8.1: Linear Momentum and Force

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General Information

Momentum implies a tendency to continue on course or the quantity of motion of a moving body, measured as a product of mass and velocity

Linear momentum the product of mass and velocity

Unit is kg • m/s

Newton's 2nd law is stated in terms of momentum

$$F_{net} = \Delta p / \Delta t$$

Formula

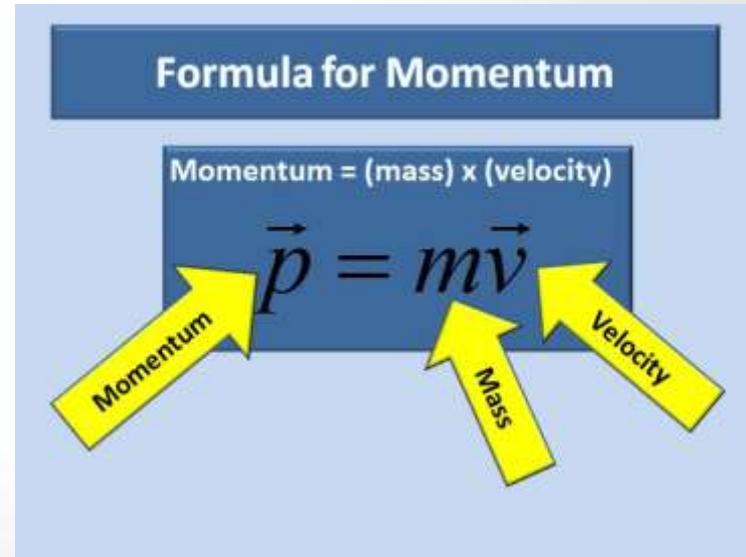Formula for momentum is P=mv
  P= momentum in kg • m/s
  m = mass in kg
  v = velocity in m/s

Formula for Momentum

Momentum = (mass) x (velocity)

$$\vec{p} = m\vec{v}$$

Momentum   Mass   Velocity

Conceptual Questions

1. An object that has a small mass and an object that has a large mass have the same momentum. Which object has the largest kinetic energy?
kinetic energy of an object is $K = (1/2)mv^2$.

Two objects of different mass are moving at the same speed; the more massive object will have the greatest momentum.

For the momentums to be equal, the product of the velocities and masses of the 2 objects must be equal

When comparing the kinetic energy of two objects, the velocity of an object is of double importance. So if two objects of different mass have the same momentum, then the object with the least mass has a greater velocity. This greater velocity will tip the scales in favor of the least massive object when a kinetic energy comparison is made.

The object with the smaller mass has the largest kinetic energy.

Conceptual Questions (cont.)

4. How can a small force impart the same momentum to an object as a large force?

   Impulse changes the momentum of an object. Impulse is defined as the integral of a force acting on an object, with respect to time. This means that impulse contains the product of force and time. As a result, a large force applied for a short period of time can produce the same momentum change as a small force applied for a long period of time.

Problems

1. (a) Calculate the momentum of a 2000-kg elephant charging a hunter at a speed of 7.50 m/s . (b) Compare the elephant's momentum with the momentum of a 0.0400-kg tranquilizer dart fired at a speed of 600 m/s . (c) What is the momentum of the 90.0-kg hunter running at 7.40 m/s after missing the elephant?

   a. $P_e= m_e v_e=$ (2000 Kg)(7.50m/s) = 1.50 x 10^4 Kg•m/s momentum of the elephant

   a. $P_d= m_d v_d =$ (.0400 Kg)(600 m/s) = 24 Kg m/s P_e/P_d = 24 Kg m/s / 1.50 x 10^4 Kg•m/s = 625
The elephant's momentum is 625 greater because the mass of the elephant is much larger

   c.   P = (90 Kg)(7.40 m/s) = 666 Kg•m/s

Problems (cont.)

4. (a) What is the momentum of a garbage truck that is 1.20×10^4 kg and is moving at 10.0 m/s ? (b) At what speed would an 8.00-kg trash can have the same momentum as the truck?

   a. $p = mv$
       $p = (1.20 \times 10^4 \, kg)(10 \, m/s)$
       $p = 1.20 \times 10^5 \; kg \cdot m/s$

   b. $1.20 \times 10^5 \, kg \cdot m/s = (8.00 kg)(v)$
       $v = 1.5 \times 10^4 \, m/s$

Lab

Momentum Transfer Demonstration

https://youtu.be/2UHS883_P60