Taylor Chapter 3: Momentum

Taylor adds up the forces on all bits of a body with N pieces. If all forces are internal, he gets

$$\dot{P} = \sum_{\alpha=1}^{N} \sum_{\beta \neq \alpha} F_{\alpha\beta}$$

If you wrote out all the terms in this double sum, how many would there be?

A) N
B) N^2
C) N(N-1)
D) N!
E) Other/not really sure

(Assume below that N-II is an experimental fact)

We just showed that we can then use N-III to *derive* the law of conservation of momentum for systems of particles.

Is the converse true? i.e.:

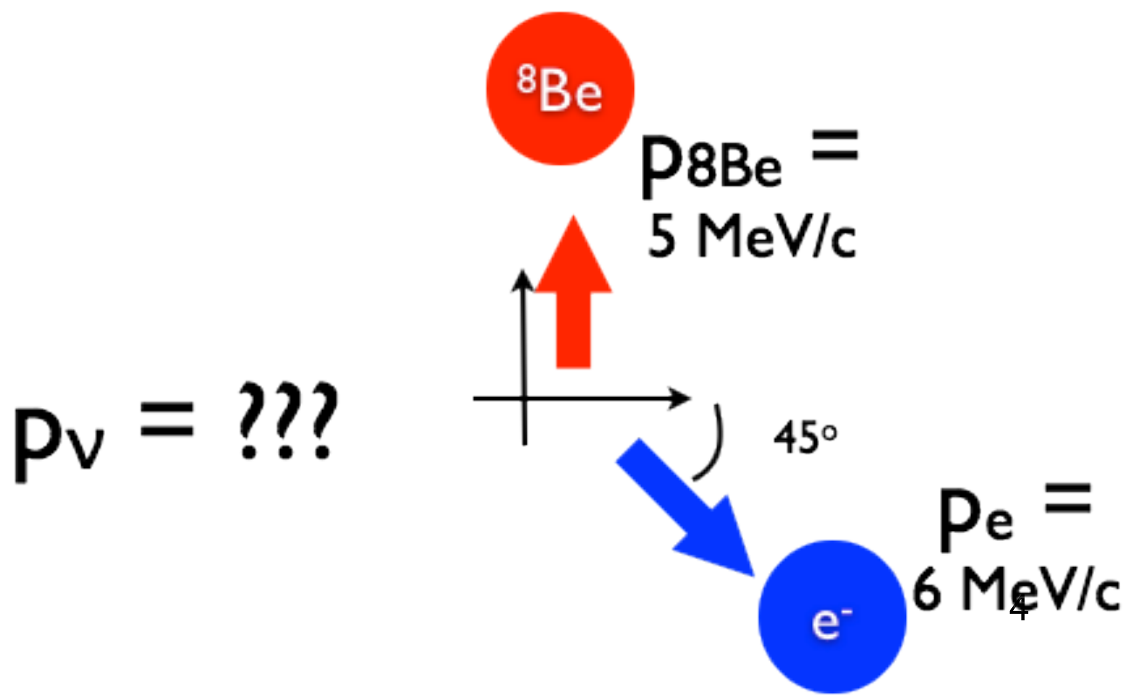
If the law of conservation of total momentum of a system (of two particles) holds, can you *derive* that it MUST be the case that $\mathbf{F}_{12}=-\mathbf{F}_{21}$?

A) Yes
B) No
C) Maybe *one* could, but *I* can't...

A ^{8}Li nucleus at rest undergoes β decay transforming it to ^{8}Be, an e^- and an (anti-)neutrino.
The ^{8}Be has $|p|=5$ MeV/c at 90°,
the e^- has $|p|=$ 6 MeV/c at 315°, what is $\mathbf{p}_\nu$?
Use the form (p_x,p_y)

$$^8Li \rightarrow {}^8Be + e^- + \bar{\nu}$$

A) (4.2, 4.2)
B) (-5,0)
C) (-5,-1)
D) (-4.2, 0.8)
E) (-4.2, -0.8)
MeV/c



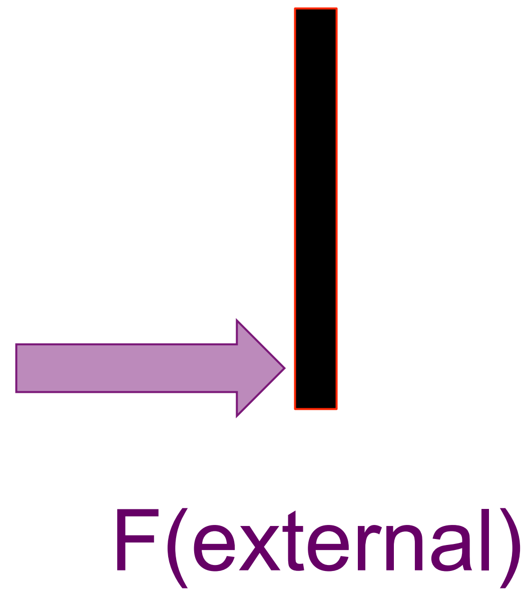
Pauli's Desperate Remedy
Dec. 4, 1930

Dear Radioactive Ladies and Gentlemen:
...I have hit upon a desperate remedy.. I admit that my remedy may appear to have a small a priori probability because neutrons, if they exist, would probably have long ago been seen, However, only those who wager can win... Unfortunately I cannot personally appear in Tübingen, since I am indispensable here on account of a ball taking place in Zürich....,Your devoted servant,

W. Pauli [Translation from Physics Today, Sept. 1978]

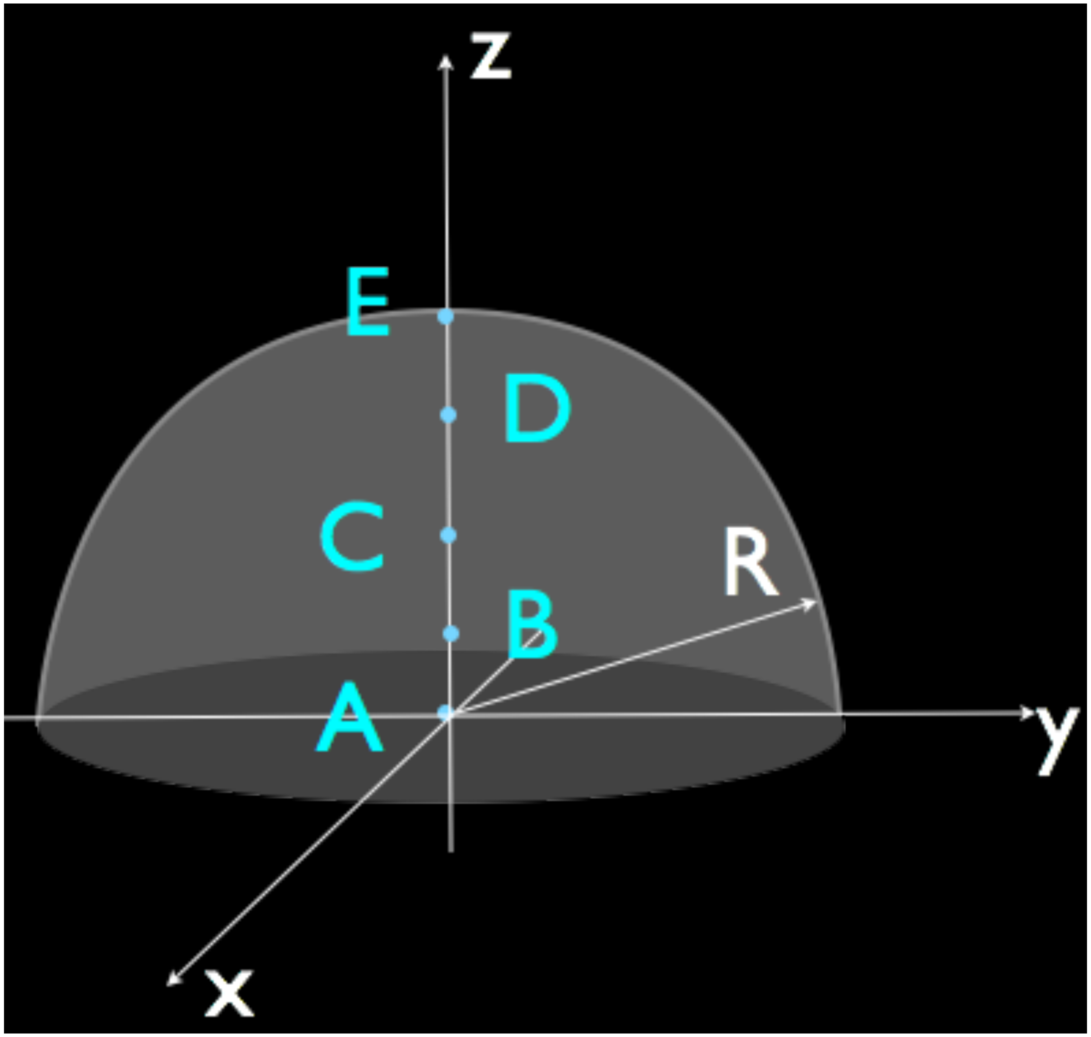
If you push horizontally (briefly!) on the *bottom* end of a long, rigid rod of mass m (floating in space), what does the rod initially do?

A) Rotates in place, but the CM doesn't move
B) Accelerates to the right, with $a_{CM}<F/m$
C) Accelerates to the right, with $a_{CM}=F/m$
D) Other/not sure/depends...



Consider a solid hemisphere of uniform density with a radius R.
Where is the center of mass?

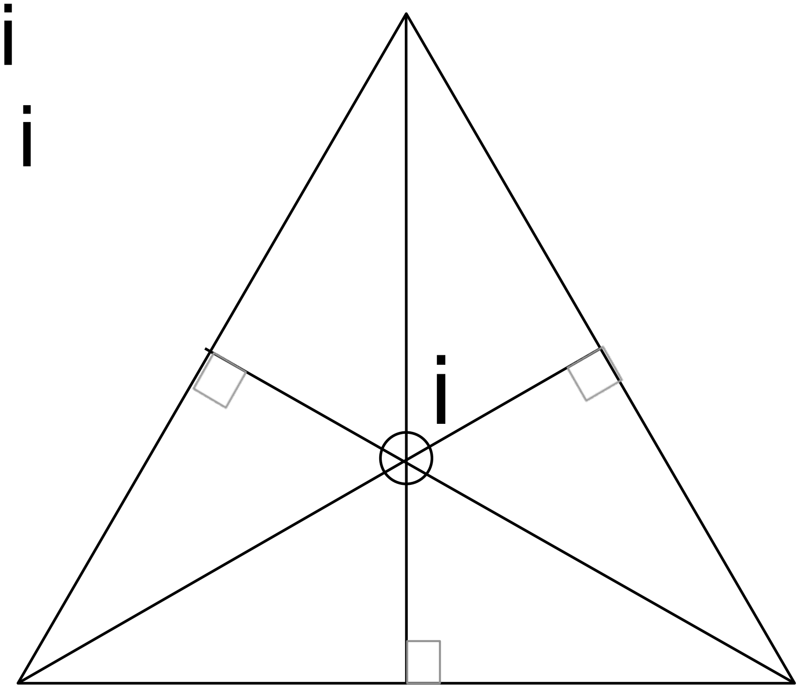
A) $z=0$
B) $0<z<R/2$
C) $z=R/2$
D) $R/2<z<R$
E) $z=R$



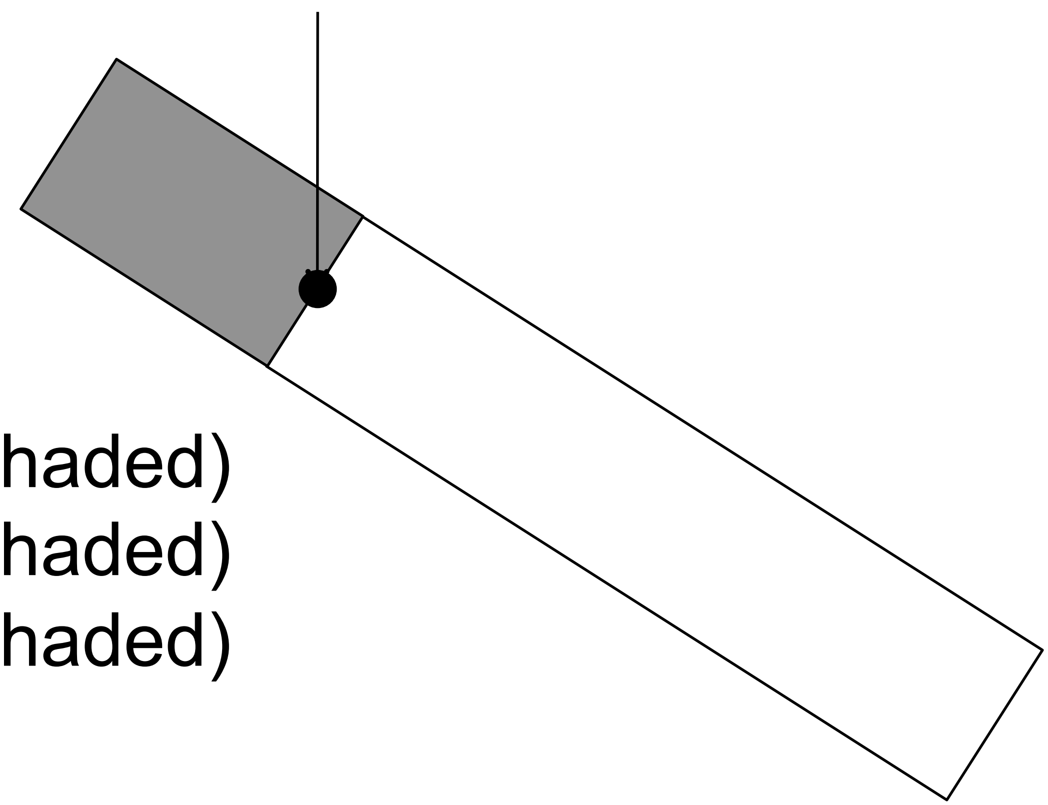
Consider a flat “equilateral triangle”.

Where is the CM?

A) Precisely at the point i
B) A little ABOVE point i
C) A little BELOW point i



The dark shaded portion of this rigid body is a different material from the light shaded portion. The object is hanging from the black "pivot point", and is in balance and stationary. (Ignore friction!)



Compare the mass of the shaded and unshaded portions:

A) M(shaded) > M(unshaded)
B) M(shaded) = M(unshaded)
C) M(shaded) < M(unshaded)
D) Not enough info!

To think about: Where is the CM of this object?

Which of the three quantities:
$\mathbf{R}_{CM}$, $\mathbf{v}_{CM}$ (=d$\mathbf{R}_{CM}$/dt), or $\mathbf{a}_{CM}$ (= d$^2\mathbf{R}_{CM}$/dt^2)
depends on the location of your choice of origin?

A) All three depend
B) $\mathbf{R}_{CM}$, $\mathbf{v}_{CM}$ depend (but $\mathbf{a}_{CM}$ does not)
C) $\mathbf{R}_{CM}$ depends (but $\mathbf{v}_{CM}$ and $\mathbf{a}_{CM}$ do not)
D) NONE of them depend
E) Something else/not sure...

Which of the three quantities:

$\mathbf{R}_{CM}$, $\mathbf{v}_{CM}$ ($=d\mathbf{R}_{CM}/dt$), or $\mathbf{a}_{CM}$ ($= d^2\mathbf{R}_{CM}/dt^2$) *depends* on your choice of origin?

(By "choice" I just mean location. Assume the new origin is still at rest)

A) All three depend

B) $\mathbf{R}_{CM}$, $\mathbf{v}_{CM}$ depend (but $\mathbf{a}_{CM}$ does not)

C) $\mathbf{R}_{CM}$ depends (but $\mathbf{v}_{CM}$ and $\mathbf{a}_{CM}$ do not)

D) NONE of them depend

E) Something else/not sure…

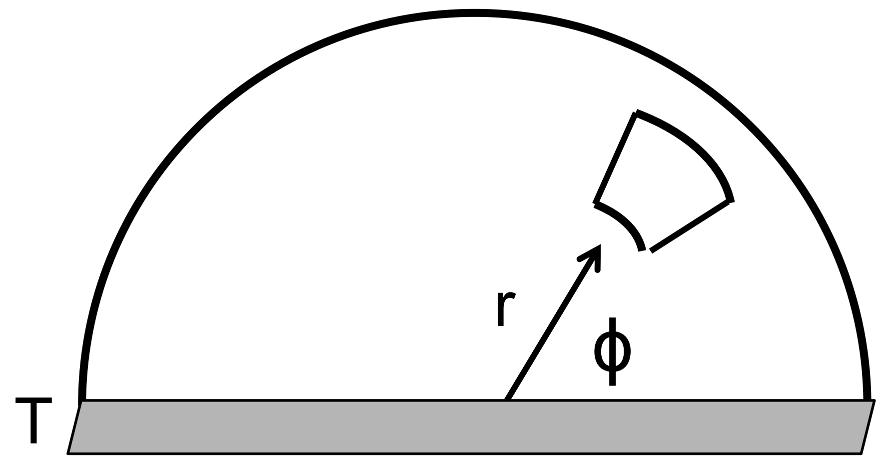
To think about: How would your answer change if the new coordinate system *did* move with respect to you? And, what if it was non-inertial?

In the last homework question for this week, you wrote a "for loop" to solve Newton's law for a mass on a spring, and you had to choose a time step, dt.

Would making dt even **smaller** be a good thing, or a bad thing?

A) Yes, the smaller the better!
B) No, the bigger the better!
C) It's complicated, there are tradeoffs!

When computing $\mathbf{r}_{CM}$ of a "uniform half hockey puck", what is dm for the small chunk shown? (ρ is constant, and the puck thickness is T)



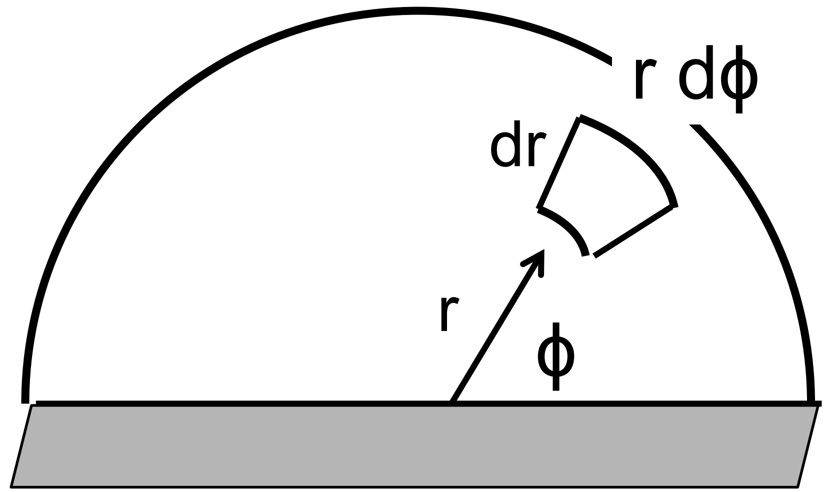
dm=

A) $dr\, d\phi$ B) $T\, dr\, d\phi$

C) $\rho\, dr\, d\phi$ D) $\rho\, T\, dr\, d\phi$

E) Something else!

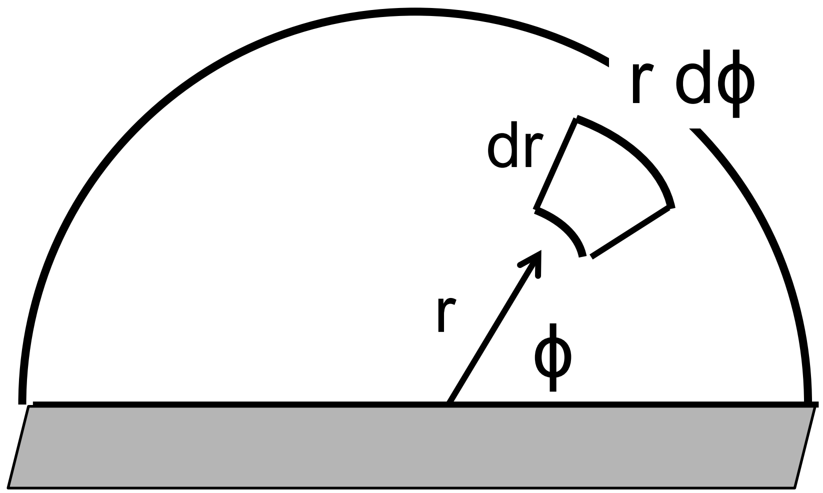
When computing $\mathbf{r}_{CM}$ of a "uniform half hockey puck", what is dm for the small chunk shown? (ρ is constant, and the puck thickness is T)



$$dm = \rho\ T\ r\ dr\ d\phi$$

When computing $y_{CM} = \frac{1}{M}\iiint y\,dm$

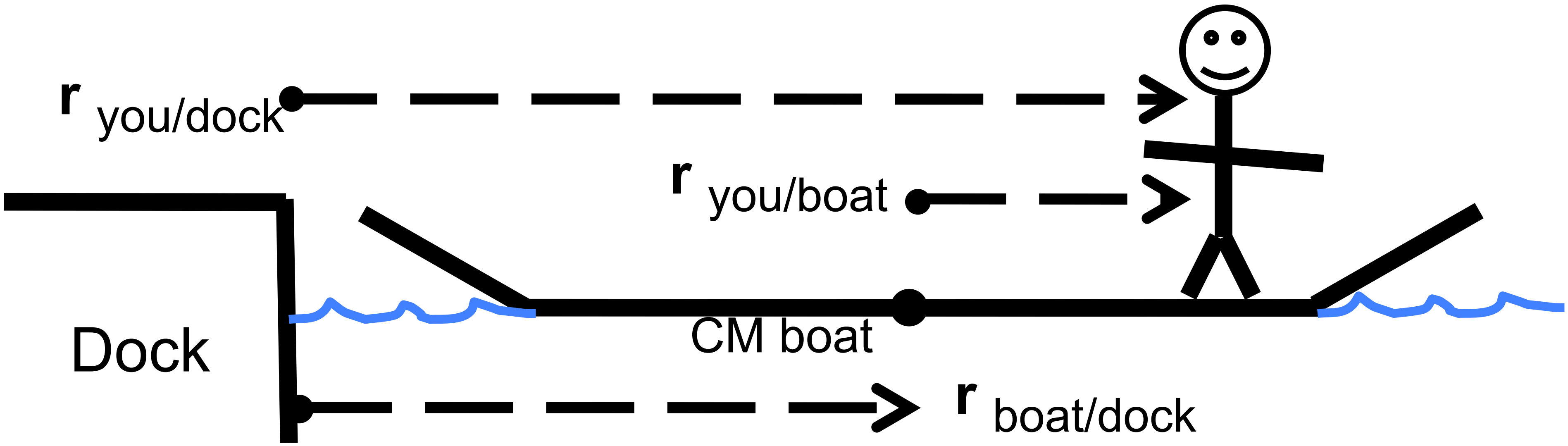
what should we put in for y?



$A)\quad \sin\phi \qquad\qquad B)\ \cos\phi$

$C)\ \ r\sin\phi \qquad\qquad D)\ r\cos\phi$

E) Isn't it just y?



You are walking on a flat-bottomed rowboat.
Which formula correctly relates position vectors?
Notation: $\mathbf{r}_{a/b}$ is "position of a with respect to b."

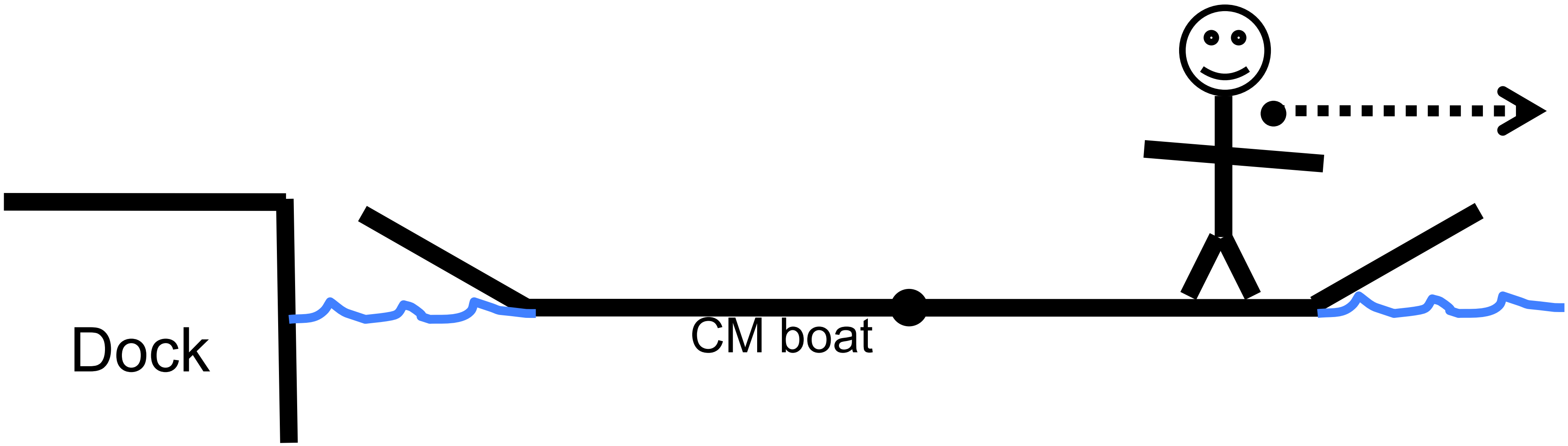
A) $\mathbf{r}_{you/dock} = \mathbf{r}_{you/boat} + \mathbf{r}_{boat/dock}$

B) $\mathbf{r}_{you/dock} = \mathbf{r}_{you/boat} - \mathbf{r}_{boat/dock}$

C) $\mathbf{r}_{you/dock} = -\mathbf{r}_{you/boat} + \mathbf{r}_{boat/dock}$

D) $\mathbf{r}_{you/dock} = -\mathbf{r}_{you/boat} - \mathbf{r}_{boat/dock}$

E) Other/not sure



You are walking on a flat-bottomed rowboat.
Which formula correctly relates velocities?
Notation: $\mathbf{v}_{a/b}$ is "velocity of a with respect to b."

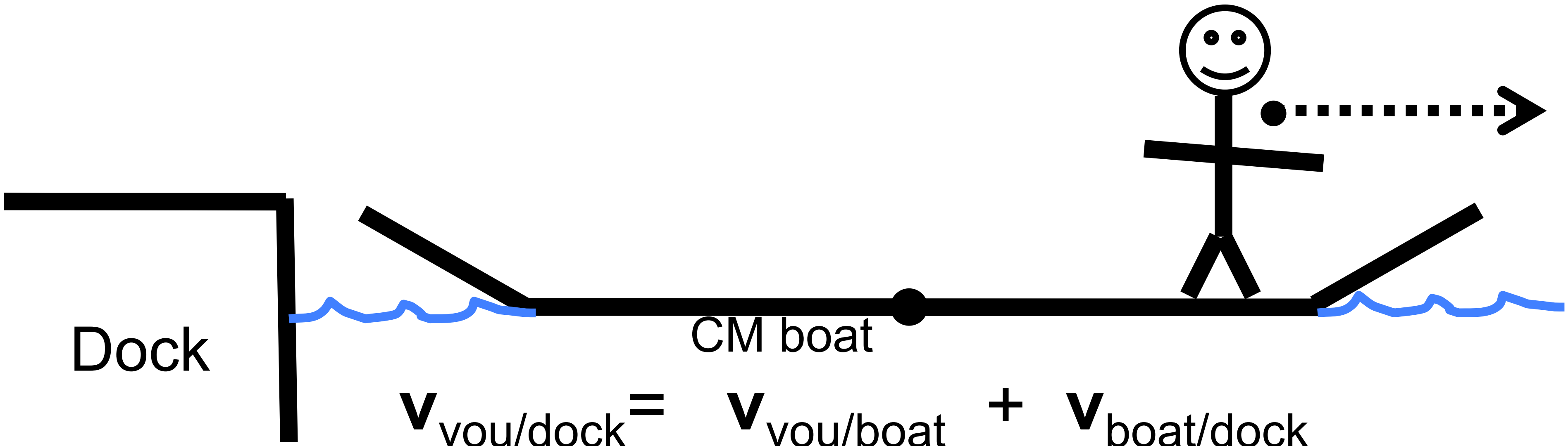
A) $\mathbf{v}_{you/dock} = \mathbf{v}_{you/boat} + \mathbf{v}_{boat/dock}$

B) $\mathbf{v}_{you/dock} = \mathbf{v}_{you/boat} - \mathbf{v}_{boat/dock}$

C) $\mathbf{v}_{you/dock} = -\mathbf{v}_{you/boat} + \mathbf{v}_{boat/dock}$

D) $\mathbf{v}_{you/dock} = -\mathbf{v}_{you/boat} - \mathbf{v}_{boat/dock}$

E) Other/not sure



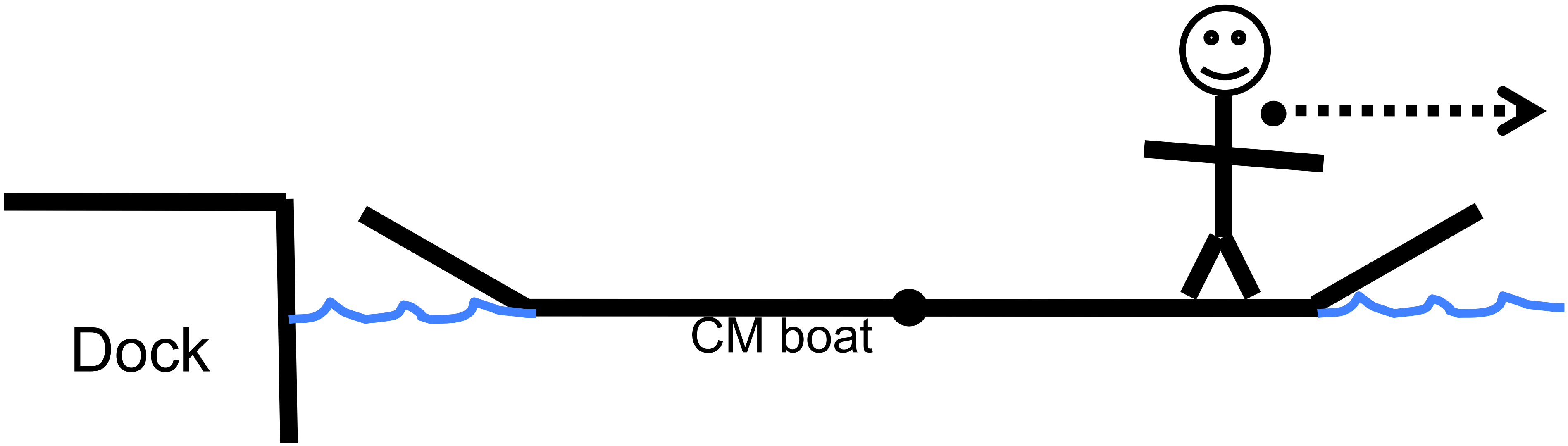
$$\mathbf{v}_{you/dock} = \mathbf{v}_{you/boat} + \mathbf{v}_{boat/dock}$$

(In general, $\mathbf{v}_{a/c} = \mathbf{v}_{a/b} + \mathbf{v}_{b/c}$)

If you are walking in the boat at what feels to you to be your normal walking pace, $\mathbf{v_0}$, WHICH of the above symbols equals $\mathbf{v_0}$?

A) $\mathbf{v}_{you/dock}$ B) $\mathbf{v}_{you/boat}$ C) $\mathbf{v}_{boat/dock}$

D) NONE of these...

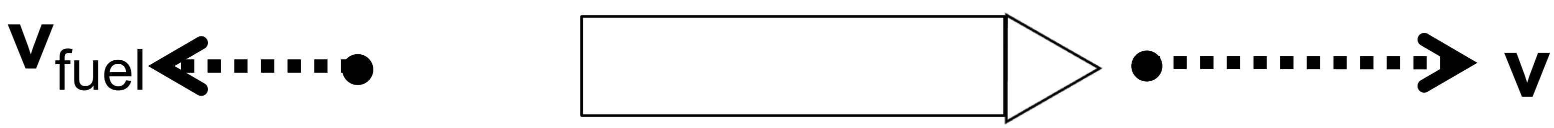


You are walking on a flat-bottomed rowboat.

$\mathbf{v}_{\text{you/dock}} = \mathbf{v}_{\text{you/boat}} + \mathbf{v}_{\text{boat/dock}}$

or

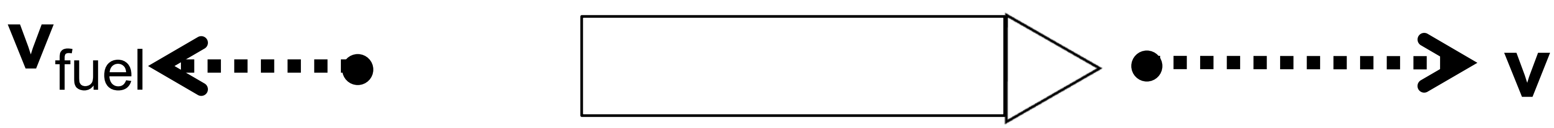
$\mathbf{v} = \mathbf{v_0} + \mathbf{v}_{\text{boat}}$



A rocket travels with velocity $\mathbf{v}$ with respect to an (inertial) NASA observer.

It ejects fuel at velocity $\mathbf{v}_{exh}$ *in its own reference frame.* Which formula correctly relates these two velocities with the velocity $\mathbf{v}_{fuel}$ of a chunk of ejected fuel with respect to an (inertial) NASA observer?

A) $\mathbf{v} = \mathbf{v}_{fuel} + \mathbf{v}_{exh}$
B) $\mathbf{v} = \mathbf{v}_{fuel} - \mathbf{v}_{exh}$
C) $\mathbf{v} = -\mathbf{v}_{fuel} + \mathbf{v}_{exh}$
D) $\mathbf{v} = -\mathbf{v}_{fuel} - \mathbf{v}_{exh}$
E) Other/not sure??



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A) $\mathbf{v} = \mathbf{v}_{fuel} + \mathbf{v}_{exh}$
B) $\mathbf{v} = \mathbf{v}_{fuel} - \mathbf{v}_{exh}$
C) $\mathbf{v} = -\mathbf{v}_{fuel} + \mathbf{v}_{exh}$
D) $\mathbf{v} = -\mathbf{v}_{fuel} - \mathbf{v}_{exh}$
E) Other/not sure??

Be careful, work it out: use the last result

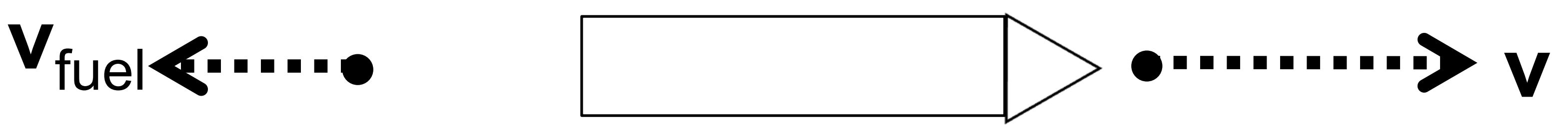
$\mathbf{v}_{a/c} = \mathbf{v}_{a/b} + \mathbf{v}_{b/c}$

to check!?)

A rocket travels with velocity $\mathbf{v}$ with respect to an (inertial) NASA observer.

It ejects fuel at velocity $\mathbf{v}_{exh}$ *in its own reference frame.* Which formula correctly relates these two velocities with the velocity $\mathbf{v}_{fuel}$ of a chunk of ejected fuel with respect to an (inertial) NASA observer?

A) $\mathbf{v}_{fuel} = \mathbf{v}_{exh} + \mathbf{v}$
B) $\mathbf{v}_{fuel} = \mathbf{v}_{exh} - \mathbf{v}$
C) $\mathbf{v}_{fuel} = -\mathbf{v}_{exh} + \mathbf{v}$
D) $\mathbf{v}_{fuel} = -\mathbf{v}_{exh} - \mathbf{v}$
E) Other/not sure??



$$\mathbf{v}_{\text{fuel/NASA}} = \mathbf{v}_{\text{fuel/rocket}} + \mathbf{v}_{\text{rocket/NASA}}$$

In other words, $\mathbf{v}_{\text{fuel}} = \mathbf{v}_{\text{exh}} + \mathbf{v}$

$\mathbf{v}_{fuel} = \mathbf{v}_{exh} + \mathbf{v}$

What happens when you take the x component?

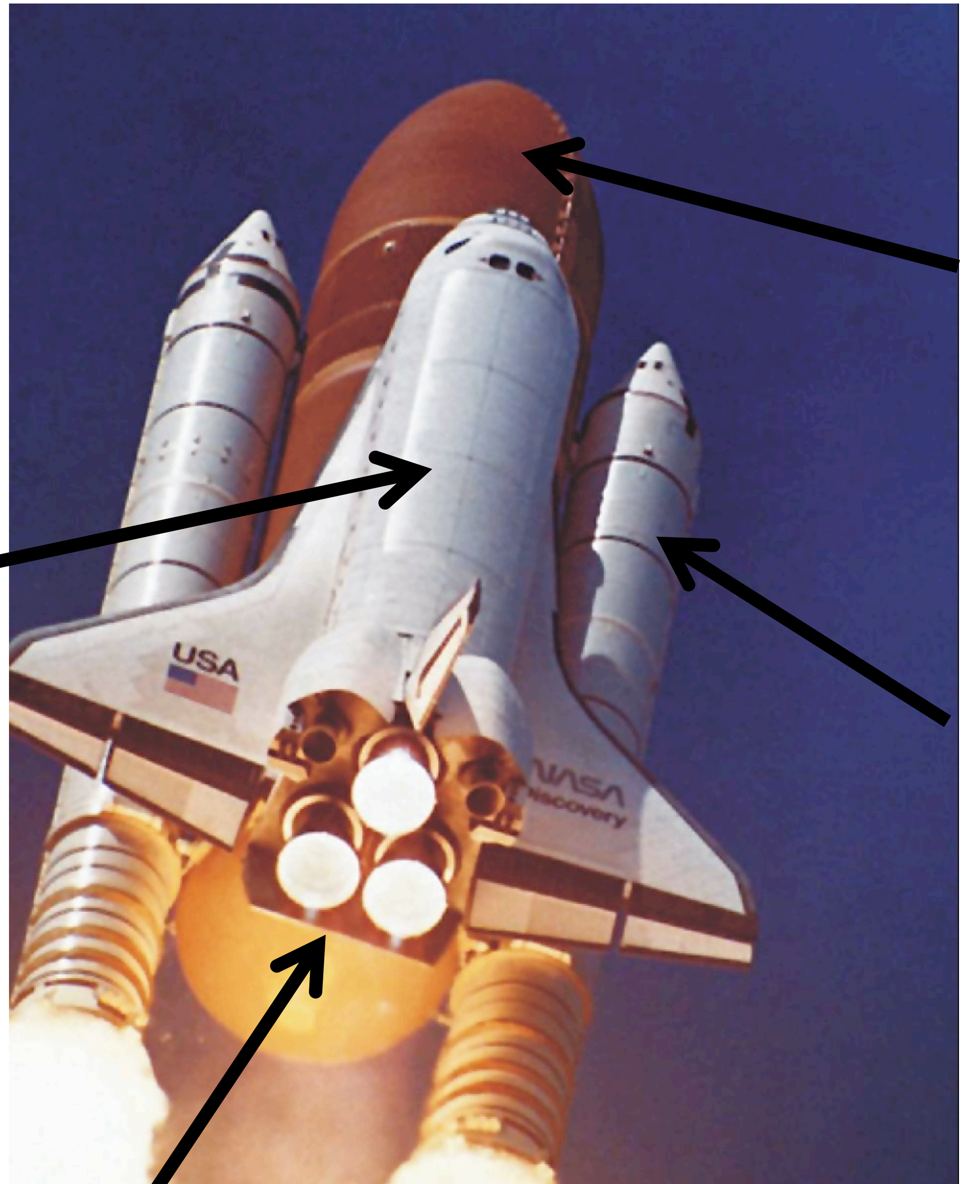
$v_{fuel,x} = v_{exh,x} + v_x$ (No problems yet)

But, be careful when writing in terms of magnitudes!

$v_{fuel,x} = -|v_{exh}| + v$ (Because $\mathbf{v}_{exh}$ is leftward)

You have TWO medicine balls on a cart, and toss the first.
Your speed will increase by Δv_1.
Now you're moving, and you toss #2 (in the same way).
How does the second increase in speed, Δv_2, compare to the first one?

A) $\Delta v_2 = \Delta v_1$
B) $\Delta v_2 > \Delta v_1$
C) $\Delta v_2 < \Delta v_1$
D) ??



Liquid fuel tank

Orbiter vehicle

2 solid rocket booster (SRB's)

3 Space Shuttle Main Engines (liquid propellant)

Solid Rocket Boosters

Which of the three quantities:
τ (torque), **L** (angular momentum), or
p (linear momentum)
depends on your choice of origin?

A) All three depend
B) **τ** depends (but **L** and **p** do not)
C) **L** depends (but **τ** and **p** do not)
D) NONE of them depend
E) Something else/not sure...

A point-like object travels in a straight line at constant speed.
Does this object have any angular momentum?

A) Yes
B) No
C) It depends….

A point-like object travels in a straight line at constant speed.
What can you say about dL/dt?

A) It’s zero
B) It’s not zero
C) It depends….

The vector **A** is in the xy plane.
B is parallel to the z-axis.
Which is true about **P =A** x **B**?

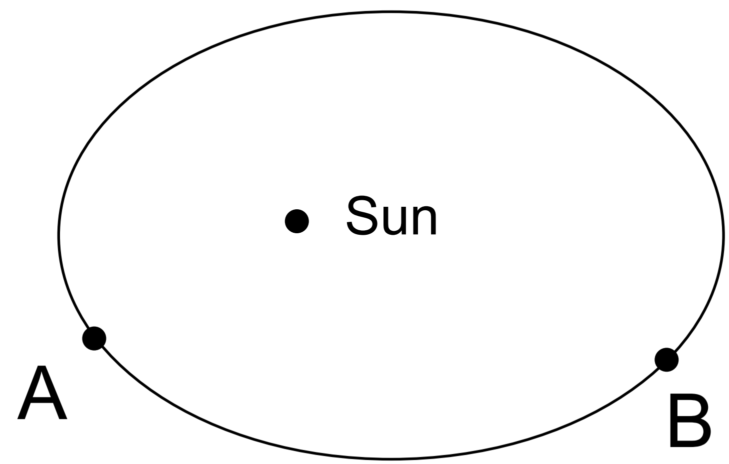
A) **P** is perpendicular to the xy plane
B) **P** lies in the xy plane
C) Px=0
D) Py=0
E) None of the above is always true.

Given a particle with mass m, velocity $\vec{v}$, $\vec{p} = m\vec{v}$, and $\vec{L} = \vec{r} \times \vec{p}$, what is $\vec{L} \cdot \vec{p}$?

A) zero
B) a non-zero scalar
C) a vector, parallel to **p**
D) a vector, perpendicular to **p**
E) Need more info!

Given a planet with mass m, velocity $\vec{v}$, $\vec{p} = m\vec{v}$, and $\vec{L} = \vec{r} \times \vec{p}$

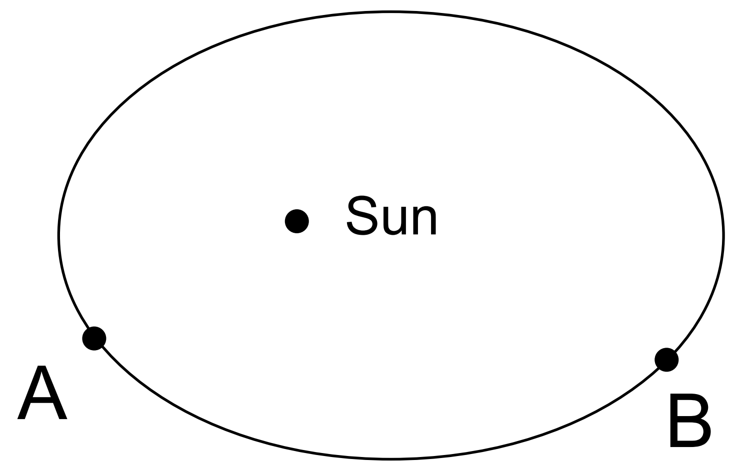
Is L conserved?



A) Yes
B) No
C) Depends on your choice of origin!

Given a planet with mass m, velocity $\vec{v}$, $\vec{p} = m\vec{v}$, and $\vec{L} = \vec{r} \times \vec{p}$ (which is conserved – do you see why?):

Compare the planet's speed at points A and B:



A) Faster at A
B) Faster at B
C) Same
D) Depends on whether the orbit is CW or CCW