

Section Average for exam 3: 8.6 out of 17 (51 %)

- **Three Common Exams:** **45%**  
(15% each)
- **Quizzes during Lect./Reci.:** **7%**
- **Homework:** **8%**
- **Workshop:** **10%**
- **Final exam:** **30%**

Work and Energy for Exam 3

"Impulse" and "Momentum" till final exam.

Today...

Definition of impulse

Definition of momentum

Impulse-Momentum Theorem

Data : Fatality of a driver in head-on collision

(With a passenger) < (Without a passenger)



### Definition of Impulse

Impulse:  $\vec{I} \equiv \vec{F} \times \Delta t$       F : force,  $\Delta t$ : time

→ A vector quantity

→ SI Unit: N s

### Definition of (Linear) Momentum

(Linear) Momentum  $\vec{p} = m\vec{v}$  (m: mass, v: velocity)

→ A vector quantity

→ SI Unit: kg m/s

### Impulse-Momentum Theorem

Let's rewrite Newton's Second Law

$$\vec{F}_{net} = m\vec{a} = m \frac{\vec{v}_f - \vec{v}_i}{\Delta t} = \frac{m\vec{v}_f - m\vec{v}_i}{\Delta t} = \frac{\Delta\vec{p}}{\Delta t}$$

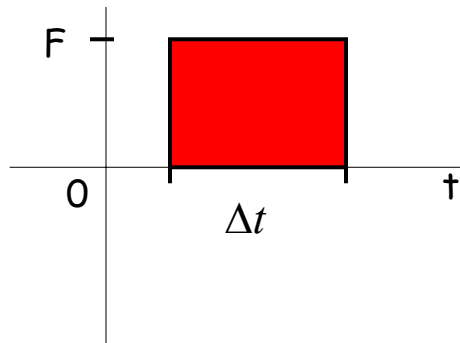
$$\vec{F}_{net} \Delta t = \Delta\vec{p}$$

$$\vec{I}_{net} = \vec{p}_f - \vec{p}_i$$

Net impulse is equal to the change in momentum

## Impulse by a constant force

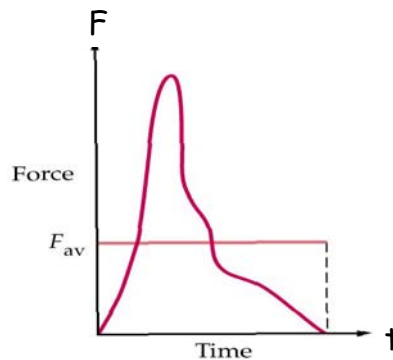
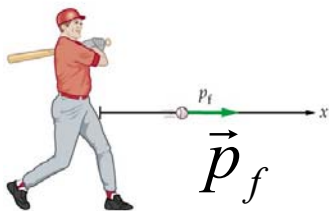
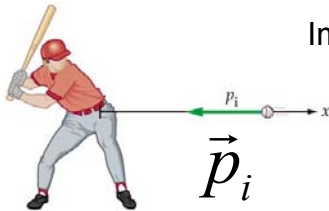
$$I = F \Delta t$$



(Area in F vs. t graph)  
= (Impulse by F)

## Impulse by a varying force

Impulse is an area under F(t) graph!



$$\vec{F}_{\text{net, average}} \times \Delta t = \vec{I}_{\text{net}} = \Delta \vec{p}$$

### Example 1

A paratrooper whose chute fails to open lands in snow; he is hurt slightly. Had he landed on bare ground, the stopping time would have been 10 times shorter and the collision lethal.

Does the presence of the snow increase, decrease, or leave unchanged the values of

- (a) the paratrooper's change in momentum, (b) the impulse stopping the paratrooper, and (c) the force stopping the paratrooper?

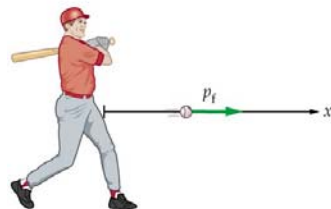
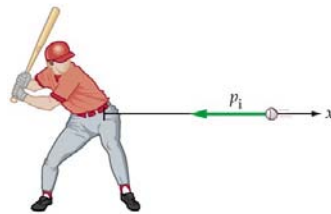


### Example 2

A 0.150 kg baseball, thrown with a speed of 40 m/s, is hit straight back at the pitcher with a speed of 50 m/s.

- (a) What is the impulse delivered by the bat to the baseball?

- (b) Find the magnitude of the average force exerted by the bat on the ball if the two are in contact for  $2.0 \times 10^{-3}$  s.



### Example 3

A superball with a mass of 54 g is dropped from a height of 1.9 m. It rebounds to a height of 1.4 m.

- (a) What is the change in its linear momentum during the collision with the floor?
- (b) Assume that the contact time is 0.1 s. Find the average force from the floor.



### Example 4

A ball with original momentum  $+4.0 \text{ kg}\cdot\text{m/s}$  hits a wall and bounces straight back without losing any kinetic energy.

The change in momentum of the ball is :

- a. 0.
- b.  $-4.0 \text{ kg}\cdot\text{m/s}$ .
- c.  $8.0 \text{ kg}\cdot\text{m/s}$ .
- d.  $-8.0 \text{ kg}\cdot\text{m/s}$ .

Ans. (d)