

HOW DO FORCES AFFECT MOTION?

A **force** is a *push* or *pull* on an object. Forces usually cannot be seen but their effects can.

Nothing moves, changes speed, stops or changes direction without force. Heavier objects need more force to get them to move or change direction.

Look at the examples below. Fill in the blanks with the correct force at work (push / pull).

What forces are at work?

The operator uses a grabber bucket to pick up the large rock.

The operator _____ the bucket and thumb against the rock to get a tight grip.

He then is able to _____ the rock off the ground.



What forces are at work?

The operator _____ the tines of the grapple claw together to grip the boulder.

The tines _____ against the boulder forming a tight grip. This allows the operator to pick up the boulder.

What forces are at work?

The rotary drill is well equipped to drill in hard or soft rock applications.

The drill head _____ through the material.



Newton's 1st Law of Motion (the law of inertia)

Newton's First Law of Motion states that an object at rest will remain at rest unless acted upon by an unbalanced force. An object in motion continues in motion in the same direction and with the same speed unless acted upon by an unbalanced force.

Friction is a force that slows down the motion of a moving object. Think about a land slide. Once a slide begins the rock, earth and debris will stay in motion until friction between the material and the ground slows the movement. Eventually, friction and gravity will work together to stop the motion of the slide.

Gravity is a force that pulls two objects toward each other because of their mass. Mass is the measurement of the amount of material (matter) that makes up an object.



Friction and gravity are at work in each picture. Explain how each are at work and how they work together.

ANSWER

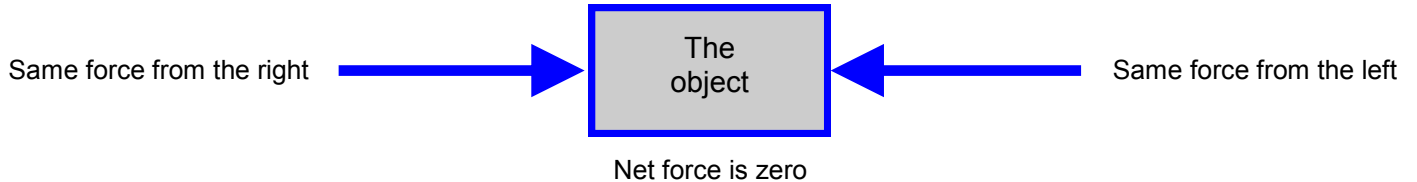
Multiple forces can act upon an object at the same time, pushing and pulling in any direction. The strength and direction of the forces determine what happens to the object.

When more than one force acts upon an object, the forces combine to form a **net force**.

Forces may work together or they may be opposite forces.

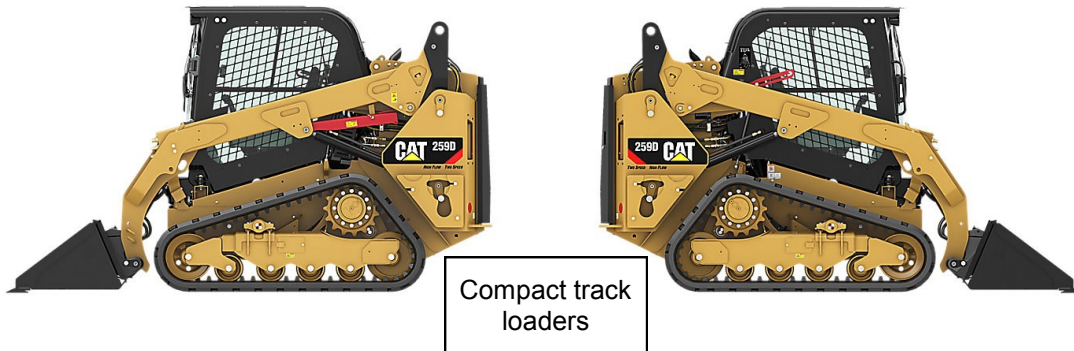
Net force of zero

If two forces of equal strength act upon an object in opposite directions, the forces will cancel each other, resulting in a net force of zero and no movement.



Balanced forces - Two or more opposite forces are balanced forces if their effects cancel each other and do not cause a change in an object's motion.

If these two identical compact track loaders play a game of tug of war moving forward at the same speed, which machine would win the game? Why? Explain your answer.



ANSWER

Unbalanced forces - If one force is stronger and the effects of the forces don't cancel each other, the forces are unbalanced. Unbalanced forces cause a change in motion, speed and/or direction.

A larger force causes a larger change in motion.

If the mini hydraulic excavator and the large excavator play a game of tug of war, which machine do you think would win? Why? Explain your answer.



Mini hydraulic excavator
Weight = 3241 lbs.



Excavator
Weight = 190,016 lbs.

ANSWER

Forces can make an object change shape.



The hammer is used to break up material like concrete and rock.

What force is at work in this picture? (push / pull)

How do the rocks change shape as they break?

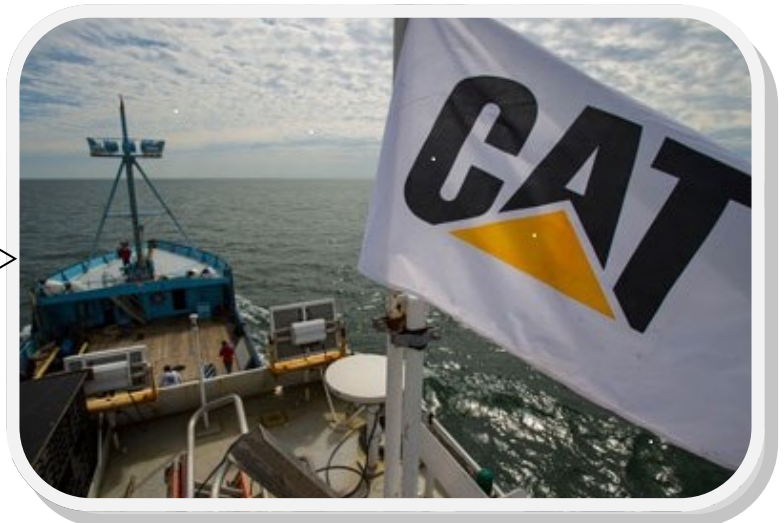
Name two more objects that change shape when a push or pull force is applied.

ANSWER

The wind is blowing the Cat flag as it flies high above the ship.

What force is at work in this picture? (push / pull)

How could the force cause the flag to change shape?



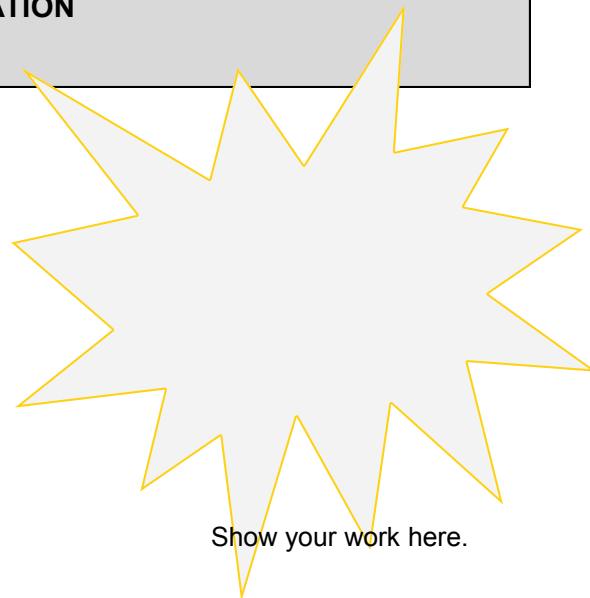
YOUR ANSWER

Newton's Second Law of Motion

Newton's Second Law of Motion states that acceleration is produced when a force acts on a mass. The greater the mass the greater the amount of force needed to accelerate the object. More force is required to move a heavier object than a lighter object.

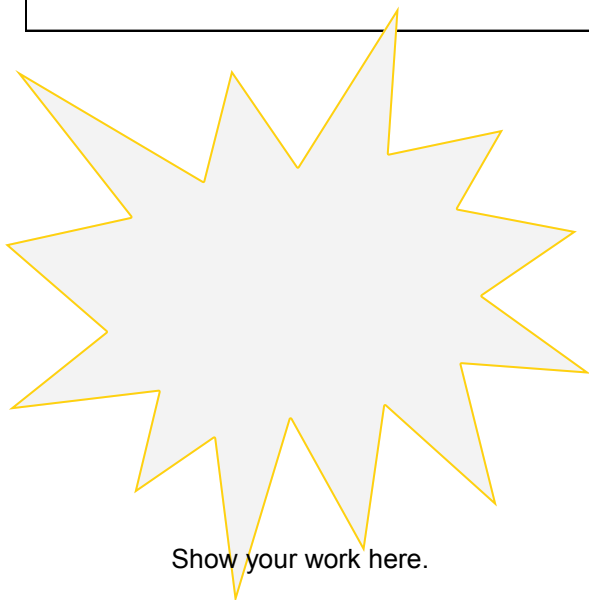
Newton's Second Law of Motion gives us an exact relationship between force, mass and acceleration. It can be expressed as a mathematical equation.

$$F = M \times A \quad \text{or} \quad \text{Force} = \text{MASS} \times \text{ACCELERATION}$$



Show your work here.

Bob uses a telehandler to pull his 1,000lb. trailer to his barn. Bob travels at 10 mph. How much force is exerted on the telehandler?



Show your work here.



During a race, the driver of the No. 31 Caterpillar Chevrolet runs an average speed of 170 mph in a Sprint car that weighs about 3,300 lbs. How much force is exerted on the car?

Weight is a measurement of how hard the earth's gravity pulls on an object's mass. The more mass an object has, the more it weighs. more mass = more pull = more weight

Which load shown below has a heavier mass? Why? Explain your answer.



Block handler



Wheel loader

ANSWER

Newton's Third Law of Motion

Newton's Third Law of Motion states for every action there is an equal and opposite reaction. For every force, there is a reaction equal in size that moves in the opposite direction. When an object pushes another object, it gets pushed back equally hard but in the opposite direction.



The propellers on this U.S. Navy patrol boat push against the water with the force of its powerful Cat marine engines. What is the reaction? In what direction does the force push the boat? Explain your answer.

As the Cat vocational truck drives to a worksite its tires push against the road. What is the reaction? In what direction does the force push the truck? Explain your answer.

ANSWER
