Edgenuity

Warm-Up | Newton's Second Law

Lesson Question

How does Newton's second law describe the motion of an object?

Lesson Goals

Describe Newton's second law of motion.

Calculate force, mass, or acceleration given the other two quantities.

Interpret free-body diagrams for accelerating objects.

Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

recoil	a backward movement or springing back to a starting point
direct relationship	a relationship between two variables whereby both variables increase or decrease together
inverse relationship	a relationship between two variables whereby one variable increases and the other variable decreases
Newton's second law of motion	the law that states the total net force acting on an object is equal to its mass times acceleration
weight	a measure of the gravitational force on an object

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Physics Terms

- Force is an action that has the ability to [change] an object's state of motion.

$$1\,\text{N} = 1\,\text{kg} \cdot \text{m/s}^2$$

- Mass is the [amount] of matter in an object.

kg

- Acceleration is the rate at which [velocity] changes over time.

m/s^2

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Newton's Second Law of Motion

- **Newton's second law of motion** states that the [acceleration] of an object is directly proportional to the net force applied to an object and [inversely] proportional to the mass of the object.

$$a = \frac{F}{[m]}$$

Newton's Second Law of Motion

$$a = \frac{F}{m}$$

$\uparrow$ [F] $\uparrow a$

$\downarrow F$ $\downarrow$ [a]

- Force and acceleration have a [direct] **relationship**.

$$a = \frac{F}{m}$$

$\uparrow m$ $\downarrow a$

$\downarrow m$ $\uparrow$ [a]

- Mass and acceleration have an [inverse] **relationship**.

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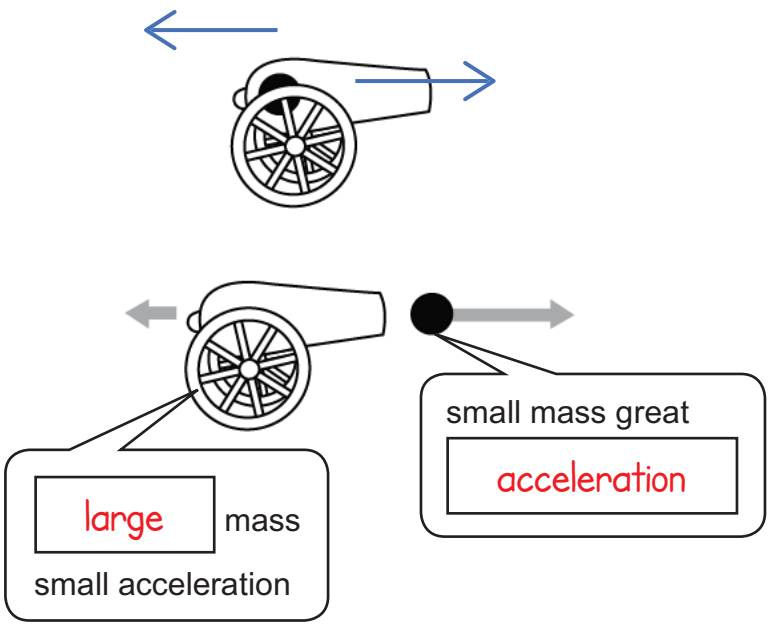
Projectile and Recoil

- When a projectile is fired from a cannon, the cannon **recoils**, or moves [backward], after firing.

  This recoil is a direct result of both Newton's second and [third] laws of motion.

  - Equal and [opposite] forces
  - Projectile: $F = m\boldsymbol{a}$
  - Recoil: $F = \boldsymbol{m}a$
    - $m\boldsymbol{a} = \boldsymbol{m}a$

The cannon and the cannonball experience equal yet opposite forces.



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Variable Relationships

To Find	Use	If You Know
force	$F = ma$	mass and acceleration
mass	$m =$ $\frac{F}{a}$	force and acceleration
acceleration	$a = \frac{F}{m}$	force and mass

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Free-Body Diagrams and Force

Ryan and Ty both kick a soccer ball at the same time. Ryan kicks the ball with a force of 270 N to the left. Ty kicks the ball to the right. The soccer ball has a mass of 450 g and accelerates 20 m/s² to the right. What is the force with which Ty kicked the ball? (Disregard gravity and air resistance.)

$$\sum F = ma$$

$$\sum F = \boxed{0.45\,\text{kg}}\,(20\,\text{m/s}^2)$$

$$= \boxed{9\,\text{N}}$$

So,

$$9\,\text{N} = \boxed{-270\,\text{N}} + F_{k2}$$

$$F_{k2} = \boxed{279\,\text{N}}$$

So we know Ty's kick to the right is 279 newtons.

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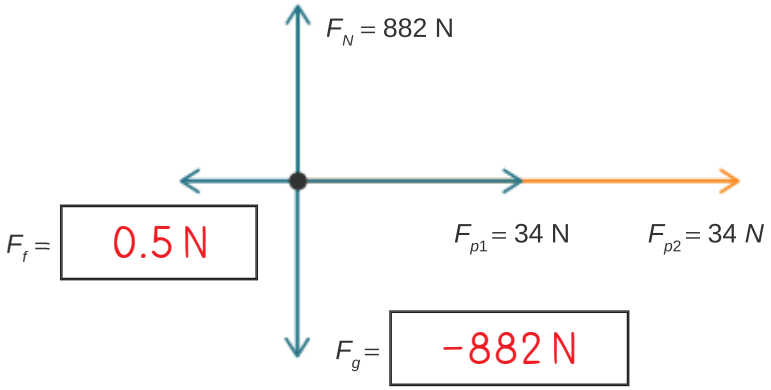
Free-Body Diagrams and Multiple Forces

Two people push a shopping cart with equal force. The cart is accelerating 0.75 m/s², and the force each person is exerting is 34 N. There is a 0.5 N force of friction, an 882 N force of gravity, and an 882 N normal force. What is the mass of the shopping cart?



Formula used is $m = \frac{F}{a}$.

$$\sum F = 34\,\text{N} + 34\,\text{N} - 0.5\,\text{N}$$
$$= 68\,\text{N} - 0.5\,\text{N}$$
$$= \boxed{67.5\,\text{N}}$$

$$m = \frac{F}{a}$$
$$= \frac{\boxed{67.5\,\text{N}}}{0.75\,\text{m/s}^2}$$
$$= \boxed{90\,\text{kg}}$$

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Weight

- Newton's second law allows us to calculate the *weight* of objects.
  - Weight is a measure of the force due to [gravity] on an object.
  - Weight is an object's mass times the acceleration due to gravity, [$9.8\ m/s^2$].
    - Like all other forces, weight is measured in newtons.

$$F_g = mg$$

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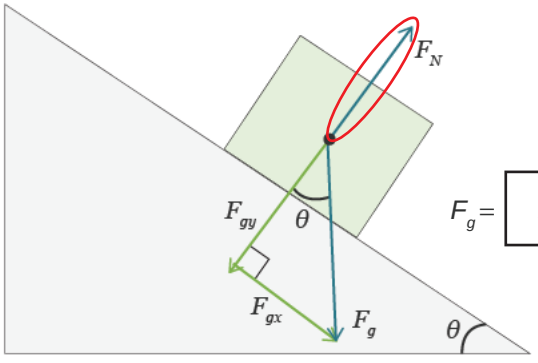
Objects on Inclined Planes

When an object is on an incline plane, break the force of gravity into *x* and *y* components and use trigonometry to find the [magnitude] of the vectors.

Circle the normal force.



$F_g =$ [mg]

$$\sin = \frac{opp}{hyp}$$

$$F_{gx} = mg([\sin\theta])$$

$$F_{gy} = mg([\cos\theta])$$

[cos] $= \frac{adj}{hyp}$

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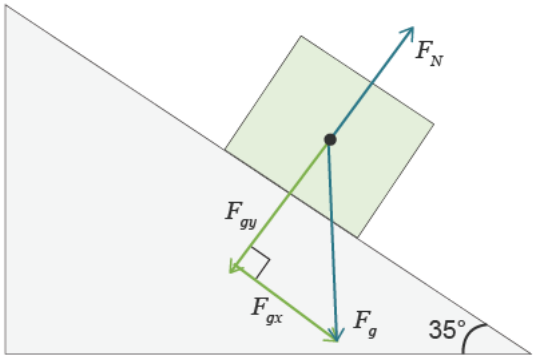
A box with a mass of 10 kg is sliding down a ramp at a 35 degree angle with no friction.What is its acceleration?



$$F_g = (10\,\text{kg})(9.8\,\text{m/s}^2)$$

$$= \boxed{98\ \text{N}}$$

$$F_{gy} = (98\,\text{N})(\cos 35°)$$

$$= \boxed{80\ \text{N}}$$

$$F_{gx} = (98\,\text{N})(\sin 35°)$$

$$= \boxed{56\ \text{N}}$$

$$a = \frac{F}{m}$$

$$= \frac{56\,\text{N}}{10\,\text{kg}}$$

$$= \boxed{5.6\ \text{m/s}^2}$$

Free-Body Diagram and Acceleration

The girl is pulling the suitcase with a force of 35 N at a 60 degree angle. There is 1.5 N force of friction to the right. The suitcase has a mass of 20 kg. What is the normal force acting on the suitcase? What is the acceleration of the suitcase?

$$F_g = (20\,\text{kg})(9.8\,\text{m/s}^2)$$

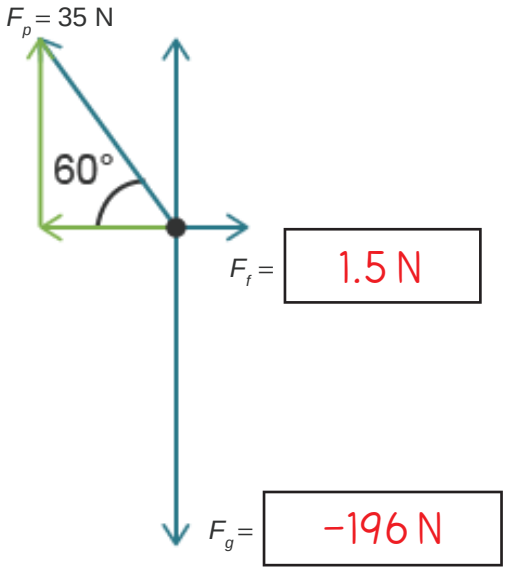
$$= \boxed{196\ \text{N}}$$

$$F_{px} = (35\,\text{N})(\cos 60^\circ)$$

$$= \boxed{17.5\ \text{N}}$$

$$F_{py} = (35\,\text{N})(\sin 60^\circ)$$

$$= \boxed{30.3\ \text{N}}$$



To find our force:

$$\sum F = 0$$

$$30.3\,\text{N} + F_N - 196\,\text{N} = 0$$

$$F_N = 196\,\text{N} - 30.3\,\text{N}$$

$$= \boxed{165.7\ \text{N}}$$

Similarly in the *x* direction:

$$\sum F = -17.5\,\text{N} + 1.5\,\text{N}$$

$$= \boxed{-16\ \text{N}}$$

$$a = \frac{F}{m}$$

$$= \frac{-16\,\text{N}}{20\,\text{kg}}$$

$$= \boxed{-0.8\ \text{m/s}^2}$$

Summary | Newton's Second Law

Lesson Question

How does Newton's second law describe the motion of an object?

Answer

(Sample answer) Newton's second law of motion states the net force acting on an object is equal to mass times acceleration.

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Review: Key Concepts

- Newton's second law of motion states that the acceleration of an object is directly proportional to the net force applied to an object and inversely proportional to the mass of the object.
  - $a = \frac{F}{m}$
- An object's weight can be determined by:

$$F_g = mg$$

- Newton's second and third laws of motion, together, explain how projectiles and recoil work.
- Trigonometry is used to break forces into *x* and *y* components so that a net force can be calculated.

Summary | Newton's Second Law

Use this space to write any questions or thoughts about this lesson.