Newton's 2nd Law

Objectives

- Explain the relationship between acceleration, net force, and mass of an object.
- Apply Newton's 2nd Law to solve a variety of problems.
- Understand the difference between mass and weight.
- Understand the conditions required for static equilibrium.

Newton's 2nd Law of Motion

The acceleration of an object is in the direction of and directly proportional to the net force applied, and inversely proportional to the object mass.

Newton's 1st Two Laws Compared

Newton's 1st Law

An object at rest will remain at rest, and an object in motion will remain in motion, at a straight line, unless acted upon by a net force.

Newton's 2nd Law

The acceleration of an object is in the direction of and directly proportional to the net force applied, and inversely proportional to the object's mass.

Applying Newton's 2nd Law

1. Draw a free body diagram
2. For any forces that don't line up with the x- or y-axes, break those forces up into components that do not lie on the x- or y- axis.
3. Write expressions for the net force in x- and y-directions. Set the net force equal to ma, since Newton's 2nd Law tells us that F=ma.
4. Solve the resulting equations.

Sample Problem 1

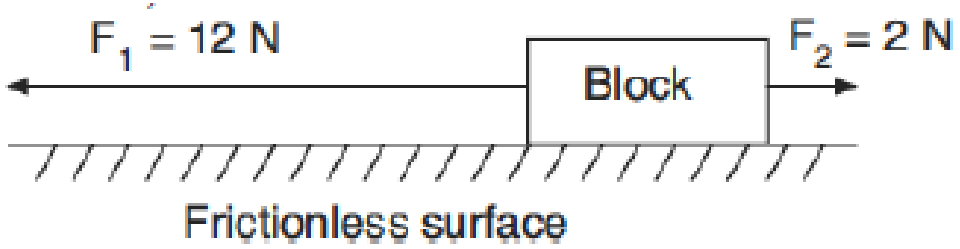
A force of 25 newtons east and a force of 25 newtons west act concurrently on a 5-kilogram cart. Find the acceleration of the cart.

Sample Problem 2

A 0.15-kilogram baseball moving at 20 m/s is stopped by a player in 0.010 seconds. What is the average force stopping the ball?

Sample Problem 3

Two forces, F1 and F2, are applied to a block on a frictionless, horizontal surface as shown below.



If the magnitude of the block's acceleration is 2.0 meters per second^2, what us the mass of the block?

Sample Problem 4

A 25-newton horizontal force northward and a 35-newton horizontal force southward act concurrently on a 15-kilogram object on a frictionless surface.

What is the magnitude of the object's acceleration?

Mass vs. Weight

- Mass is the amount of "stuff" something is made up of. It remains constant.
- Weight (mg) is the force of gravity on an object.
  - Weight varies with gravitational field strength (g).

Problem: Mass vs. Weight

- An astronaut weighs 1000N on Earth. What is the weight of the astronaut on Planet X, where the gravitational field strength (g) is 6 m/s^2?

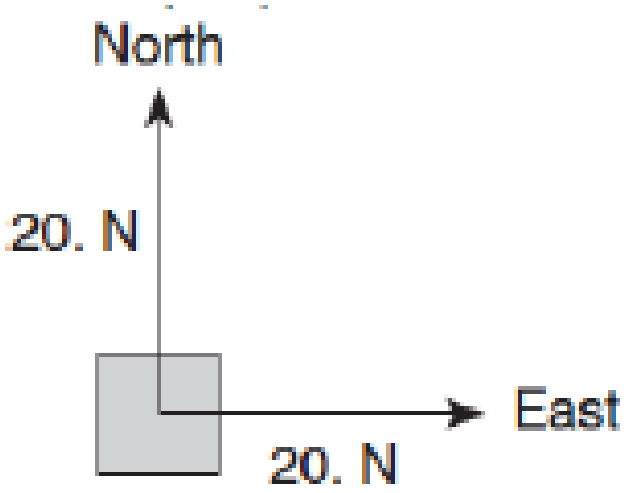
- An alien on Planet X weighs 400N. What us the mass of the alien?

Static Equilibrium

- Static equilibrium occurs when there is no net force on an object (therefore acceleration is zero).
- The equilibrant is a single force vector that you add to the unbalanced forces on an object in order to bring it into static equilibrium.

Static Equilibrium Problem 1

In the diagram, a 20-newton force due north and a 20-newton force due east act concurrently on an object.



What additional force is required to bring the object into equilibrium?

Static Equilibrium Problem 2

A 3-newton force and a 4-newton force are acting concurrently on a point. Which force could not produce equilibrium with these two forces?

1. 1N
2. 7N
3. 9N
4. 4N

Newton's 3rd Law

Objectives

- Explain the meaning of Newton's 3rd Law of Motion
- Recognize and identify force pairs
- Utilize Newton's 3rd Law to solve dynamic problems.

Newton's 3rd Law of Motion

- All forces come in pairs. If Object 1 exerts a force on Object 2, then Object 2 must exert a force back on Object 1 which is equal in magnitude and opposite in direction.

$$F_{1on2} = -F_{2on1}$$

Examples

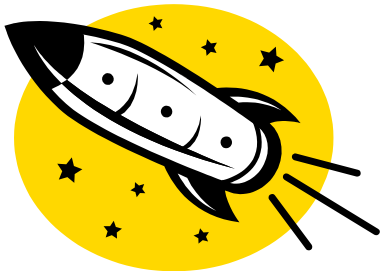
- How does a tiger run forward?

- If you want to swim forward, which way do you push the water?

- How do you jump in the air?

Action-Reaction Pairs

- Girl kicking soccer ball
- Rocket in space
- Gravity on you



Sample Problem 1

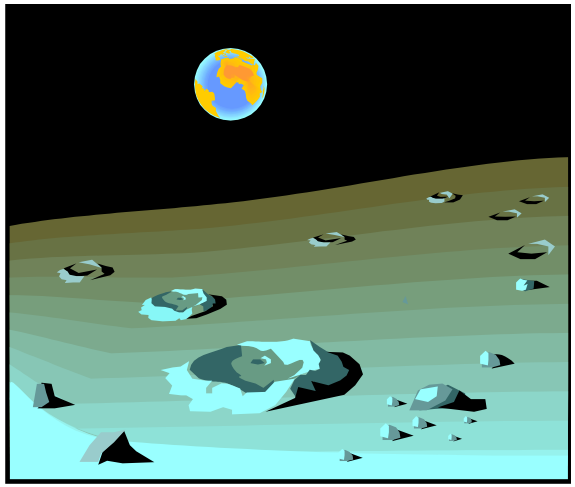
- Earth's mass is approximately 81 times the mass of the Moon. If the Earth exerts a gravitational force of magnitude F on the moon, the magnitude of the gravitational force of the Moon on the Earth is

a) F

b) F/81

c) 9F

d) 81F



Sample Problem 2

- A 400-newtion girl standing on a dock exerts a force of 100 newtons on a 10,000-newton sailboat as she pushes it away from the dock. How much force does the sailboat exert on the girl?

Sample Problem 3

- A carpenter hits a nail with a hammer. Compare to the magnitude of the force the hammer exerts on the nail, the magnitude of the force the nail exerts on the hammer during contact is

a) Less

b) Greater

c) The same