Sample Test Question

- You and a friend wish to push a couch across the room. Do you have to push more, less than, or an equal force compared to the force of friction? Explain your answer in terms of forces.
Sample Question

- Two books sit on top of each other on a table. Identify all the forces on the bottom book. Pick an example of two forces that are Newton’s third law force pairs.
Bonus - case study: constant acceleration

- Moving man simulation from PhET

\[ x = v_{\text{avg}}t \]
\[ v_{\text{avg}} = \frac{v_1 + v_2}{2} \]

if starting from rest:
\[ v_1 = 0 \text{ m/s} \]
\[ v_{\text{avg}} = \frac{v_2}{2} \]

so:
\[ x = \frac{1}{2}v_2t \]
but also:
\[ a = \frac{v_2 - v_1}{t} = \frac{v_2}{t} \]
\[ v_2 = at \]
\[ x = \frac{1}{2}at^2 \]
What is wrong with this?
What is wrong with this?
Chapter 3

2 principles
Key things to review

- Force - interaction between TWO objects
- Net Force changes motion

\[ a = \frac{F_{\text{net}}}{m} = \frac{10 \text{ N}}{5 \text{ kg}} = 2 \text{ m/s}^2 \]
Key points:

• What happens when the force is applied for some time?

• What happens when force is applied over a distance?
Time

- Momentum:
  \[ p = mv \]
  direction matters

- Momentum principle:
  \[ F \Delta t = \Delta p = p_2 - p_1 \]
  impulse
Distance

- **Work**
  \[ W = F \Delta x \]

- **Energy**
  \[ KE = \frac{1}{2}mv^2 \]
  \[ PE_{\text{grav}} = mgh \]

- **Work-Energy Principle**
  \[ W = \Delta E = \Delta KE + \Delta PE \]
A moving object has

A. momentum.
B. energy.
C. speed.
D. All of the above.
When the speed of an object is doubled, its momentum

A. remains unchanged in accord with the conservation of momentum.
B. doubles.
C. quadruples.
D. decreases.
When the force that produces an impulse acts for twice as much time, the impulse is

A. not changed.
B. increased by two times.
C. increased by four times.
D. decreased by half.
Momentum vs. Energy

- Momentum is a vector
- Energy is a scalar
- distance vs. time
- Note: vectors in 1-d will be + or -
A fast-moving car hitting a haystack or hitting a cement wall produces vastly different results. Both experience

A. the same change in momentum.
B. the same impulse.
C. the same force.
D. A and B.
Momentum Example
When a dish falls, will the change in momentum be less if it lands on a carpet than if it lands on a hard floor? (Careful!)

A. No, both are the same.
B. Yes, less if it lands on the carpet.
C. No, less if it lands on a hard floor.
D. No, more if it lands on a hard floor.
Colliding Objects (before)
Colliding Objects (during)

For A:
\[ \Delta p_A = F_B \text{ on } A \Delta t \]

For B:
\[ \Delta p_B = F_A \text{ on } B \Delta t = -\Delta p_A \]

\[ F_B \text{ on } A = -F_A \text{ on } B \]

time is the same
Conservation of momentum

- Ball A and B have opposite changes in momentum
- Total momentum is constant
- Momentum $A + B$ before $=$ momentum $A + B$ after
- Don’t forget the sign!
Example

Inelastic collision - objects stick together
What if?

$v = ?$
Check this out
Which has greater impulse?

1. The dart that bounces back
2. The dart that sticks in
3. They have the same impulse
Bouncing dart

\[ p_1 = +5 \text{ kg*m/s} \]

\[ p_2 = -2 \text{ kg*m/s} \]

\[ \Delta p = p_2 - p_1 = (-2 - 5) \text{ kg*m/s} = -7 \text{ kg*m/s} \]
Sticking dart

\[ p_1 = +5 \text{ kg}\cdot\text{m/s} \]

\[ p_2 = +3 \text{ kg}\cdot\text{m/s} \]

\[ \Delta p = (p_2 - p_1) = (3 - 5) \text{ kg}\cdot\text{m/s} = -2 \text{ kg}\cdot\text{m/s} \]
Example: Professor Splash