

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

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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Impulse

2.1 Systems & Surroundings

Bookkeeping motion

2.2 Momentum Principle

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

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

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

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

$$\Delta \vec{p}_{\text{system}} = \sum_{\text{all external}} \vec{F}_{\rightarrow \text{system}} \Delta t$$

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

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

$\langle 10, 0, 5 \rangle$ kg m/s when it is suddenly struck by a hockey stick with a force $\langle 0, 0, 2000 \rangle$ N that lasts for only 3 milliseconds (3×10^{-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 $\langle -8, 3, 0 \rangle$ kg· m/s and is pulled by a string, which exerts a force $\langle 20, -10, 0 \rangle$ N on the ball. What is the ball's (vector) momentum 2 seconds later?

- A. $\langle -28, 23, 0 \rangle$ kg· m/s
- B. $\langle 12, -7, 0 \rangle$ kg· m/s
- C. 36.2 kg· m/s
- D. $\langle 32, -17, 0 \rangle$ kg· m/s
- E. $\langle 40, -20, 0 \rangle$ 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)

$$\vec{p}_{object_new} = \vec{p}_{object_old} + \vec{F}_{net \rightarrow object_ave} \Delta t$$

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

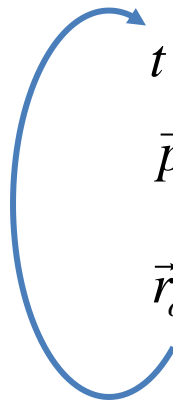
A “while loop”

while $t < t_{max}$

$$t \leftarrow t + \Delta t$$

$$\vec{p}_{object} \leftarrow \vec{p}_{object} + \vec{F}_{net \rightarrow object} \Delta t$$

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



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 $\langle 0.5, 0, 0 \rangle$ m with velocity $\langle 1.2, 0, 0 \rangle$ m/s. The force due to the fan is $\langle 0.2, 0, 0 \rangle$ N; comparatively, friction is negligible. What are the momentum and position of the cart 3 seconds later?

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