Day	Reading	Due
Today	1.6-.10 Velocity & Momentum	RE 1.b
Mon. Tues.	2.1-.3, (.9, .10) Momentum Principle & Simple Examples	RE 2.a EP1, HW1: Ch 1 Pr.98

Principle in *English*:

Motion is neither created nor destroyed but transferred via interactions.

↓ *momentum*

↓ *force*

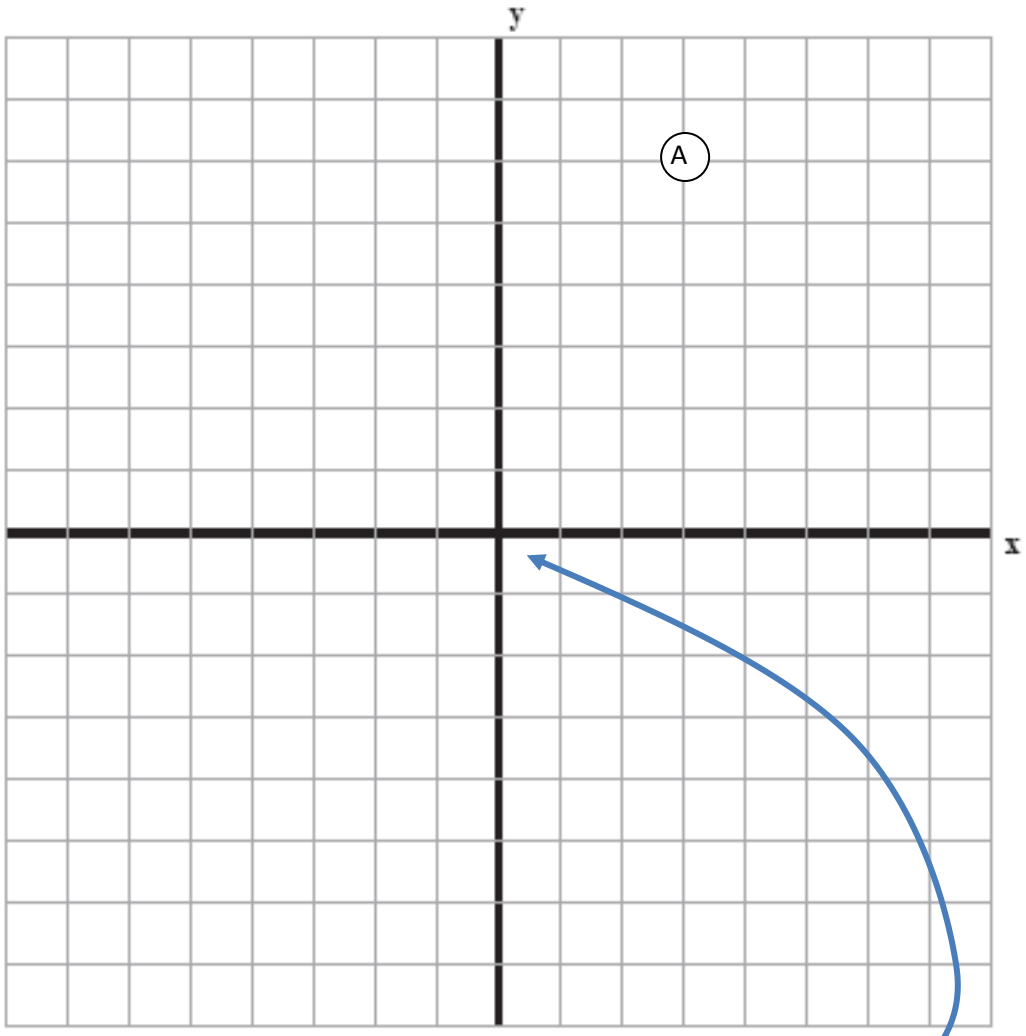
Principle in *Mathematics*:

Outline

- Vector math overview
- Units
- Displacement & Velocity
- Momentum

Practice with Vectors

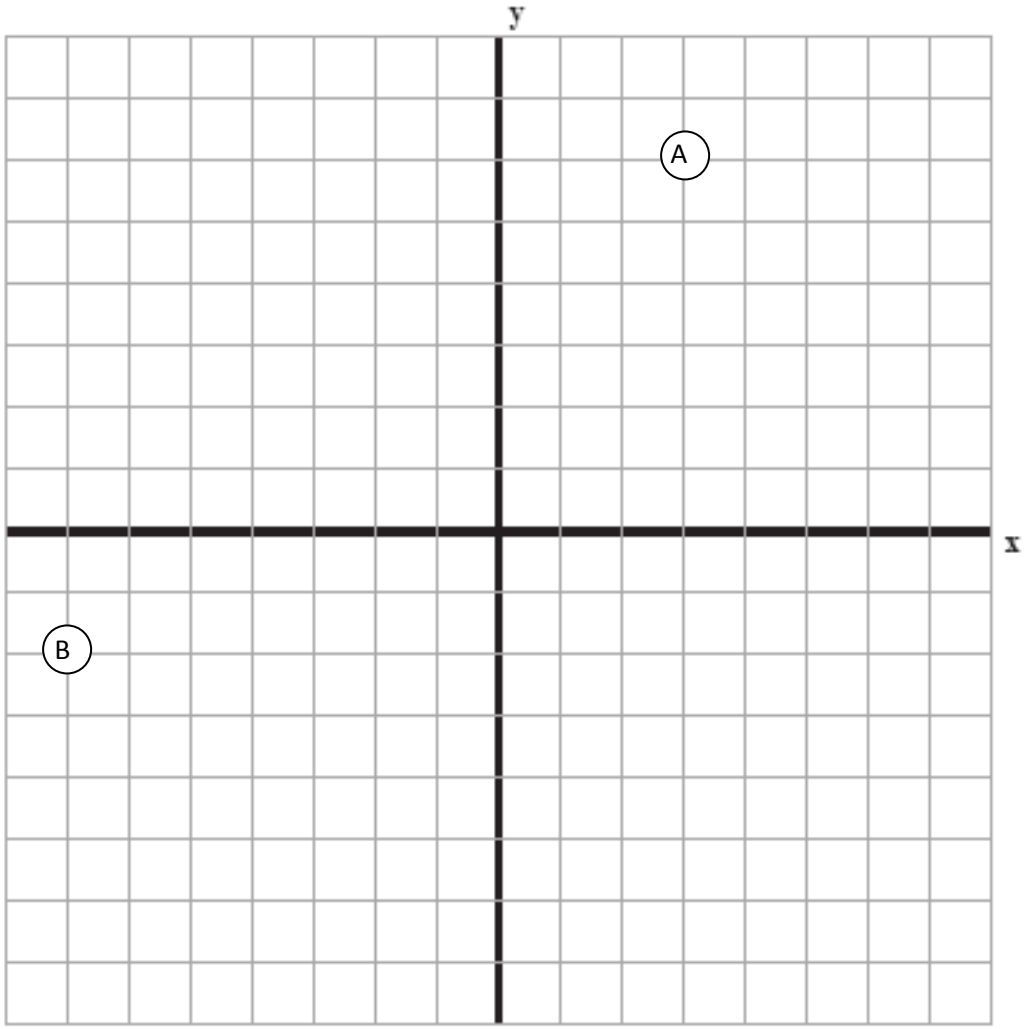
Component Representation: $\vec{r} = \langle r_x, r_y, r_z \rangle$



A's Position: <3,6,0>units (relative to the origin)

Practice with Vectors

Component Representation: $\vec{r} = \langle r_x, r_y, r_z \rangle$

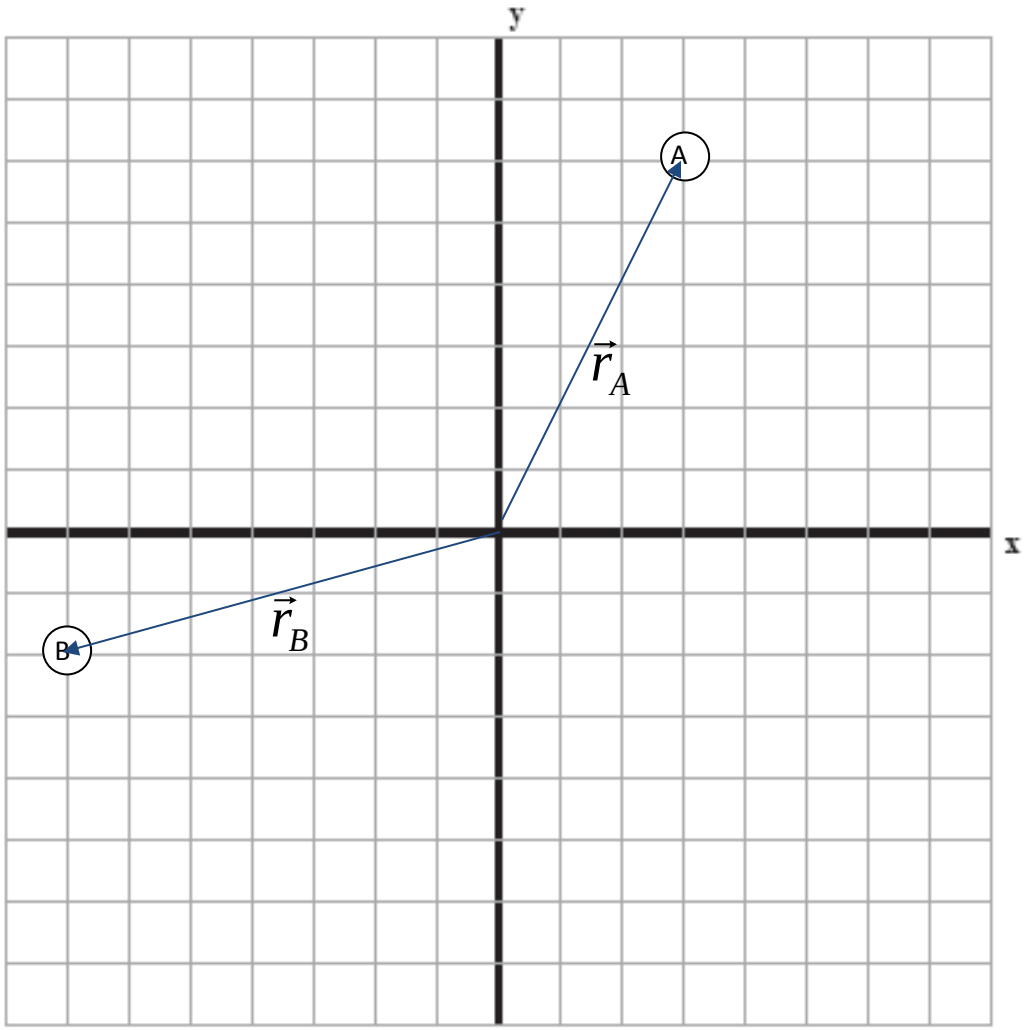


A's Position: <3,6,0>units

B's Position: <____,_____,0>units

Practice with Vectors

Graphical / Arrow Representation:

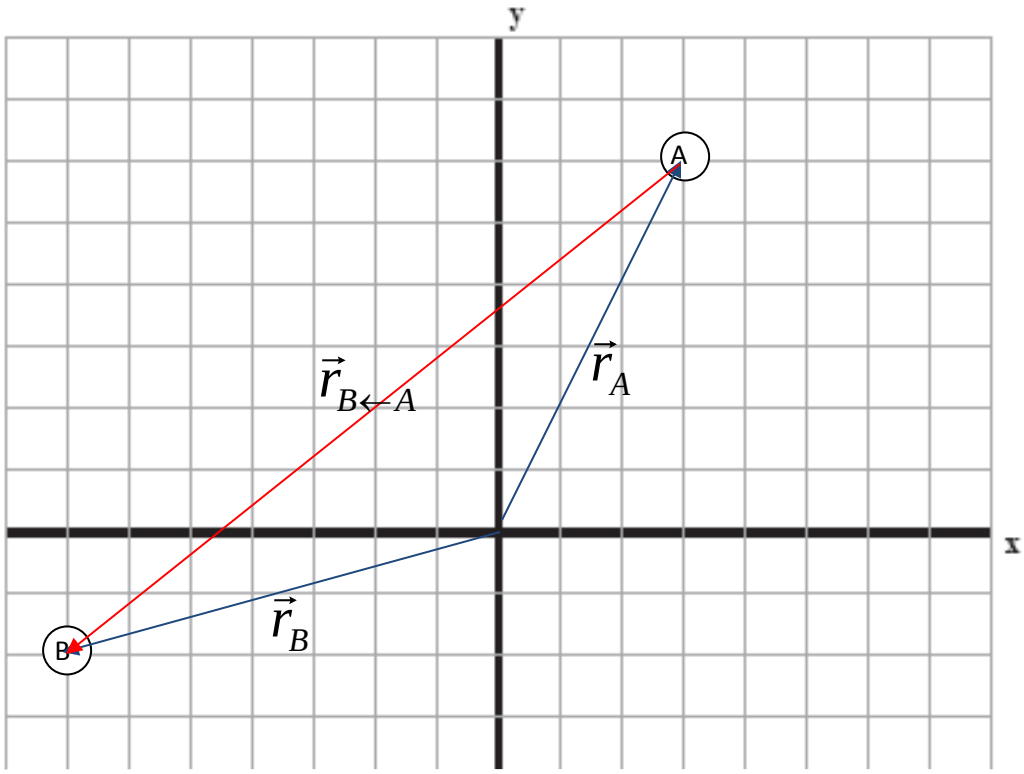


A's Position: <3,6,0>units

B's Position: <-7,-2,0>units

Practice with Vectors

Subtraction: $\vec{r}_{B\leftarrow A} = \vec{r}_B - \vec{r}_A$



Q1.5.b

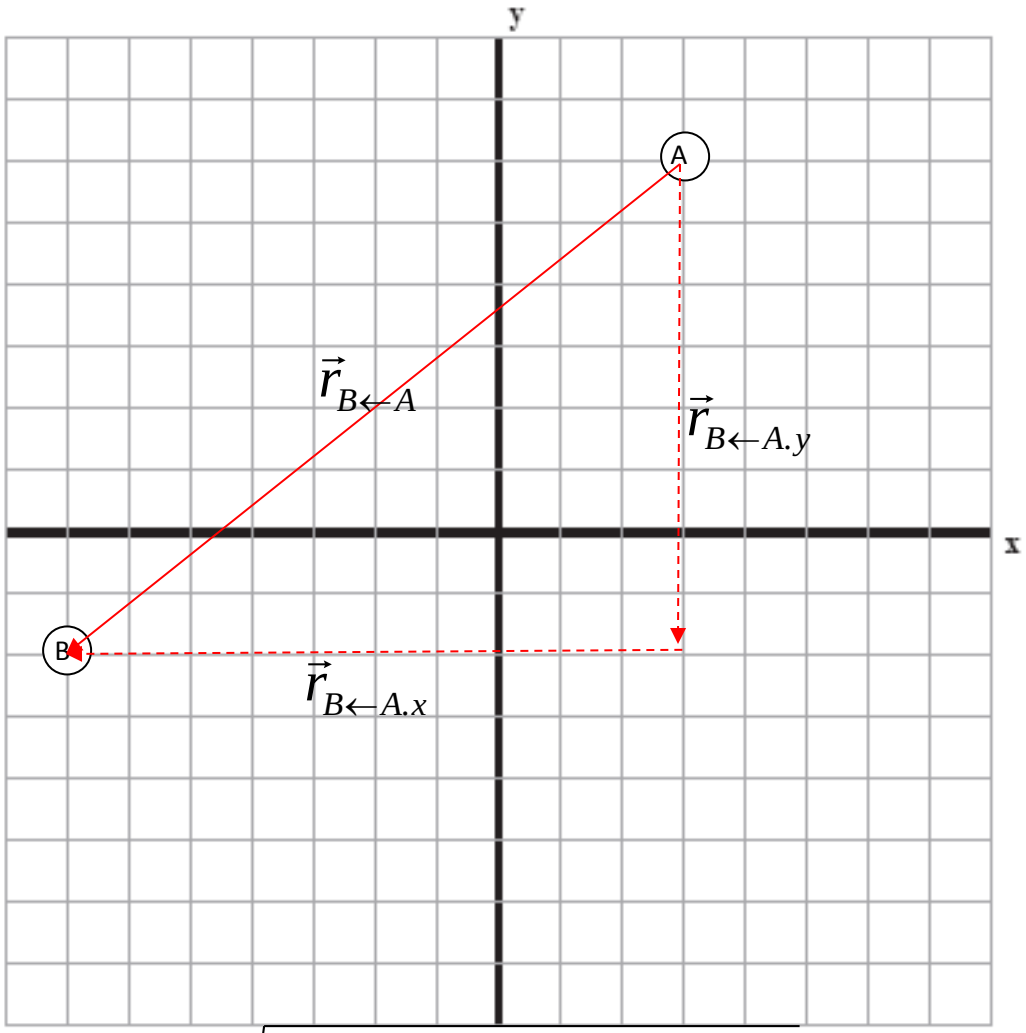
What is $\langle 10, 20, -15 \rangle - \langle 5, -8, 7 \rangle$?

A) 19
B) 38.7
C) $\langle 15, 12, 8 \rangle$
D) $\langle 5, 28, -22 \rangle$
E) $\langle 5, 12, -8 \rangle$

Practice with Vectors

Magnitude: $\left|\vec{r}_{B\leftarrow A}\right|$

Pythagorean's Theorem:



$$\left|\vec{r}_{B\leftarrow A}\right| = \sqrt{\left|\vec{r}_{B\leftarrow A.x}\right|^2 + \left|\vec{r}_{B\leftarrow A.y}\right|^2 + \left|\vec{r}_{B\leftarrow A.z}\right|^2}$$

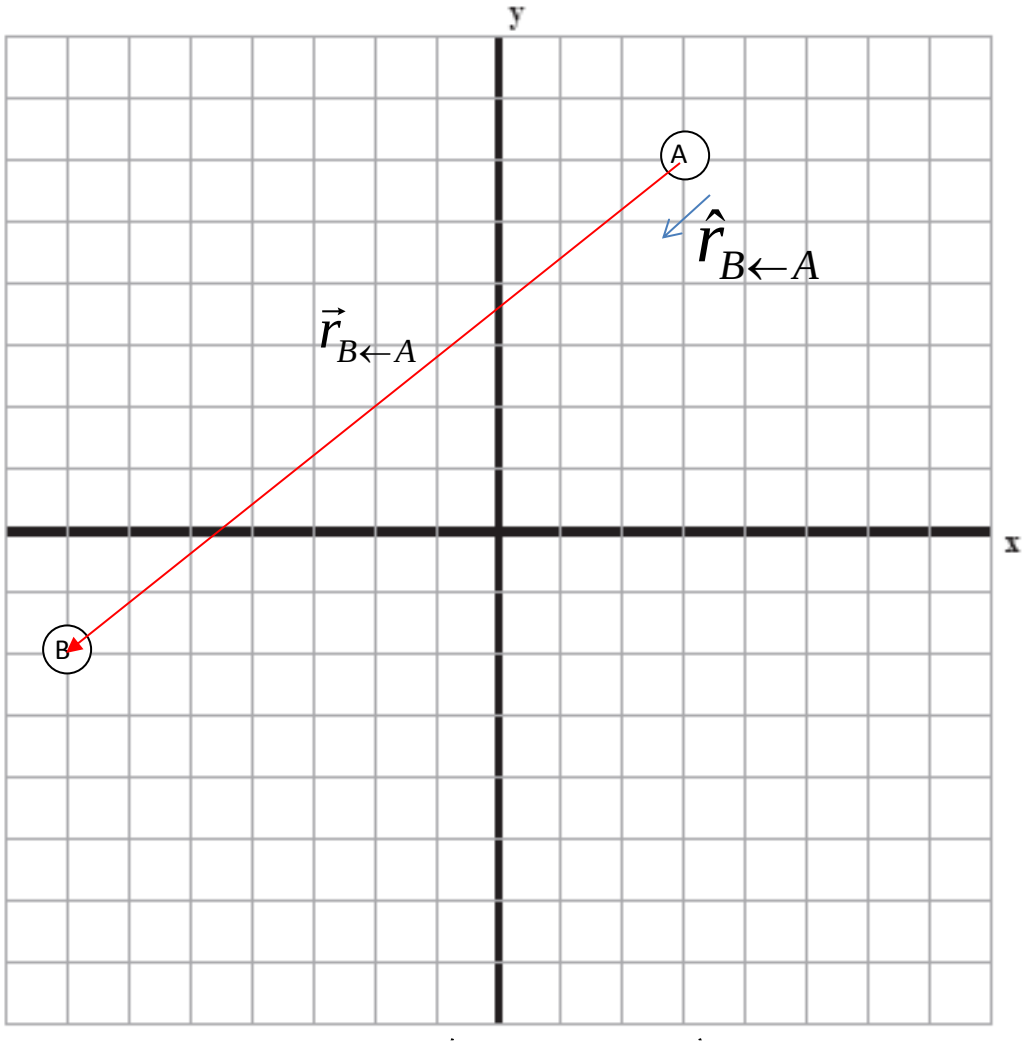
Q1.5.d

What is the magnitude of the vector < 3, 5, −2 >?

a) 5.48
b) 6.16
c) 6.00
d) 30.00
e) 38.00

Practice with Vectors

Direction: $\hat{r}_{B\leftarrow A}$



$$\hat{r}_{B\leftarrow A} = \frac{\vec{r}_{B\leftarrow A}}{\left|\vec{r}_{B\leftarrow A}\right|}$$

Q1.5.e

What is the unit vector in the direction of the vector $\langle 3, 5, -2 \rangle$?

a) $\langle 3, 5, -2 \rangle$
b) $\langle 1, 1, -1 \rangle$
c) $\langle 0.49, 0.81, 0.32 \rangle$
d) $\langle 0.49, 0.81, -0.32 \rangle$
e) $\langle 0.3, 0.5, -0.2 \rangle$

Q1.5.d

What is the magnitude of the vector < 3, 5, −2 >?

a) 5.48
b) 6.16
c) 6.00
d) 30.00
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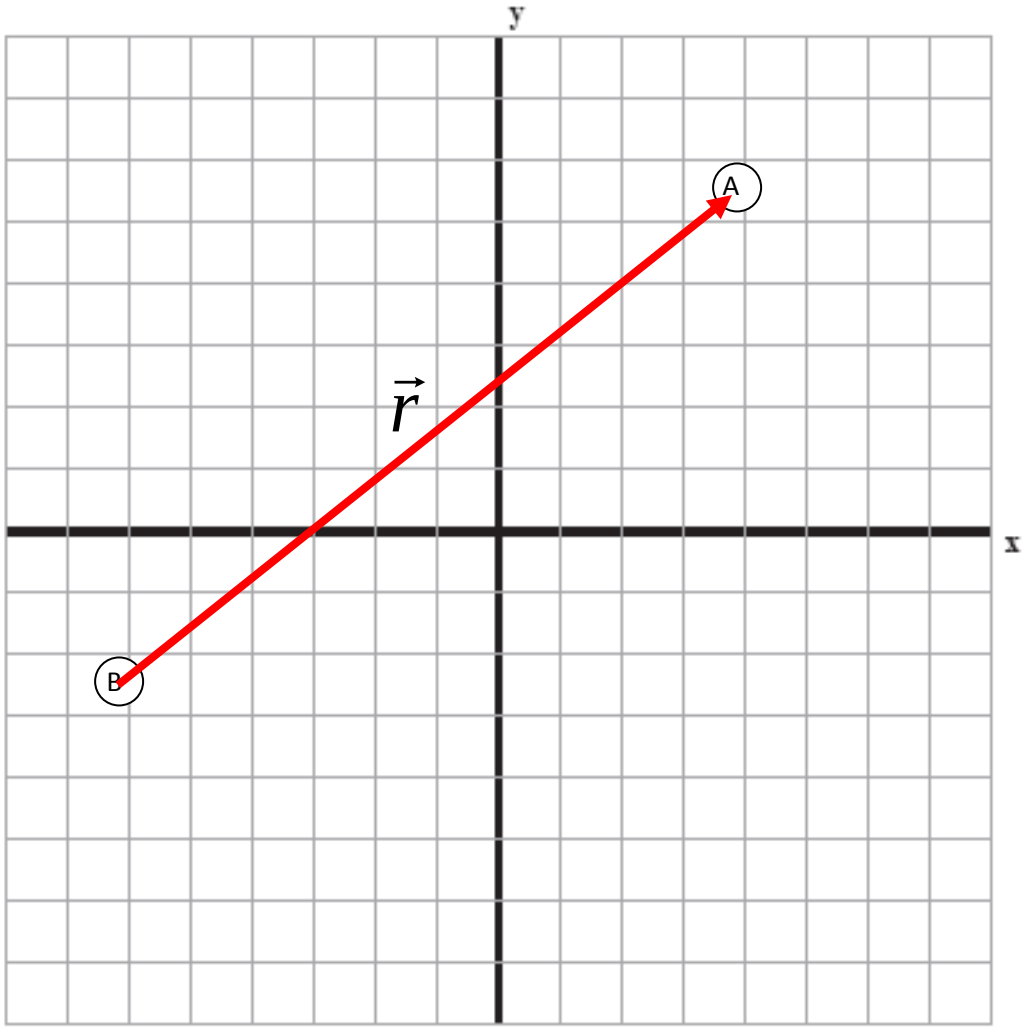
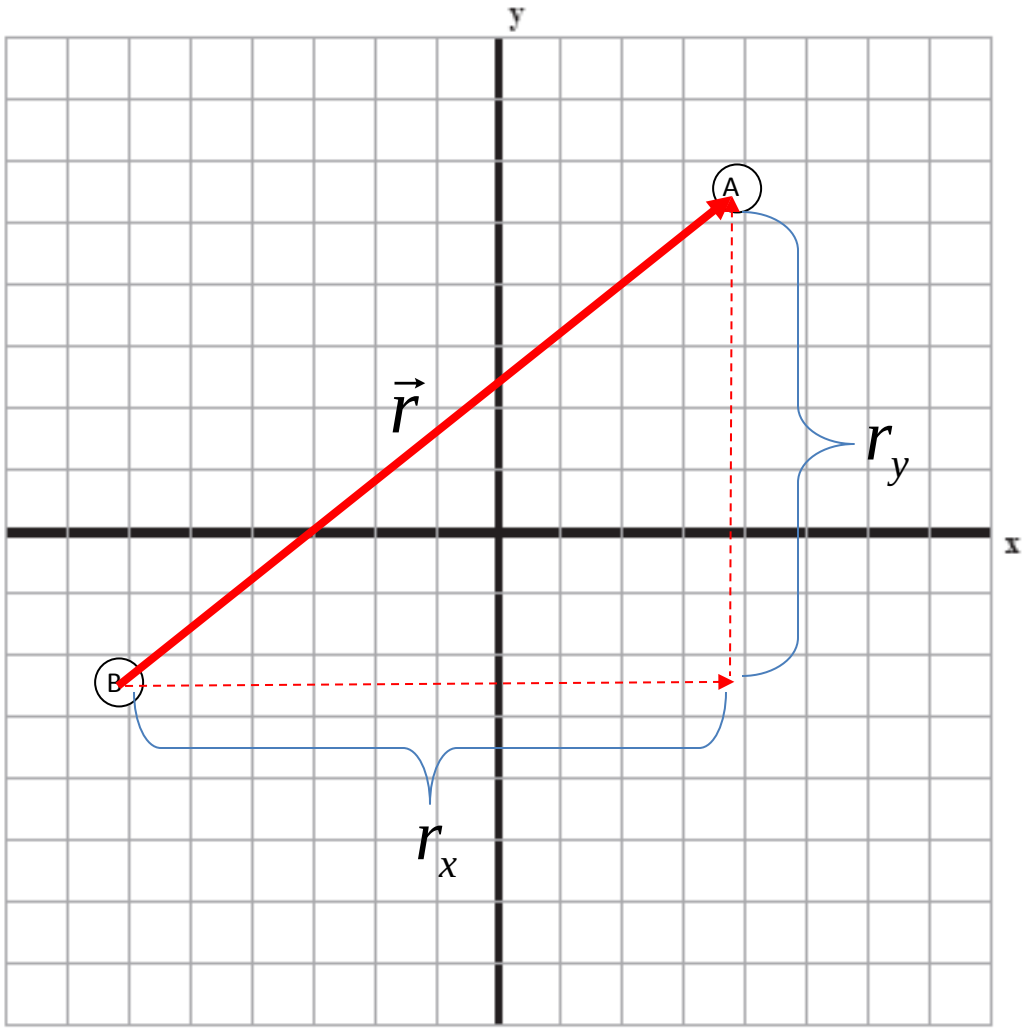
Practice with Vectors

Translating between Cartesian and Polar descriptions



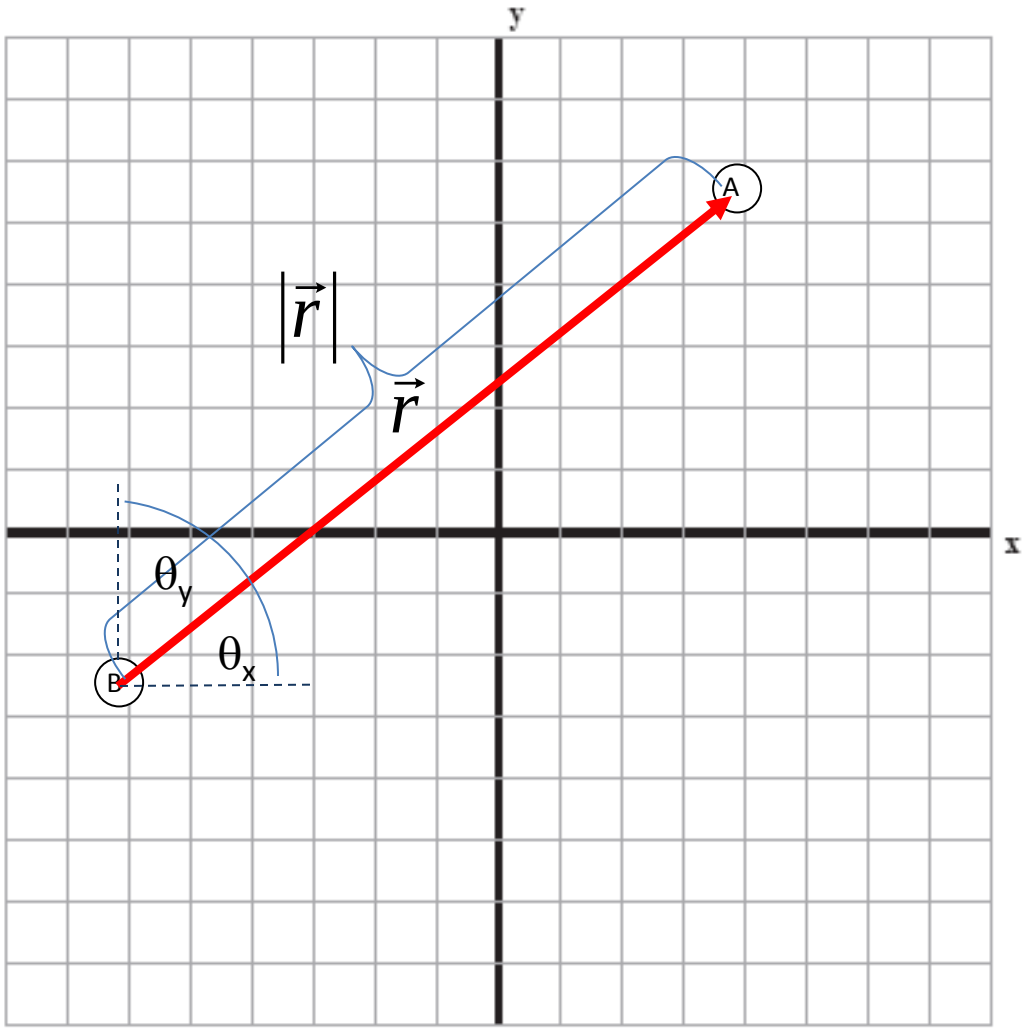
Practice with Vectors

Translating between Cartesian and Polar descriptions



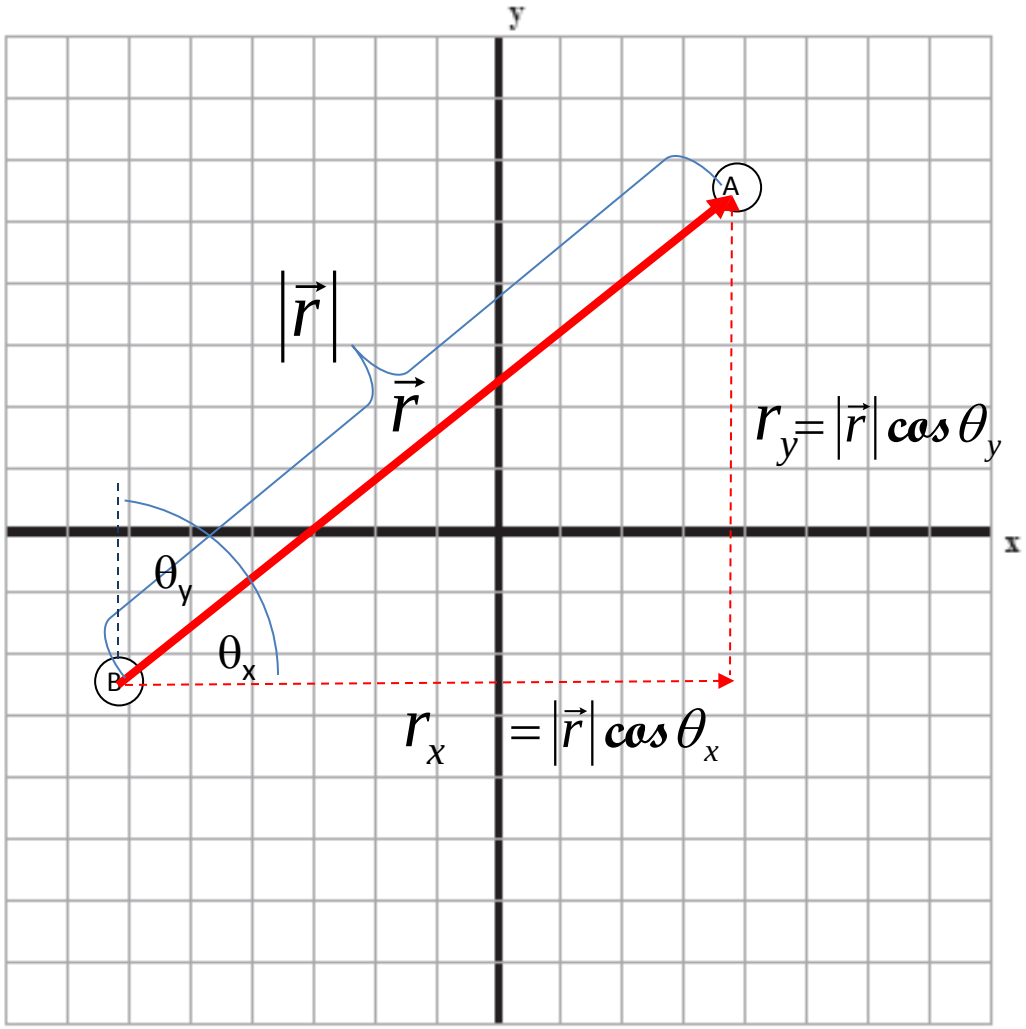
Practice with Vectors

Translating between Cartesian and Polar descriptions



Practice with Vectors

Translating between Cartesian and Polar descriptions



$$r_z = |\vec{r}| \cos\theta_z$$

1.6 Units

- Always use them
- Always use SI units
- Conversions
  - Practice …

1.7 Velocity

- Average

Q1.7.a

A bee flies in a straight line at constant speed. At 15 s after 9 AM, the bee's position is < 2, 4, 0> m. At 15.5 s after 9 AM, the bee's position is < 3, 3.5, 0> m.

What is the average velocity of the bee?

a) < 6, 7, 0 > m/s
b) < .193, .225, 0 > m/s
c) 2.236 m/s
d) < 0.500, -0.250, 0 > m/s
e) < 2.000, -1.000, 0 > m/s

1.7 Velocity

- Average
  - Position update form

Q1.7.c: At 12.18 s after 1:30 PM, a ball's position is < 20, 8, -12> m, and the ball's velocity is < 9, -4, 6 > m/s.

What is the (vector) position of the ball at 12.21 s after 1:30 PM? Assume that the ball's velocity does not change significantly in this short time interval.

a) 24.75 m

b) < 20.27, 7.88, -11.82 > m

c) < 0.27, -0.12, 0.18 > m

d) < 129.62, -40.72, 61.08 > m

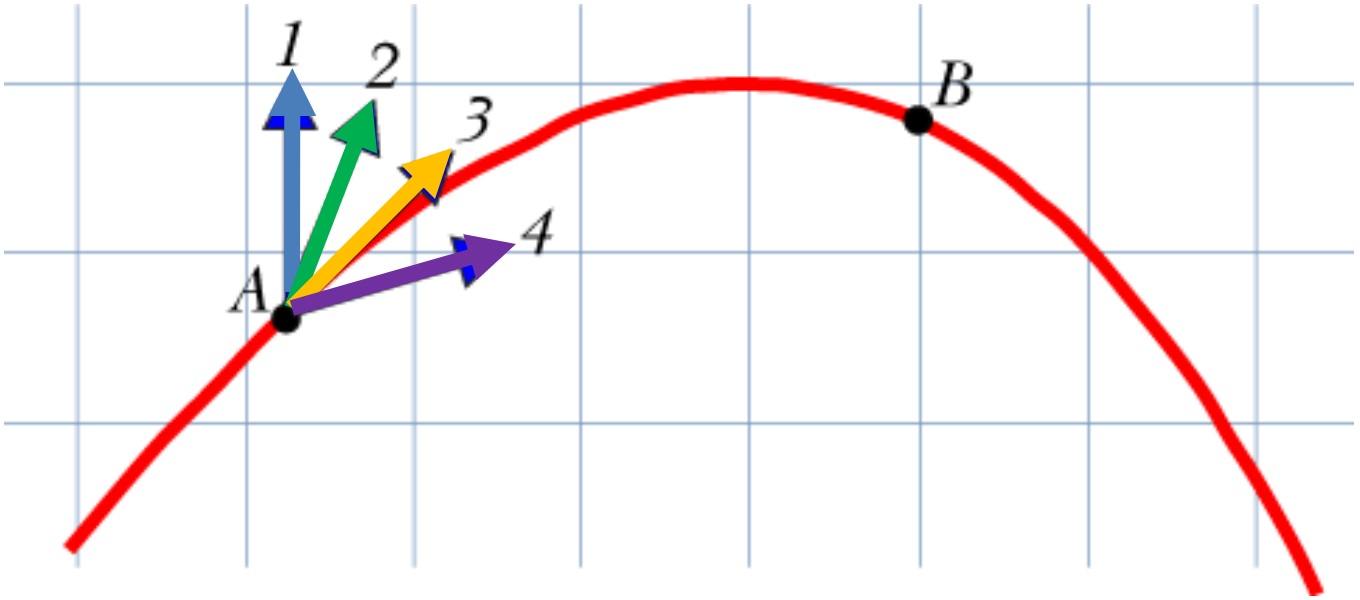
e) < 129.89, -40.84, 61.26 > m

1.7 Velocity

- Average
  - Position update form
- Instantaneous
  - Calculus

Q 1.7 d

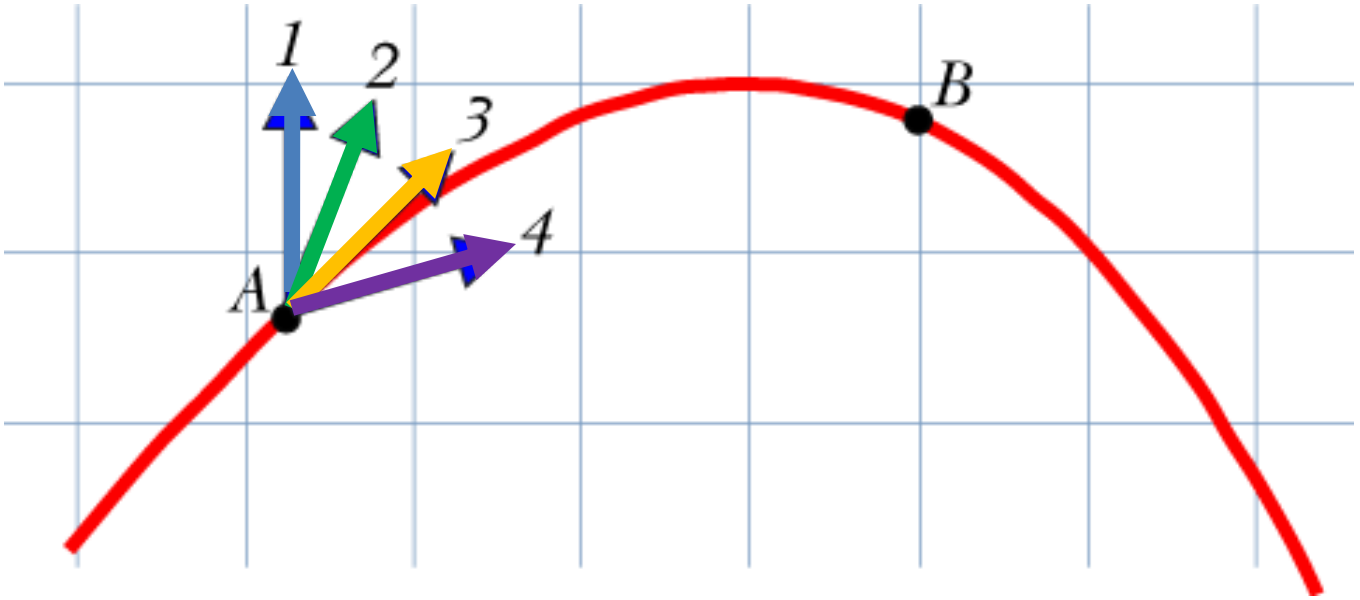
A ball travels through the air. Part of its trajectory is shown in red.



Which arrow best represents the direction of the average velocity of the ball as it travels from location A to location B?

Q 1.7 e

A ball travels through the air. Part of its trajectory is shown in red.



Which arrow best represents the direction of the *instantaneous* velocity of the ball as it travels from location A to location B?

Q1.7.b: At 15 s after 10 AM two bees are observed to be at position < 2, 4, 0> m. Bee #1 flies in a straight line with constant speed and arrives at position <3, 3.5, 0 > m at 15.5 s after 10 AM. Bee #2 buzzes around, repeatedly changing speed and direction, sometimes going quickly and other times just hovering in the air, but it also arrives at position < 3, 3.5, 0 > m at 15.5 s after 10 AM.

Which statement about their average velocities is correct?

a) The magnitude of Bee #1's average velocity is greater.

b) The magnitude of Bee #2's average velocity is greater.

c) The two bees have the same velocity at all times.

d) The two bees have the same average velocity although their velocity at a given time may not be the same.

Rephrase in *Mathematics*

Motion is neither created nor destroyed but transferred via interactions.

$\vec{v}$:

$$? \ \vec{v}_{1.before} + \vec{v}_{2.before} = \vec{v}_{1.after} + \vec{v}_{2.after} ?$$

Only for equal masses

$m\vec{v}$:

$$? \ m_1\vec{v}_{1.before} + m_2\vec{v}_{2.before} = m_1\vec{v}_{1.after} + m_2\vec{v}_{2.after} ?$$

Only for speeds much less than light

Momentum: $\vec{p}_{1.before} + \vec{p}_{2.before} = \vec{p}_{1.after} + \vec{p}_{2.after}$

$$\vec{p} \equiv \frac{m\vec{v}}{\sqrt{1 - \left(\frac{|\vec{v}|}{c}\right)^2}} :$$

$C = 3.0\times10^8 \text{m/s}$

Q 1.8 b

Calculate the factor $\gamma = \frac{1}{\sqrt{1-\left(\frac{|v|}{c}\right)^2}}$ if the speed is 0.9999c.

a) 0.9998
b) 1.0000
c) 22.4
d) 1.414×10^{-2}
e) 70.7

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

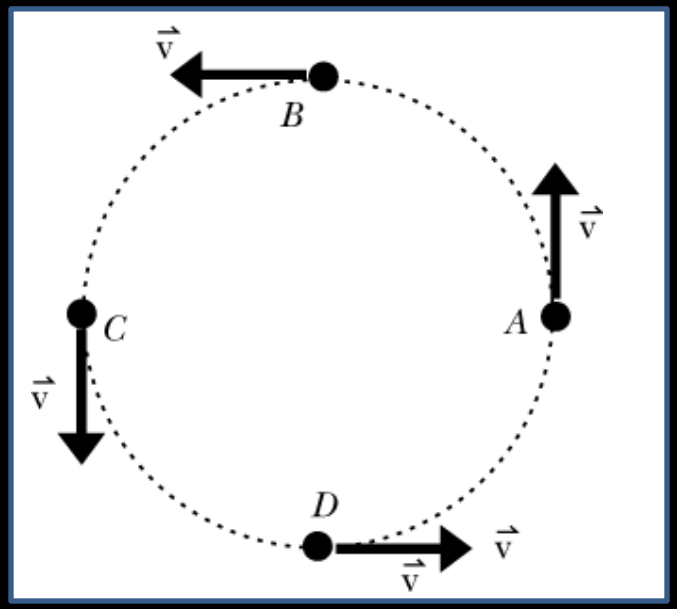
Proton C: 2.9×10^{8} m/s

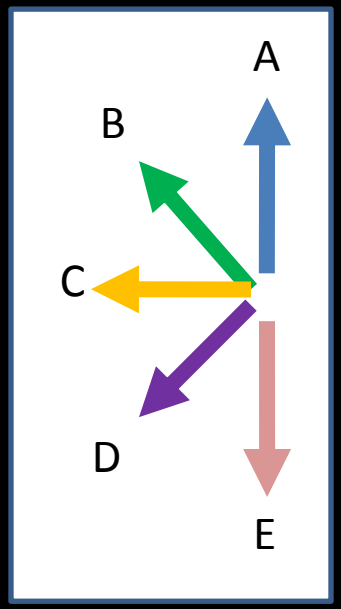
For which proton(s) is it reasonable to use the approximation when calculating its momentum?

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

Q1.9.a:
A child rides on a merry-go-round, traveling from location A to location C at a constant speed.

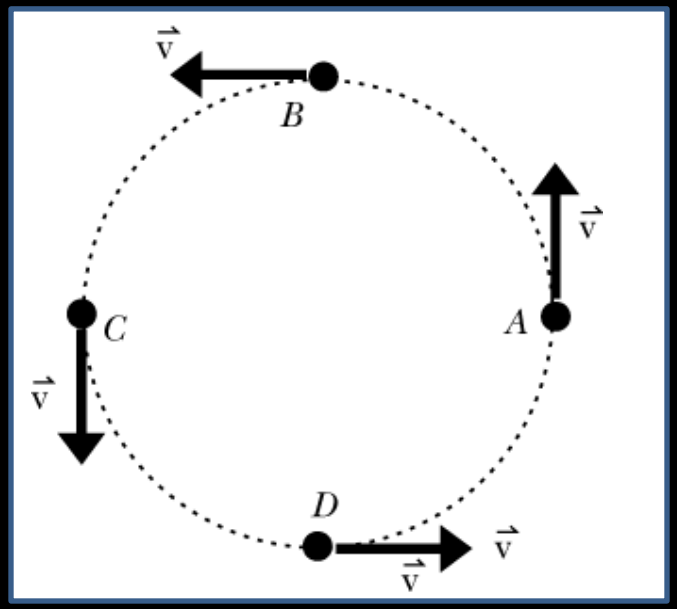
What is the direction of the change in the child's momentum, between locations A and C?

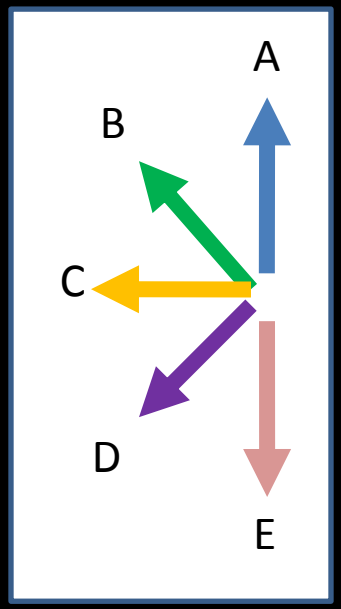




Q1.9.b:
A child rides on a merry-go-round, traveling from location A to location B at a constant speed.

What is the direction of the change in the child's momentum, between locations A and C?





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

Q1.9.c:

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e) 8.0e4 kg· m/s

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Today	1.6-.10 Velocity & Momentum	RE 1.b
Mon. Tues.	2.1-.3, (.9, .10) Momentum Principle & Simple Examples	RE 2.a EP1, HW1: Ch 1 Pr.98

Principle in *English*:

Motion is neither created nor destroyed but transferred via interactions.

↓ *force*

Momentum: $\vec{p} \equiv \dfrac{m\vec{v}}{\sqrt{1-\left(\frac{|\vec{v}|}{c}\right)^2}}$

Principle in *Mathematics*: