Name: _____ Date: _____

PRACTICE 112m = 4 sec 3.1

Impulse

READ

A change in momentum for an object is equal to impulse. Momentum changes when velocity changes.

$$\text{impulse} = \text{change in momentum}$$

Force is what changes velocity. Therefore, when momentum changes a force must be involved for a period of time. The following equation relates impulse to change in momentum.

$$\text{Force} \times \text{time} = \text{Final momentum} - \text{Initial momentum}$$

$$F \times t = mv_2 - mv_1$$

Momentum (p) is expressed in units of kg·m/s; m is the mass of the object, in kg; and v is the velocity of the object in m/sec. Impulse is expressed in units of N·sec.

1 N·sec = 1 kg·m/sec because 1 newton = 1 kg·m/sec^2:

$$1 \text{ N-sec} = 1\frac{\text{kg-m}}{\text{sec}^2} \times \text{sec} = 1\frac{\text{kg-m}}{\text{sec}}$$

EXAMPLES

A net force of 50 newtons is applied to a 20-kilogram cart that is already moving at 1 meter per second. The final speed of the cart was 3 meters per second. For how long was the force applied?

Looking for

The speed of the cart after 3 seconds.

Given

Force applied = 50 newtons

Mass of the car = 20 kilograms

Initial speed of the cart = 1 m/sec

Final speed of the cart = 3 m/sec

Relationships

time = change in momentum ÷ Force

$$t = \frac{mv_2 - mv_1}{F}$$

Solution

$$t = \frac{mv_2 - mv_1}{F}$$

$$t = \frac{(20 \text{ kg})(3 \text{ m/sec}) - (20 \text{ kg})(1 \text{ m/sec})}{50 \text{ N}}$$

$$t = \frac{(60 \text{ kg-m/sec}) - (20 \text{ kg-m/sec})}{50 \text{ N}}$$

$$t = \frac{(40 \text{ kg-m/sec})}{50 \text{ N}} = 0.8 \text{ sec}$$

The force was applied to the cart for 0.8 second.

PRACTICE

1. A net force of 100 newtons is applied to a 20-kilogram cart that is already moving at 3 meter per second. The final speed of the cart was 8 meters per second. For how long was the force applied?

Looking for	**Solution**
Given	
Relationships	

2. A 3-kilogram ball is accelerated from rest to a speed of 10 m/sec.
   a. What is the ball's change in momentum?
   b. What is the impulse?
   c. If a constant force of 40 newtons is applied to change the momentum in this situation, for how long does the force act?

3. A 2,000-kilogram car uses a braking force of 12,000 newtons to stop in 5 seconds.
   a. What impulse acts on the car?
   b. What is the change in momentum of the car?
   c. What is the initial speed of the car?

4. A 60-kilogram high jumper lands on a mat after her jump. The mat brings her to a stop after 1 second. She was traveling at 5.0 m/sec when she landed on the mat. Note: The speed of the jumper at the top of her jump, before she started to fall toward the mat, was 0 m/sec.
   a. What is the change in momentum for the jumper?
   b. What is the force felt by the jumper upon impact with the mat?

5. A 0.5-kilogram soccer ball is kicked with a force of 50 newtons for 0.2 seconds. The ball was at rest before the kick. What is the speed of the soccer ball after the kick?

6. A baseball player hits a 0.155-kilogram fastball traveling at 44.0 m/sec into center field at a speed of 50.0 m/sec. If the impact lasts for 0.00450 second, with what force does he hit the baseball?

7. Tow Sawyer launches his 180-kilogram raft on the Mississippi River by pushing on it with a force of 75 newtons. How long must Tom push on the raft to accelerate it to a speed of 2.0 m/sec?

8. In terms of impulse, why is the ride much more comfortable when an airplane is flying at constant speed versus when it is taking off or landing?

Thought questions

9. In certain martial arts, people practice breaking a piece of wood with the side of their bare hand. Use your understanding of impulse to explain how this can be done without injury to the hand.

10. If identical bullets are shot from a pistol and a rifle, a bullet shot from the rifle will travel at a higher speed than a bullet from the pistol. Why? (Hints: Assume shooting force is the same in each case. The barrel of the rifle is longer than the barrel of the pistol.)

11. Boxers attempt to move with an opponent's punch when it is thrown. In other words, a boxer moves in the same direction as their opponent's punch. This movement may prevent a knockout blow being delivered by their opponent. Explain how.

12. Show that the relationship between impulse and the change in momentum is another way of stating Newton's second law of motion.

13. Mats in a gym, airbags, and padding in sports uniforms are used to protect people from being injured. Explain why these soft objects used instead of rigid objects using your understanding of impulse and change of momentum.