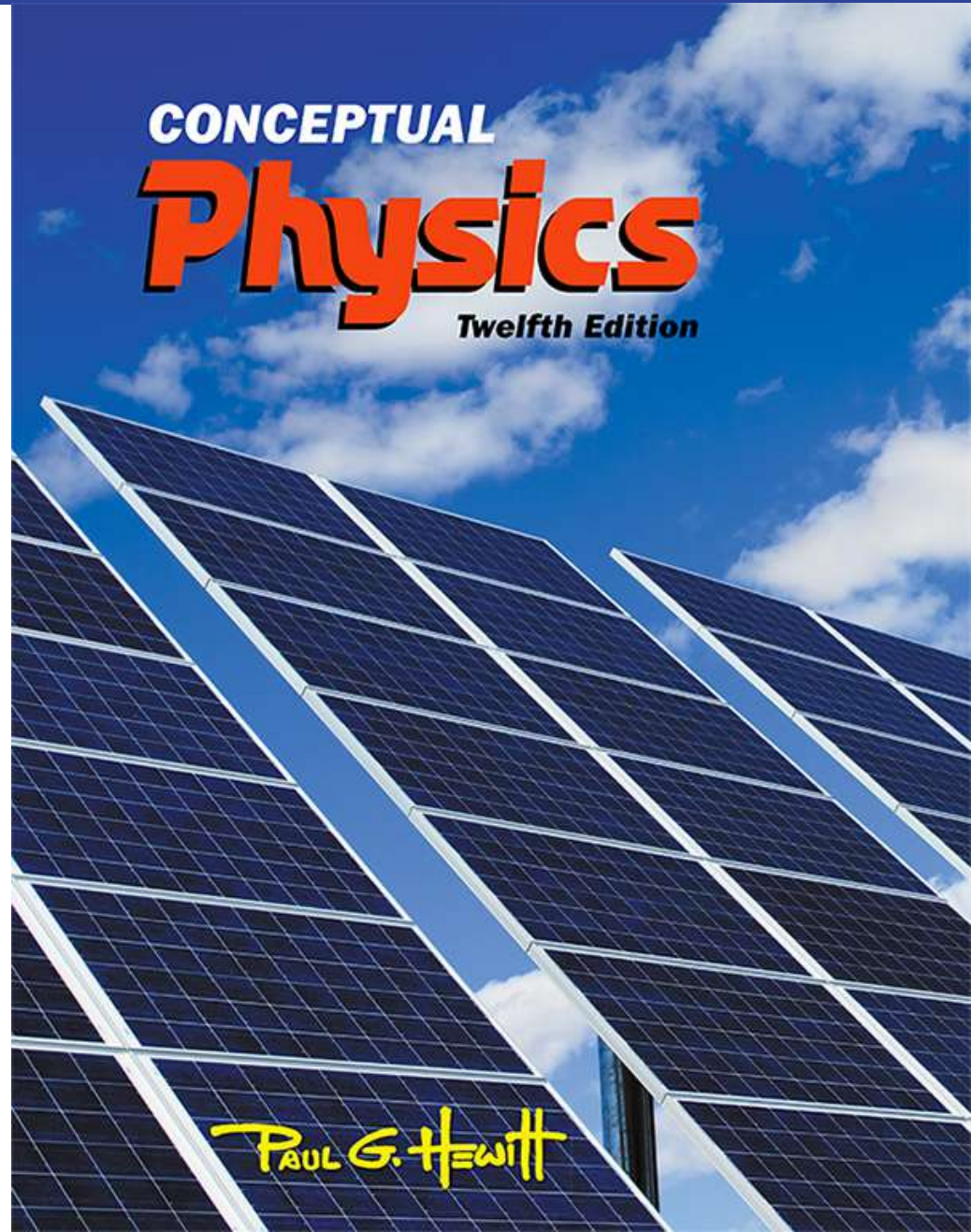


# Lecture Outline

## Chapter 6: Momentum



# This lecture will help you understand:

- Momentum
- Impulse
- In the next lecture, we will see how they are connected.

# I. Momentum

- a property of *moving* things
- means “inertia in motion”
- more specifically, it equals:  
mass of an object multiplied by its velocity
- in equation form:

$$\text{momentum} = \text{mass} \times \text{velocity}$$

Momentum is a *vector*:

Its direction is the same direction as the velocity

If direction is not important, then

$$\text{momentum} = \text{mass} \times \text{speed}$$

- Ex: What is the momentum of a 1200-kg car driving at a speed of 20 m/s eastward on Hwy 610?
- Momentum = mass x velocity
- = (1200 kg) x (20 m/s east)
- = 24,000 kg m/s, east
- If direction is not important, the “magnitude” of the momentum is simply its value without the direction:
- Momentum = 24,000 kg m/s

# Momentum, Continued

- Example:
  - A moving boulder has more momentum than a stone rolling at the same speed.
  - A fast boulder has more momentum than a slow boulder.
  - A boulder at rest has no momentum.



# Momentum

## CHECK YOUR NEIGHBOR

A moving object has

- A. momentum.
- B. energy.
- C. speed.
- D. All of the above.

# Momentum

## CHECK YOUR ANSWER

A moving object has

**D. All of the above.**

### **Comment:**

We will see in the next chapter that energy in motion is called kinetic energy.

# Momentum

## CHECK YOUR NEIGHBOR, Continued

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.

**B. doubles.**

# Momentum vs. Inertia

- Inertia is “resistance to changes in velocity”
- More mass  $\rightarrow$  more inertia
- Inertia is a property of matter
- Inertia does not depend on speed or velocity.

Ex. A 3.0 fox is running at 2 m/s.



A aircraft carrier with a mass of 92 million kg is at rest.

A) Which has more momentum?

B) Which has more inertia?



## Ex. A wood and steel ball are dropped from the same height at same time (ignore air).

- Which ball hits the ground first?

same

wood



steel



- Which ball hits the with more speed?

same

- Which ball hits the ground with more momentum?

Steel – more mass



## Ex. A ball tossed straight up.

What happens to the ball's momentum as it rises?

decreases

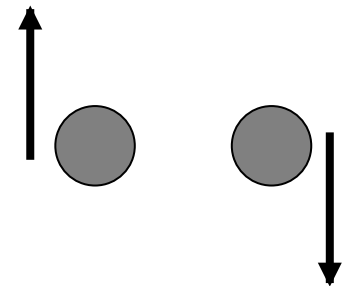


As it falls?

decreases!

What is its momentum at its highest point?

0 b/c it's speed = 0



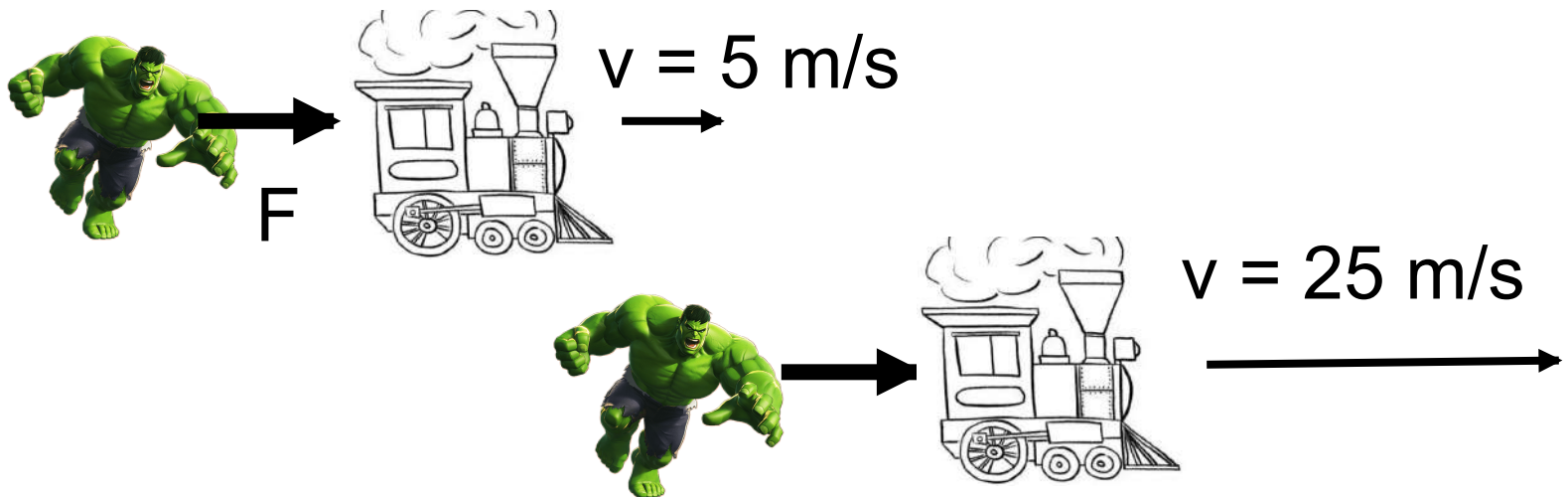
## II. Impulse

- Product of force and time (force x time)
- In equation form: Impulse =  $F \cdot t$
- ***Impulses are what change momentum!***
- Example:
  - A brief force applied over a short time interval produces a smaller change in momentum than the same force applied over a longer time interval.
- or
  - If you push with the same force for twice the time, you impart twice the impulse and produce twice the change in momentum.

# Does a moving object have impulse?

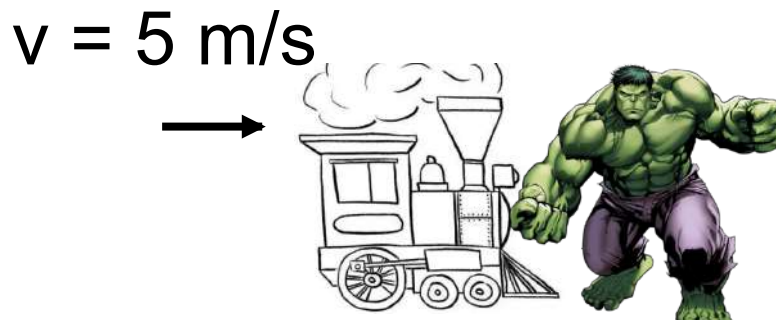
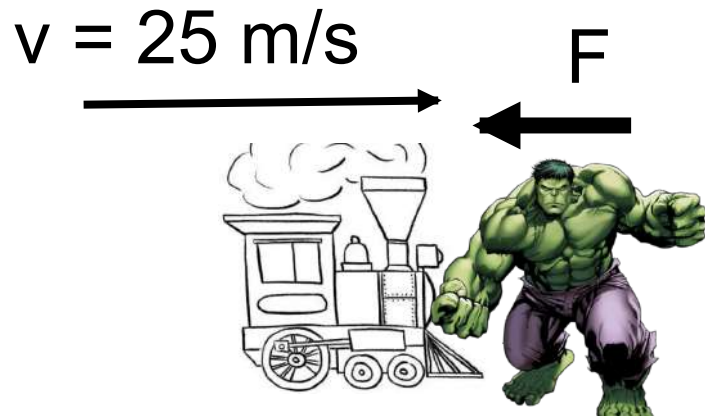
No. Like forces, impulses are “exerted on” or “applied to” an object.

- Ex Train moving east. Impulse to east:



→ As a result, momentum increases

- Ex Train moving east. Impulse to west:



→ As a result, momentum decreases

- Ex: Kirby Puckett hits a baseball with a force of 3000 N for a time of 0.01 s. How much impulse is exerted?

$$\begin{aligned}\text{Impulse} &= \text{force} \times \text{time} \\ &= 3000 \text{ N} \times 0.01 \text{ s} \\ &= 30 \text{ N s}\end{aligned}$$



# How does increasing force $F$ affect impulse?

- Increasing  $F$ :
- Impulse = force  $\times$  time
- New impulse = bigger force  $\times$  time
- $\rightarrow$  new impulse will be bigger
- $\rightarrow$  Hitting the ball with more force will change its momentum even more.

# How does increasing time of impact $t$ affect impulse?

- Increasing time of impact  $t$ :  
Impulse = force  $\times$  time
- New impulse = force  $\times$  longer time
- $\rightarrow$  new impulse will be bigger
- $\rightarrow$  This is called “following through”

# Homework due Wednesday: 7 pm

- Page 103:
  - Reading Check Questions:  
#1-4
- 
- Page 104: Plug and Chug:
  - #22-25.....Show your work
  - *Example: Read # 22 now.*
  - #22:     momentum = mass x velocity  
             = (8 kg) x (2 m/s)  
             = 16 kg m/s