Find the gravitational attraction between two identical 40-kg lead spheres with centres 0.65 m apart.

J. When a platinum sphere is placed 20 cm from a lead sphere of mass 5.0 kg, the attraction of one sphere to the other is found to be 7.0×10^{-7} N. What is the mass of the platinum sphere?

SOLUTIONS

A. Newton's First Law: the inertia of the coin lets it drop straight down into the glass.
B. (1) Gravity is pulling the book down onto the table. (2) The table exerts a force (a normal force) to hold the book up.
C. 5.0×10^2 N D. 2×10^3 N E. 1.5 $^{m}/_{s^2}$ F. 1.0 kg G. 4×10^3 N H. 40 N
I. 2.5×10^{-7} N J. 84 kg