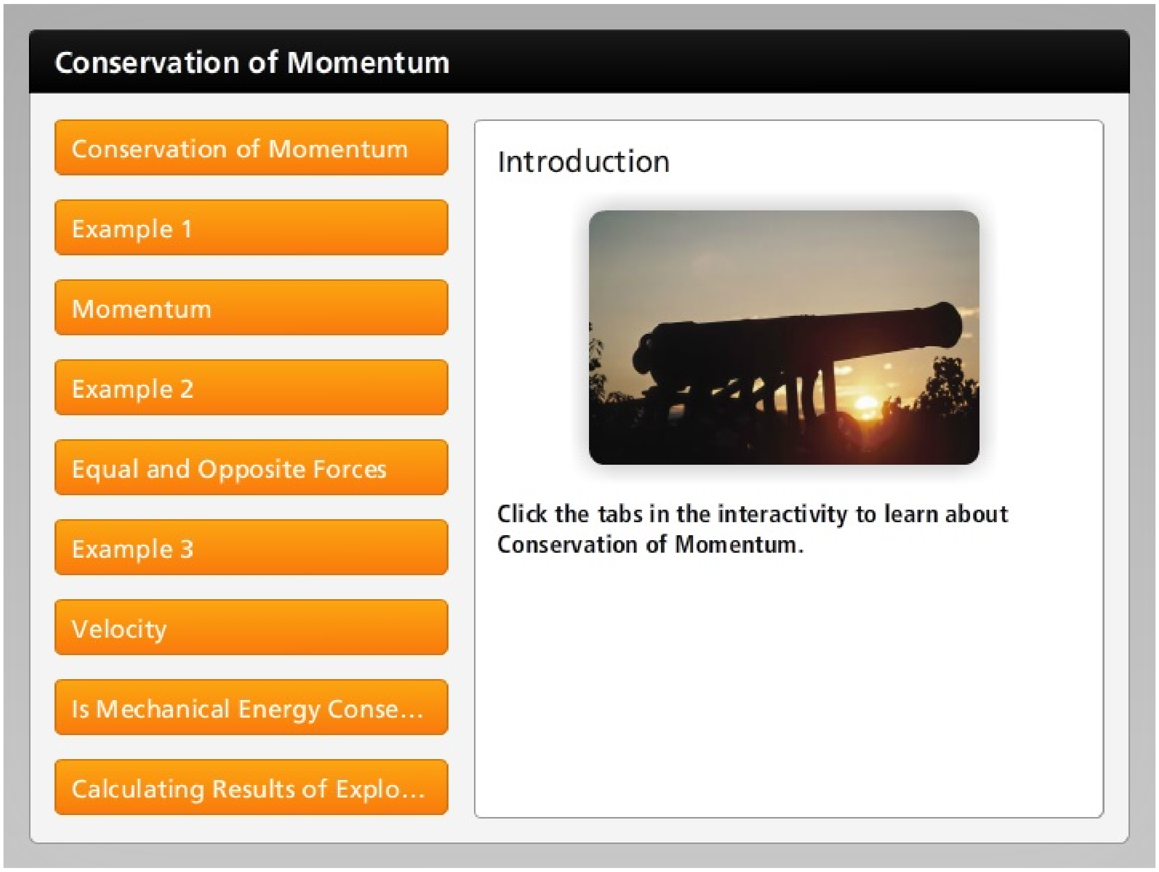
Module 5: Impulse and Momentum
Topic 3 Content: Conservation of Momentum

Introduction



Click the tabs in the interactivity to learn about Conservation of Momentum.

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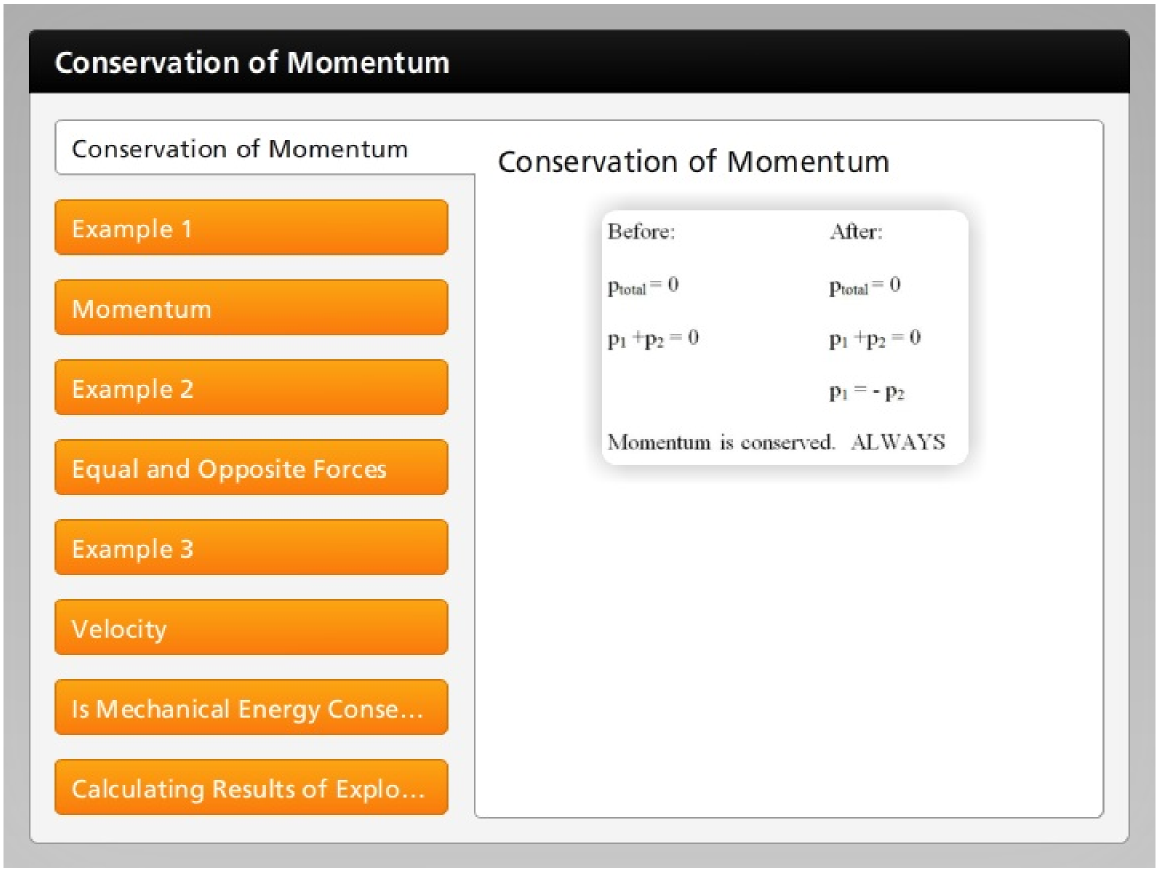
Conservation of Momentum



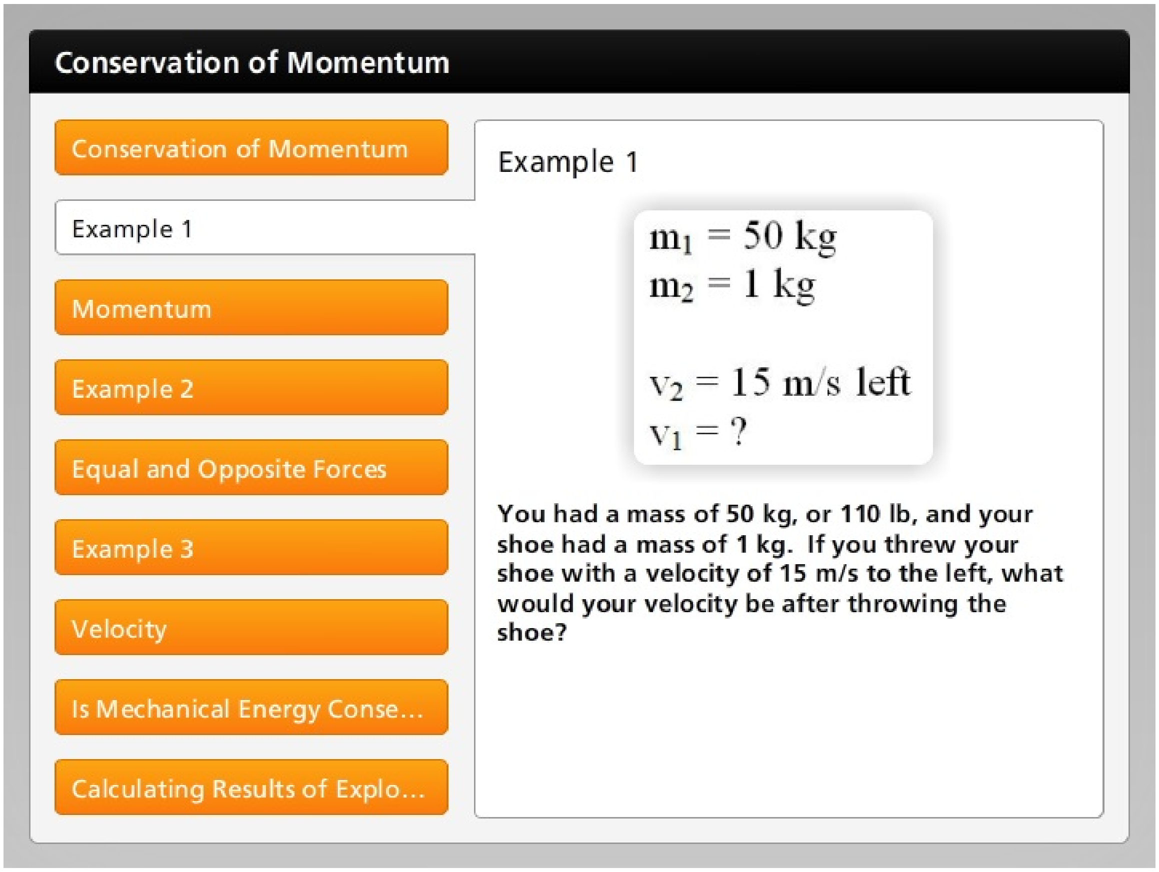
Since the objects involved in an explosion have equal and opposite momentums, and since momentum is a vector, the momentums cancel out. Two objects start at rest and neither is moving so the total momentum is zero. After the explosion, the objects have equal and opposite momentum, so again the total momentum is zero.

This is one example of conservation of momentum.

Conservation of momentum is even more powerful than conservation of energy, since energy takes multiple forms and can sometimes be hard to track. But momentum is always mass times velocity, and momentum is conserved in all interactions without exception.

In calculations of conservation of momentum, you will always be dealing with two objects at a time. In order to keep track of each object's mass, velocity and momentum, you will use subscripts to identify the properties of each object. P one will be the momentum of object one and p two will be the momentum of object two, and so on."

Example 1



You had a mass of 50 kg, or 110 lb., and your shoe had a mass of 1 kg. If you threw your shoe with a velocity of 15 m/s to the left, what would your velocity be after throwing the shoe?

Let's again take a look at the situation of being stuck on the frozen, frictionless pond. Let's say you had a mass of fifty kilograms, or one hundred ten pounds, and your shoe had a mass of one kilogram. If you threw your shoe with a velocity of 15 m/s to the left, what would your velocity be after throwing the shoe?

The subscript one will refer to you and the subscript two will refer to the shoe.

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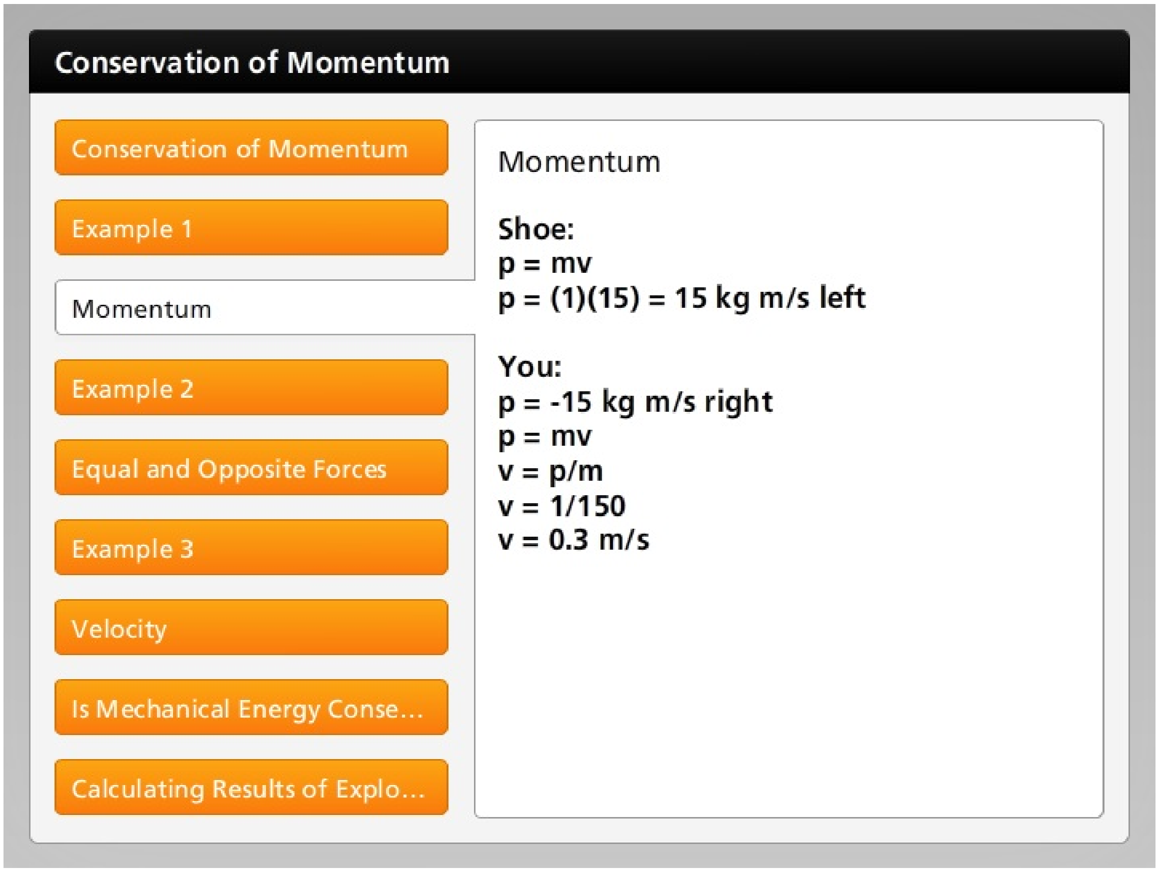
Momentum



Shoe:
p = mv
p = (1)(15) = 15 kg m/s left

You:
p = -15 kg m/s right
p = mv
v = p/m
v = 1/150
v = 0.3 m/s

Let's calculate the momentum of the shoe. Momentum is mass times velocity, so the shoe would have one times fifteen or fifteen kilogram meters per second of momentum to the left. Since equal but opposite impulses are exerted on the shoe and you, you will have a momentum equal to fifteen kilogram meters per second to the right. Your mass is fifty kilograms, therefore you can calculate your velocity since you know your mass and momentum. Fifteen kilogram meters per second divided by fifty kilograms is zero point three meters per second.

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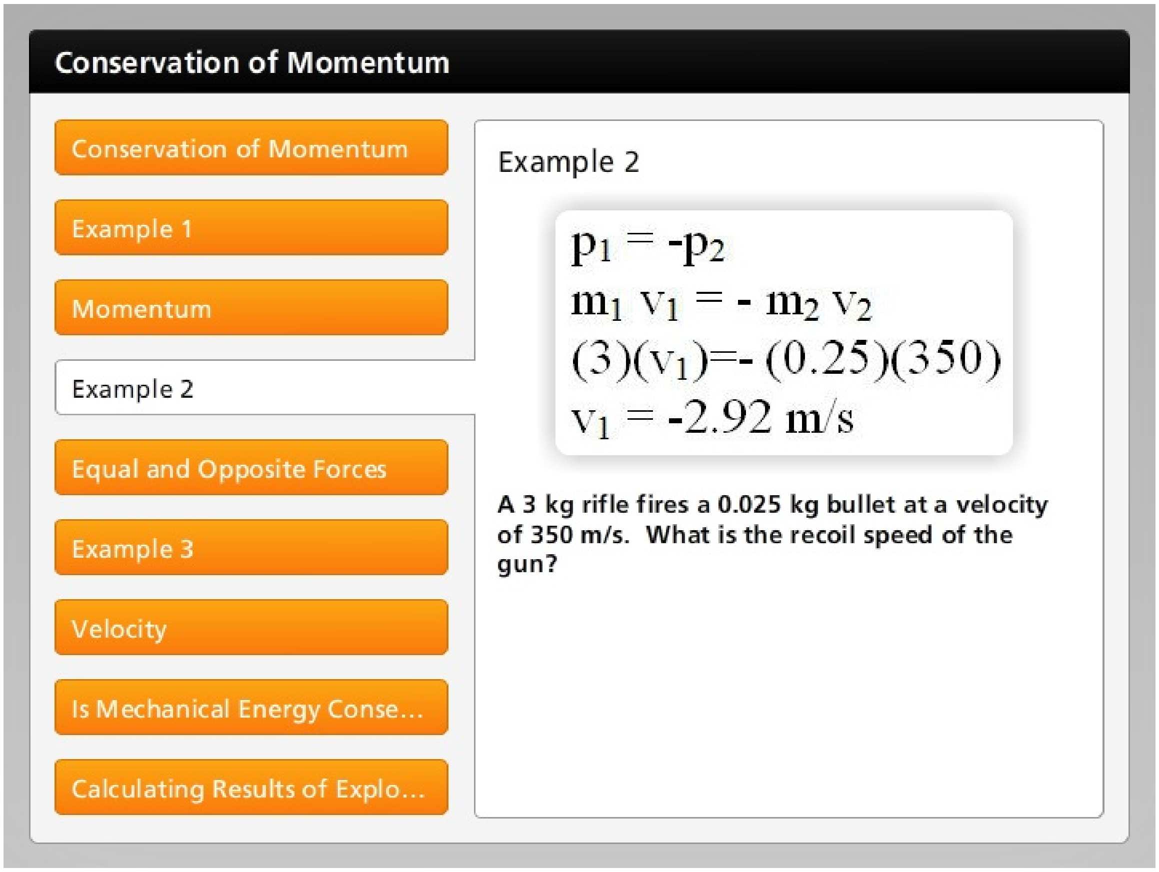
Example 2



A 3 kg rifle fires a 0.025 kg bullet at a velocity of 350 m/s. What is the recoil speed of the gun?

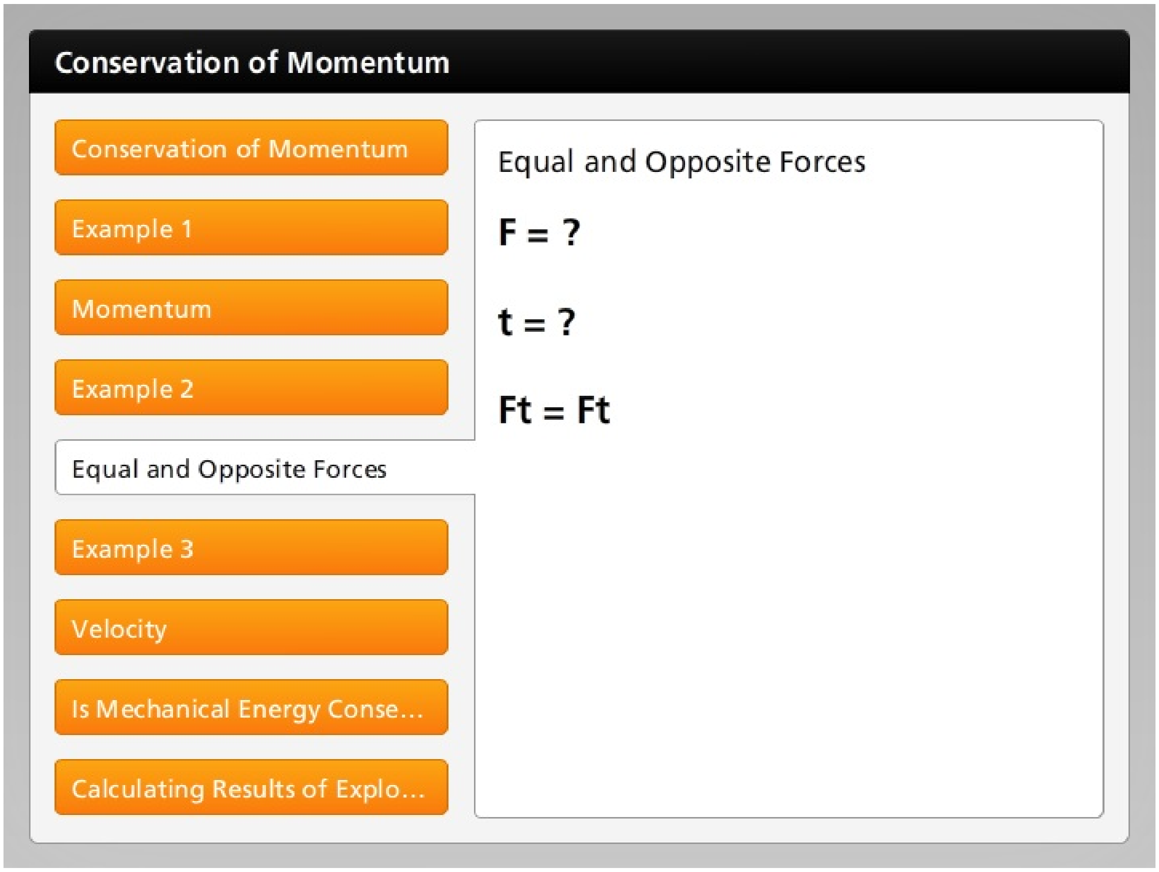
Let's look at another example. A three kilogram rifle fires a zero point zero two five kilogram bullet at a velocity of three hundred fifty meters per second. What is the recoil speed of the gun?

You know that the momentum of the bullet will be equal and opposite the momentum of the gun, so you can write m one v one equals negative m two v two.

Substituting both masses and the velocity of the bullet, you can solve for the velocity of the rifle.

You see that the rifle has a recoil speed of negative two point nine two meters per second. The negative tells us that it is going in the opposite direction as the bullet.

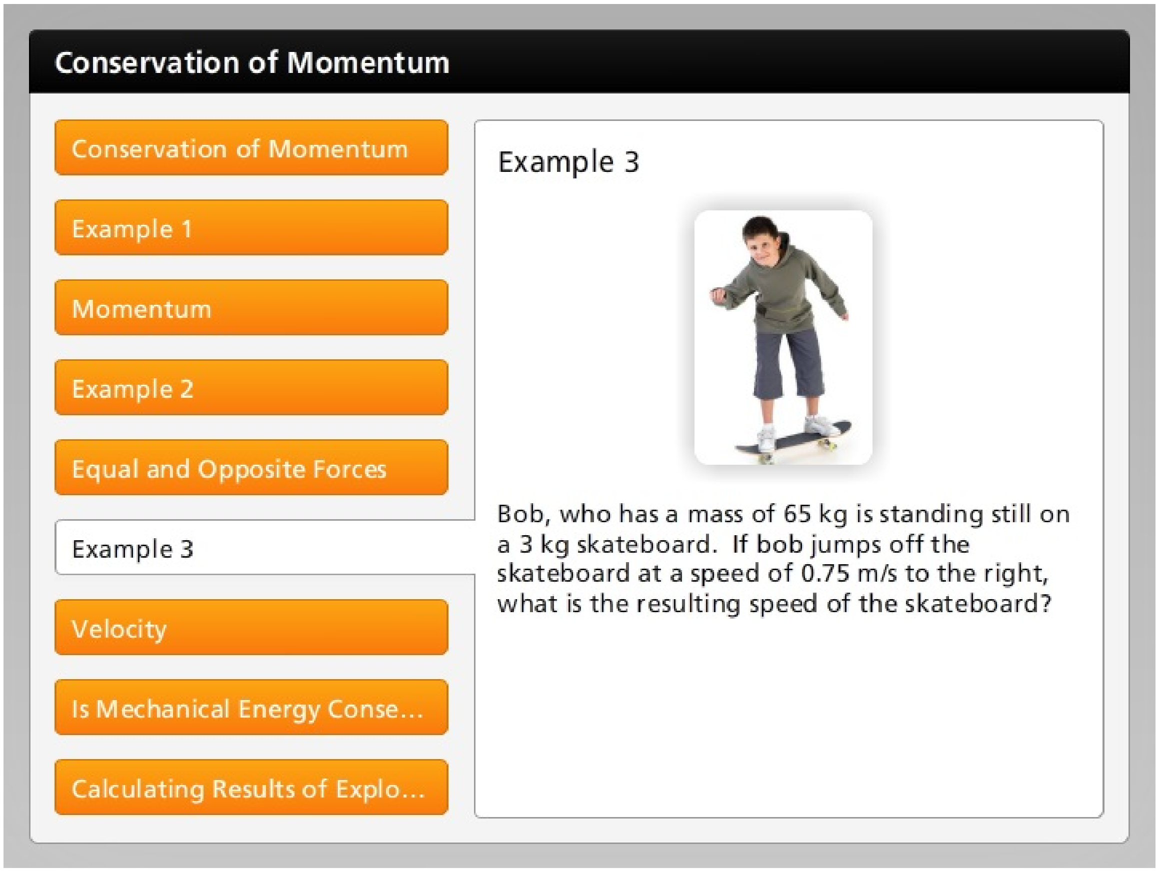
Equal and Opposite Forces



F = ?
t = ?
Ft = Ft

Notice that in these calculations you don't have to actually know the force or the time of the interaction. Since you know that they must be equal and opposite forces and that the time of interaction is the same for both objects, you know that the impulse must be the same, so you can focus entirely on the momentum of each object.

Example 3



Bob, who has a mass of 65 kg is standing still on a 3 kg skateboard. If bob jumps off the skateboard at a speed of 0.75 m/s to the right, what is the resulting speed of the skateboard?

Bob, who has a mass of sixty five kilograms is standing still on a three kilogram skateboard. If bob jumps off the skateboard at a speed of zero point seven five meters per second to the right, what is the resulting speed of the skateboard?

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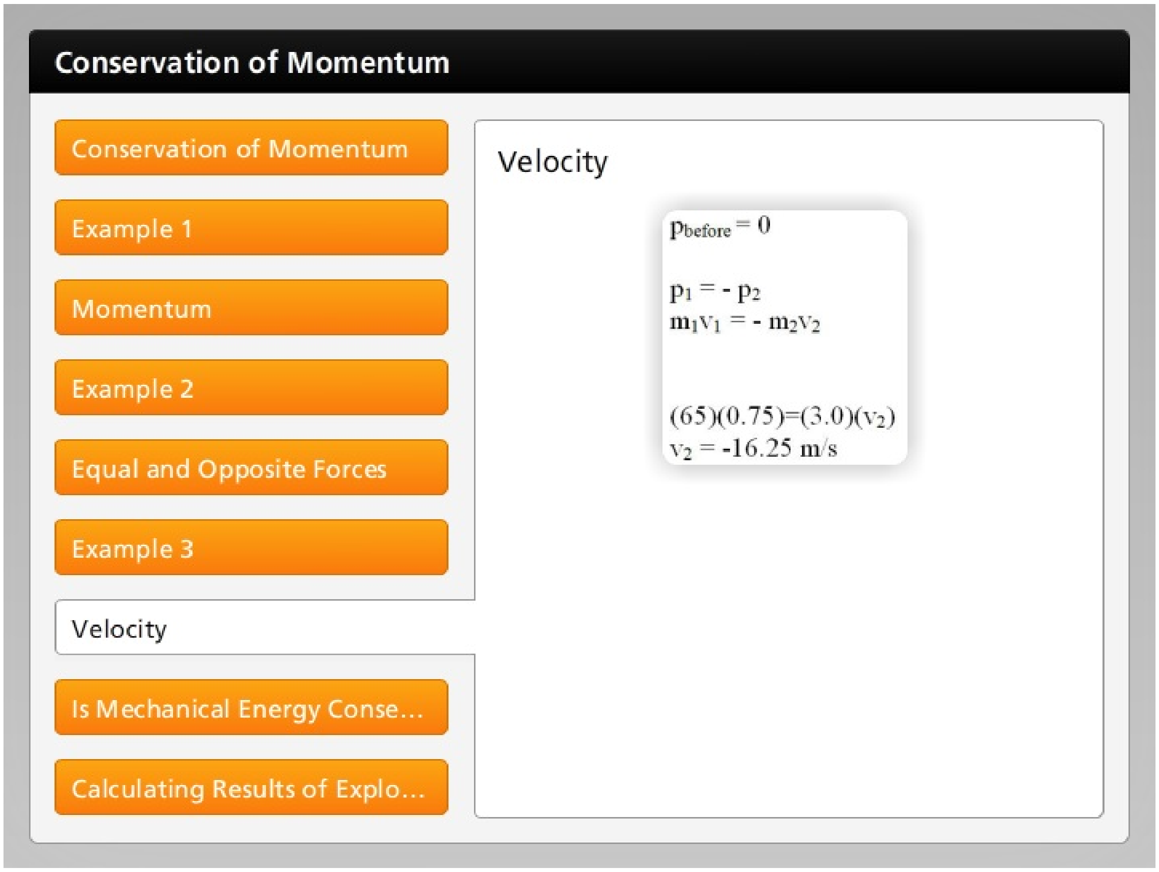
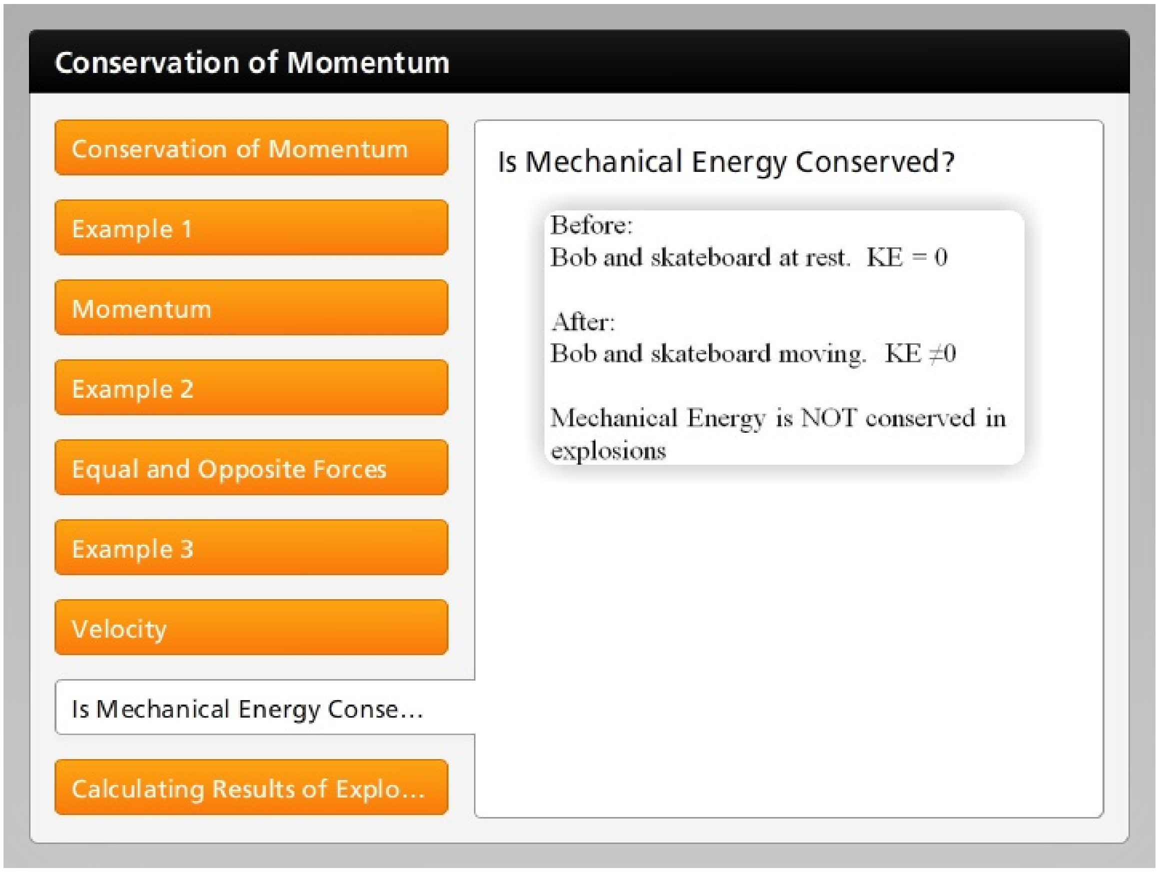
Velocity



Since both Bob and the skateboard start at rest, the initial momentum is zero. After Bob jumps, his momentum to the right will equal the skateboard's momentum to the left. You write the equation m one v one equals negative m two v two.

Substituting Bob's mass, Bob's velocity and the skateboard's mass, you solve and see that the skateboard's velocity will be negative sixteen point two five meters per second, which means sixteen point two five meters per second to the left.

Is Mechanical Energy Conserved?

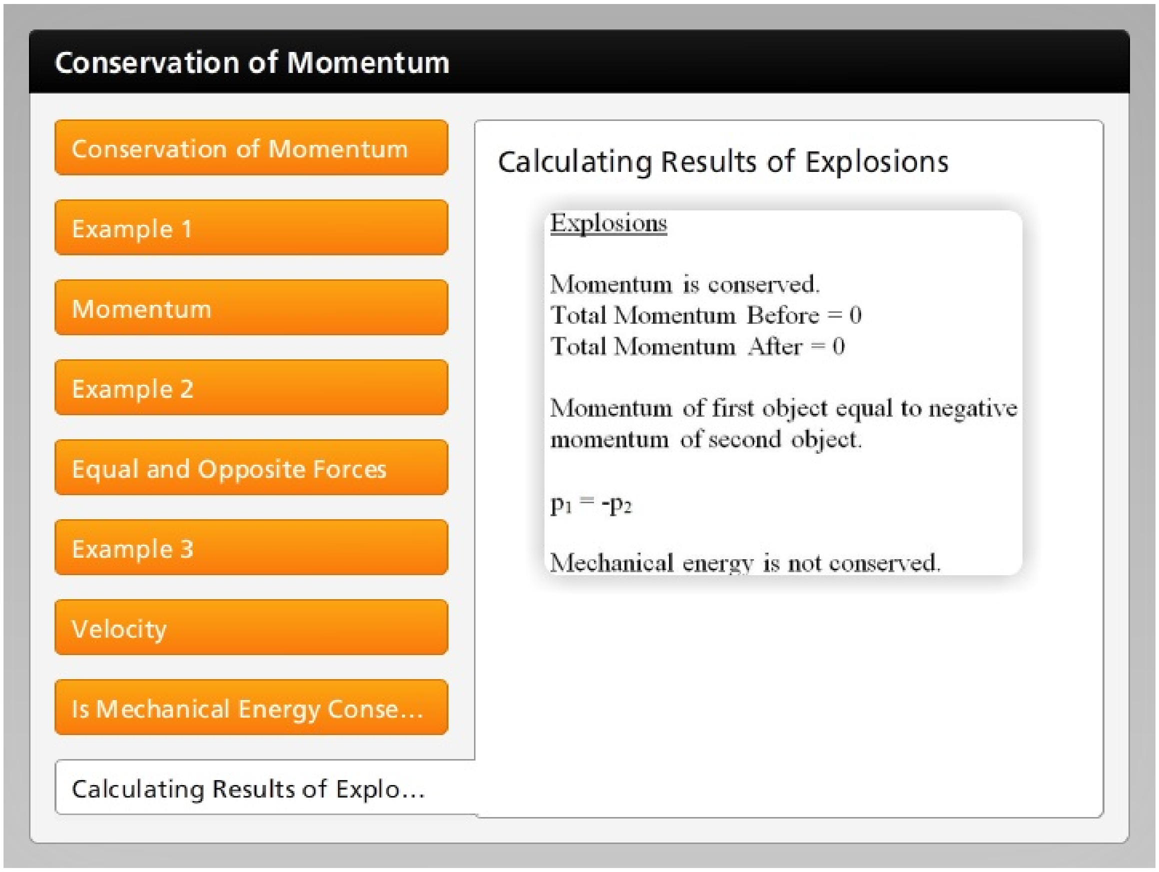


Is mechanical energy conserved in an explosion?

If you look at the energy before the explosion, you see that both Bob and the skateboard are at rest, so they have no kinetic energy. After the explosion, both Bob and the skateboard have significant kinetic energy, since both are moving. This is clearly not a situation in which energy is conserved.

Energy is conserved, even when mechanical energy is not. Where does the mechanical energy come from? Chemical energy inside Bob's body is used by Bob to do work on the skateboard. The work done on the skateboard is transformed into kinetic energy.

Calculating Results of Explosions



You can see that conservation of momentum makes it easy to calculate the results of explosions. Since both objects start with zero momentum, the momentum must add up to zero after the explosion. This means that the momentum of the first object will be the negative of the momentum of the other object. You use the equation m one v one equals negative m two v two to solve problems involving explosions. It is also important to note that mechanical energy is not conserved in an explosion.