Today	2.1-.3, (.9, .10) Momentum Principle & Simple Examples	RE 2.a
Tues.		EP1, HW1: Ch 1 Pr.98
Wed.	2.4 – .5 Momentum with Changing Force, **Quiz 1**	RE 2.b, bring smart device
Lab	L2 Measuring & Modeling 1-D Motion	Could bring headphones
Fri.	2.6 – .8 Constant Force, time estimates, Models	RE 2.c

motion is neither created nor destroyed, but transferred via interactions.

↓

Momentum = $\vec{p} \equiv \frac{m\vec{v}}{\sqrt{1-\left(\frac{|\vec{v}|}{c}\right)^2}} \approx m\vec{v} \quad \text{for} \quad |\vec{v}| << c$

Q 1.8 a

Three protons travel through space at three different speeds.

Proton A: 290 m/s
Proton B: 2.9×10^6 m/s
Proton C: 2.9×10^8 m/s

For which proton(s) is it reasonable to use the approximation when calculating its momentum?

1. A only
2. A and B
3. A and B and C
4. none of the protons

Q1.9.c:

Suppose you are driving a 1000 kg car at 20 m/s in the +x direction. After making a 180 degree turn, you drive the car at 20 m/s in the –x (opposite) direction. What is the magnitude of the change of the momentum $|\Delta\vec{p}|$ of the car ?

a) 0 kg· m/s
b) 2.0e4 kg· m/s
c) 4.0e4 kg· m/s
d) 6.0e4 kg· m/s
e) 8.0e4 kg· m/s

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Momentum = $\vec{p} \equiv \frac{m\vec{v}}{\sqrt{1-\left(\frac{|\vec{v}|}{c}\right)^2}} \approx m\vec{v} \quad \text{for} \quad |\vec{v}| << c$ *Impulse*

2.1 Systems & Surroundings

Bookkeeping motion

2.2 Momentum Principle

$$\Delta \text{Motion}_{system} = \sum_{all.external} \text{Interactions}$$

$$\Delta \text{Momentum}_{system} = \sum_{all.external} \text{Impulse}$$

$$\Delta \vec{p}_{system} = \sum_{all.external} \vec{I}$$

$$\vec{I} = \vec{F} \Delta t$$ Force

$$\Delta \vec{p}_{system} = \sum_{all.external} \vec{F}_{\to system} \Delta t$$

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

Units:

Q 2.2 a

An object is moving in the +x direction.

Which of the following statements about the net force acting on the object could be true?

A. The net force is in the +x direction
B. The net force is in the –x direction
C. The net force is zero
D. A and B
E. B and C
F. A and C
G. A B and C

Q 2.2 b

Which cart(s) experience a net force to the left?

A. Green Cart which moves to the left at nearly constant speed.
B. Red Cart which moves to the left, gradually speeding up.
C. Blue Cart which moves to the left, gradually slowing down.
D. Both Green and Red carts
E. Both Blue and Red carts
F. Both Green and Blue carts

Problem-Solving Style Example

A hockey puck is sliding along the ice with nearly constant momentum < 10, 0, 5 > kg m/s when it is suddenly struck by a hockey stick with a force < 0, 0, 2000 > N that lasts for only 3 milliseconds (3e-3 s). What is the new (vector) momentum of the puck?

Q 2.3 d: You practice on paper like homework

Inside a spaceship in outer space there is a small steel ball. At a particular instant, the ball has momentum < -8, 3, 0 > kg· m/s and is pulled by a string, which exerts a force < 20, -10, 0 > N on the ball. What is the ball's (vector) momentum 2 seconds later?

A. < -28, 23, 0 > kg· m/s
B. < 12, -7, 0 > kg· m/s
C. 36.2 kg· m/s
D. < 32, -17, 0 > kg· m/s
E. < 40, -20, 0 > kg· m/s

Updating Position in Computer Simulations

Position Update (ch 1)

$$\vec{r}_{object_{new}} = \vec{r}_{object_{old}} + \vec{v}_{object_{ave}} \Delta t$$

$$\vec{v}_{object_{ave}} \approx \frac{\vec{p}_{object_{ave}}}{m_{object}} \Delta t$$

Momentum Update (ch 2)

$$\vec{p}_{object_{new}} = \vec{p}_{object_{old}} + \vec{F}_{net \to object_{ave}} \Delta t$$

Note: If Δt is small enough, old speed is close enough to average, old force is close enough to average to approximate in simulation.

A "while loop"

while t<t_{max}

$$t \Leftarrow t + \Delta t$$

$$\vec{p}_{object} \Leftarrow \vec{p}_{object} + \vec{F}_{net \to object} \Delta t$$

$$\vec{r}_{object} \Leftarrow \vec{r}_{object} + \frac{\vec{p}_{object}}{m_{object}} \Delta t$$

1-D Motion fan cart (1-D). Suppose you have a fan cart whose mass is 400 gram and it’s on a *huge*, 8m long track. Initially you set the cart moving down the track in the x-direction at location <0.5,0,0>m with velocity <1.2,0,0>m/s. The force due to the fan is <0.2,0,0>N; comparatively, friction is negligible. What are the momentum and position of the cart 3 seconds later?

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