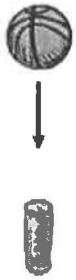
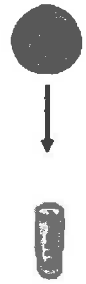
Ms. Rosenthal (P.3)

Momentum

Demonstration 1	Demonstration 2
 mV $m\vec{v} < M\vec{v}$	 MV

Is there a way the results could have been identical?

momentum = mass x velocity
To be equal, basketball has to have much higher velocity.

Mass: amount of matter (atoms) in an object

Inertia: resistance to a change in an object's motion

Kinetic energy: energy of motion

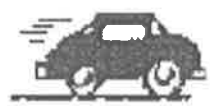
Momentum: product of mass times velocity

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

Direction: from velocity

Symbol	p	m	KE
Quantity	momentum	mass	Kinetic energy
Units	$Kg\frac{m}{s}$	Kg	$Kg\frac{m^2}{s^2}$ = J
Type	vector	scalar	scalar

1. What is the momentum of a 1500 kg car traveling east at 20. m/s?



$\vec{p} = m\vec{v} = 1500Kg \cdot 20\frac{m}{s}$

$3.0 \times 10^4 Kg\frac{m}{s}$ to the east

Did you know?

Momentum is so fundamental in Newton's mechanics that Newton called it simply "quantity of motion." The symbol for momentum, p, comes from Leibniz's use of the term *progress*, defined as "the quantity of motion with which a body proceeds in a certain direction."

2. Compare the inertia, momentum, and kinetic energy of a 100. kg football player running at 2.0 m/s and a 50. kg field hockey player running at 3.0 m/s.

Inertia	Momentum $\vec{p} = m\vec{v}$	Kinetic energy $\frac{1}{2}mv^2$
F 100.Kg	$100Kg \times 2\frac{m}{s} = 200Kg\frac{m}{s}$ → $2.0 \times 10^2 Kg m/s$	$\frac{1}{2}(100Kg)(2\frac{m}{s})^2 = 2.0 \times 10^2 J$
H 50.Kg	$50Kg \cdot 3\frac{m}{s} = 150Kg\frac{m}{s}$ → $1.5 \times 10^2 Kg\frac{m}{s}$	$\frac{1}{2}(50Kg)(3\frac{m}{s})^2 = 2.3 \times 10^2 J$

Compare the quantities listed below for each pair of objects.

v = 25 m/s v = 25 m/s

Inertia	✓	
Momentum	✓	
Kinetic Energy	✓	

v = 0 m/s v = 25 m/s

Inertia	✓	
Momentum		✓
Kinetic Energy		✓

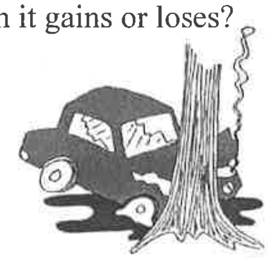
$m_1 = m_2$

v = 7 m/s v = 3 m/s

Inertia	same	same
Momentum	✓	
Kinetic Energy	✓	

How does an object gain or lose momentum? What determines how much momentum it gains or loses?

Determined by how much force is applied for a length of time.



Impulse

1. a change in momentum
2. the product of a force and the amount of time the force acts on the object

Formula:

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

$\vec{F} \cdot t = m\Delta\vec{v}$ $a = \frac{\Delta \vec{v}}{t}$

impulse = change in momentum

$\vec{J}$

Symbol	$\vec{J}$	$\Delta\vec{p}$
Quantity	impulse	change in momentum
Units	$N \cdot s$ $\left(kg\frac{m}{s^2} \cdot s\right)$	$kg\frac{m}{s}$
Type	vector	vector

1. A 50. kg runner accelerates from 2.0 m/s to 3.0 m/s. What is her:
   a) initial momentum?
   b) final momentum?
   c) change in momentum?
   d) What impulse did she apply?

a. $50 kg \cdot 2 m/s = \boxed{1.0 \times 10^2 \, kg\frac{m}{s}}$

b. $50. kg \cdot 3 m/s = \boxed{1.5 \times 10^2 \, kg\frac{m}{s}}$

c. $\Delta\vec{p} = \vec{p}_f - \vec{p}_i = \boxed{50. \, kg\frac{m}{s}}$

d. $50. N \cdot s$ $(\vec{F} \cdot t)$

initially at rest

2. A player kicks a 0.50 kg soccer ball with an average force of 10. N. His foot is in contact with the ball for 0.40 s.

a) What impulse does he apply to the ball? $\vec{F} \cdot t = \vec{J}$

$10.N(0.40s)$ $\boxed{4.0 N \cdot s}$

b) How much does the momentum of the ball change as a result? $\Delta\vec{p} = \boxed{4.0 \, kg \, m/s}$

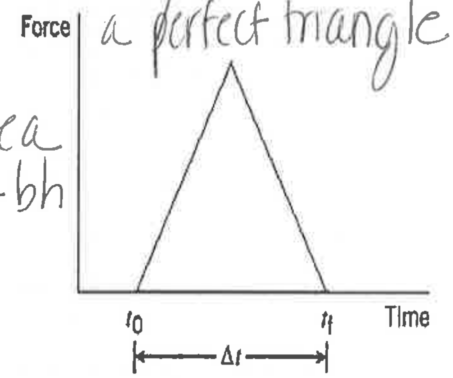
c) What is the final velocity of the soccer ball?

$V_i = \emptyset \frac{m}{s}$ $V_f = ?$ $\frac{\Delta\vec{p}}{m} = \Delta\vec{v} = V_f - V_i = \frac{4.0 \, kg \, m/s}{0.50 \, kg} = \boxed{8.0 \frac{m}{s} = V_f}$

Notice that the force

a) not a constant

b) not instantaneous



may not be a perfect triangle

area $= \frac{1}{2} bh$

3. How can an impulse be determined from a force-time graph?

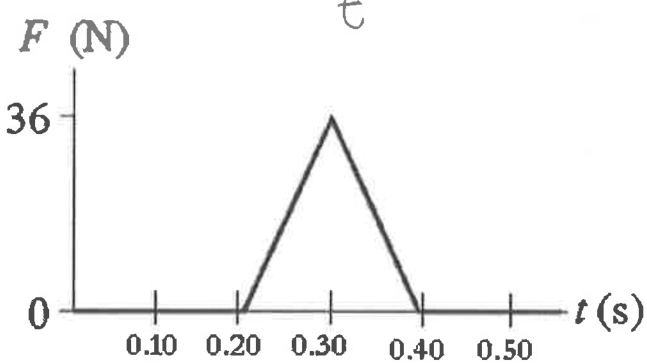
area under the triangle = impulse or change in momentum

area $= \vec{F} \cdot t = \vec{J}$

slope $= \frac{\vec{F}}{t}$

$\vec{J} = \frac{1}{2} F_{max} \cdot t$ or $F_{AVG} \cdot t$

4. A player kicks a 0.50 kg football and the force versus time graph is shown at right.



a) What impulse does he apply to the ball?

$\vec{J} = \frac{1}{2} F_{max} \cdot t$ $\frac{1}{2}(36N)(0.2s) = 3.6 N \cdot s$

b) How much does the momentum of the ball change as a result?

$\Delta\vec{p} = 3.6 \, kg \frac{m}{s}$

c) How fast is the football going after the kickoff?

$\frac{\Delta\vec{p}}{m} = \Delta\vec{v}$ $V_i = \emptyset \frac{m}{s}$ $\frac{3.6 \, kg \frac{m}{s}}{0.5 \, kg} = \boxed{7.2 \frac{m}{s} = \vec{V}}$