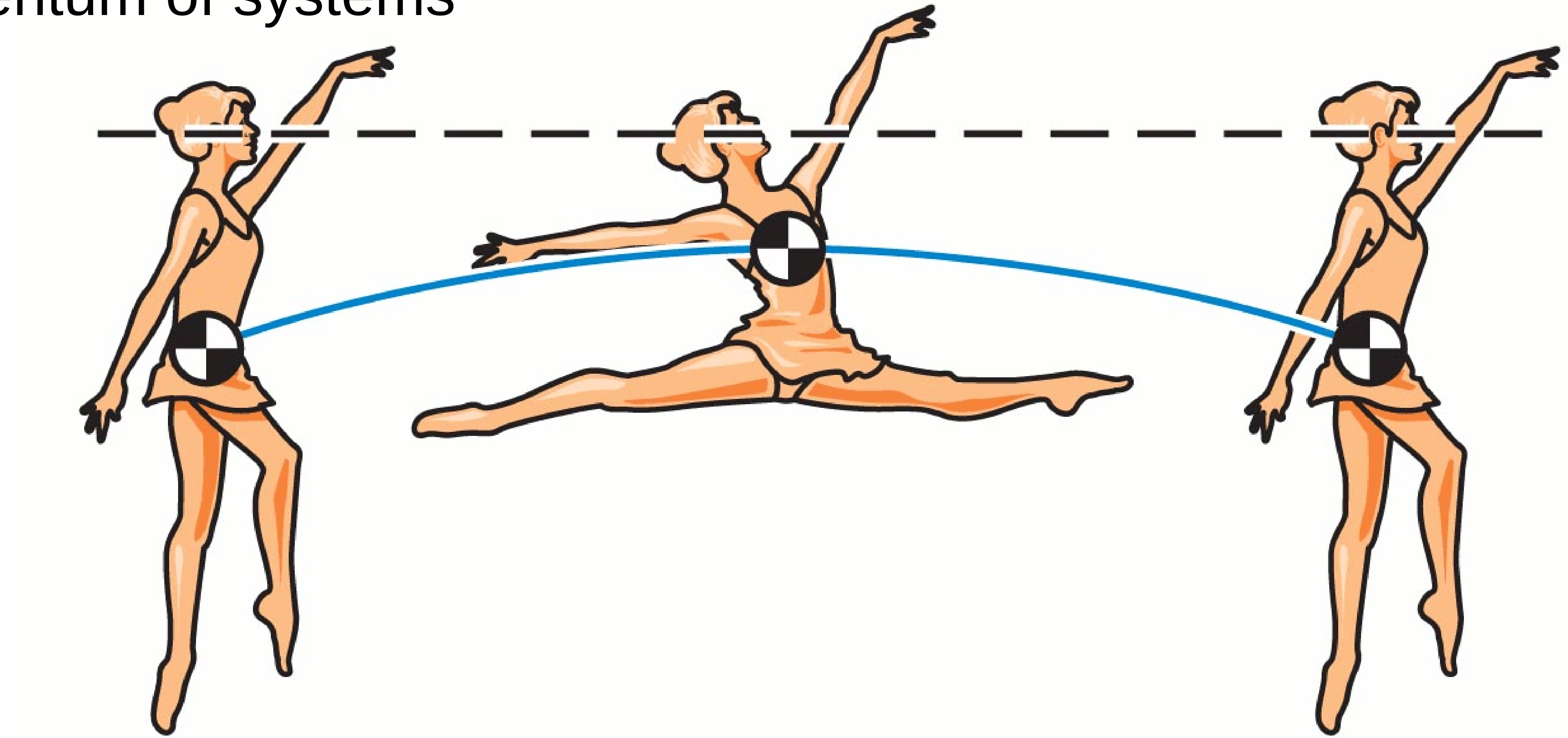
PHY131H1F - Class 14

Today, we are starting Chapter 9 on Momentum:

- Centre of Mass
- Momentum of systems



http://www.chegg.com/homework-help/questions-and-answers/grand-jete-classic-ballet-manoeuvre-dancer-executes-horizontal-leap-moving-arms-legs--cent-q5975347

From Fall 2017 PHY131H1F Midterm Test 2

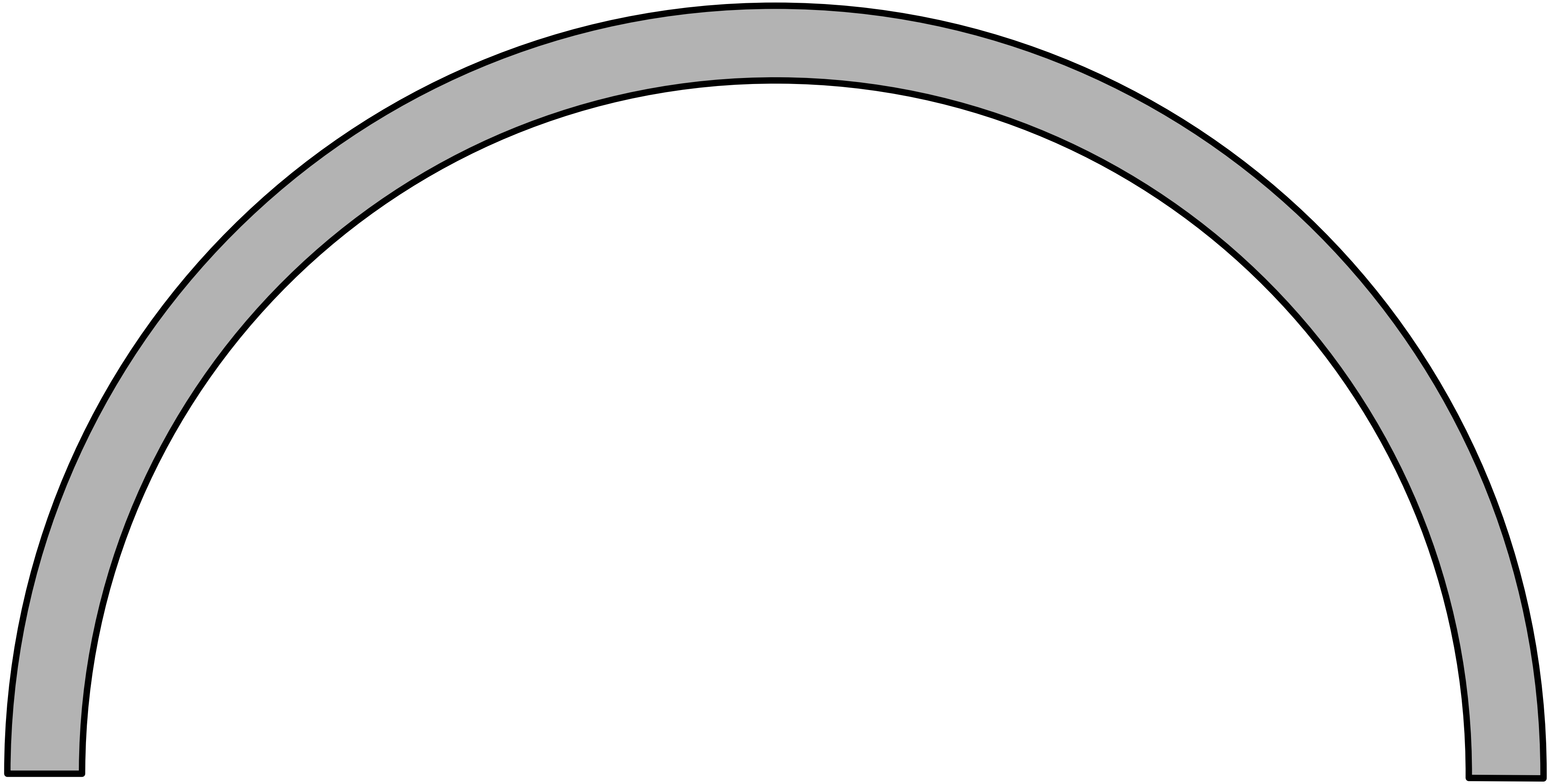
Question7

A satellite in an elliptical orbit has a height above the surface of the Earth which ranges from 630 km at its lowest point, up to 7600 km at its highest. When it is at its lowest point (closest to the surface of the Earth), it's moving at 8.7 km/s. How fast is it moving at its highest point? [Assume the Earth is a sphere of radius 6370 km and mass 5.97×10^{24} kg.]

(A) 2.2 km/s (B) 4.4 km/s (C) 6.2 km/s (D) 8.7 km/s (E) 17 km/s

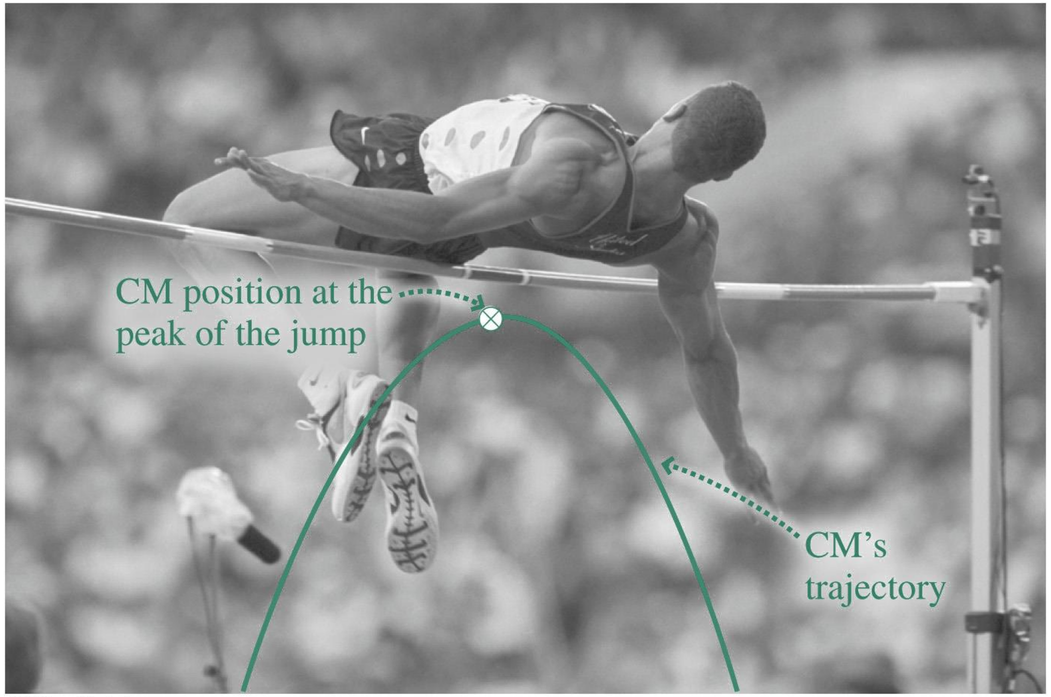
Learning Catalytics Question 1

Where do you think is the centre of mass of this object?



Last day I asked at the end of class:

- How is it possible to clear the bar in a high jump if your center of mass does not reach to the height of the bar?
- ANSWER:
- For a projectile, the motion of the centre of mass is governed by the equations of constant acceleration we already know.



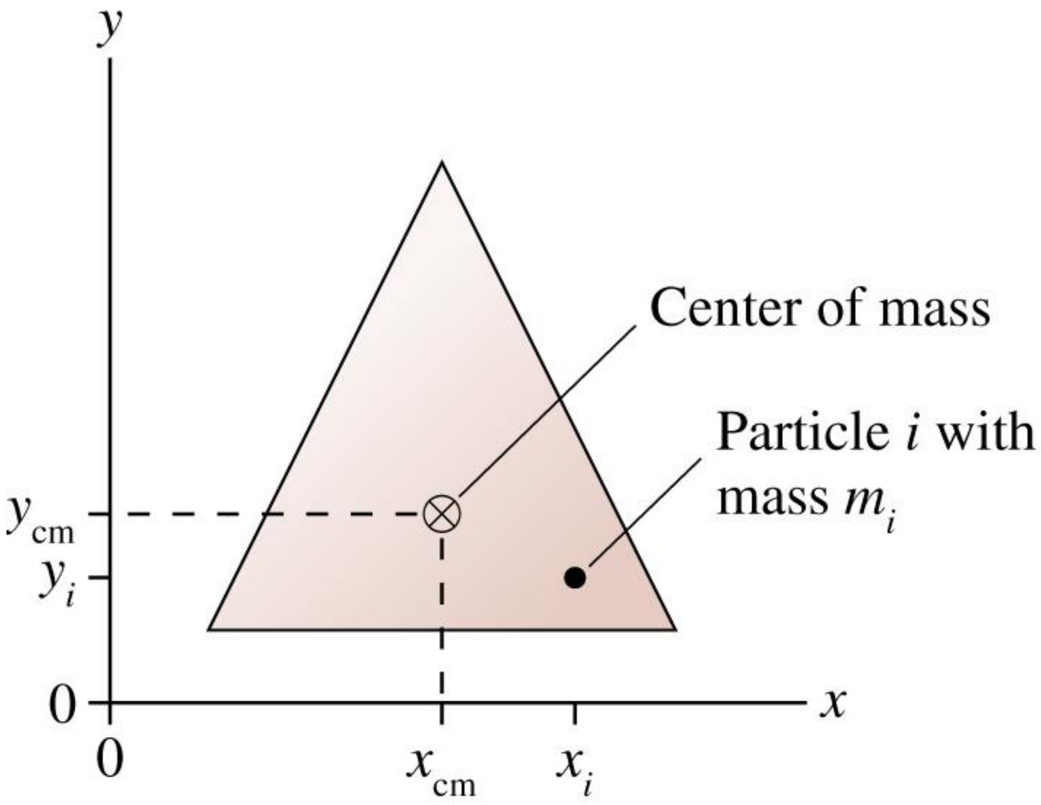
- The center of mass of a complicated shape (like a person doing a back arch) does not need to be within the object.

Center of Mass

Consider an object made of particles. Particle i has mass m_i. The center-of-mass is at

$$x_{cm} = \frac{1}{M}\sum_i m_i x_i = \frac{m_1x_1 + m_2x_2 + m_3x_3 + \cdots}{m_1 + m_2 + m_3 + \cdots}$$

$$y_{cm} = \frac{1}{M}\sum_i m_i y_i = \frac{m_1y_1 + m_2y_2 + m_3y_3 + \cdots}{m_1 + m_2 + m_3 + \cdots}$$

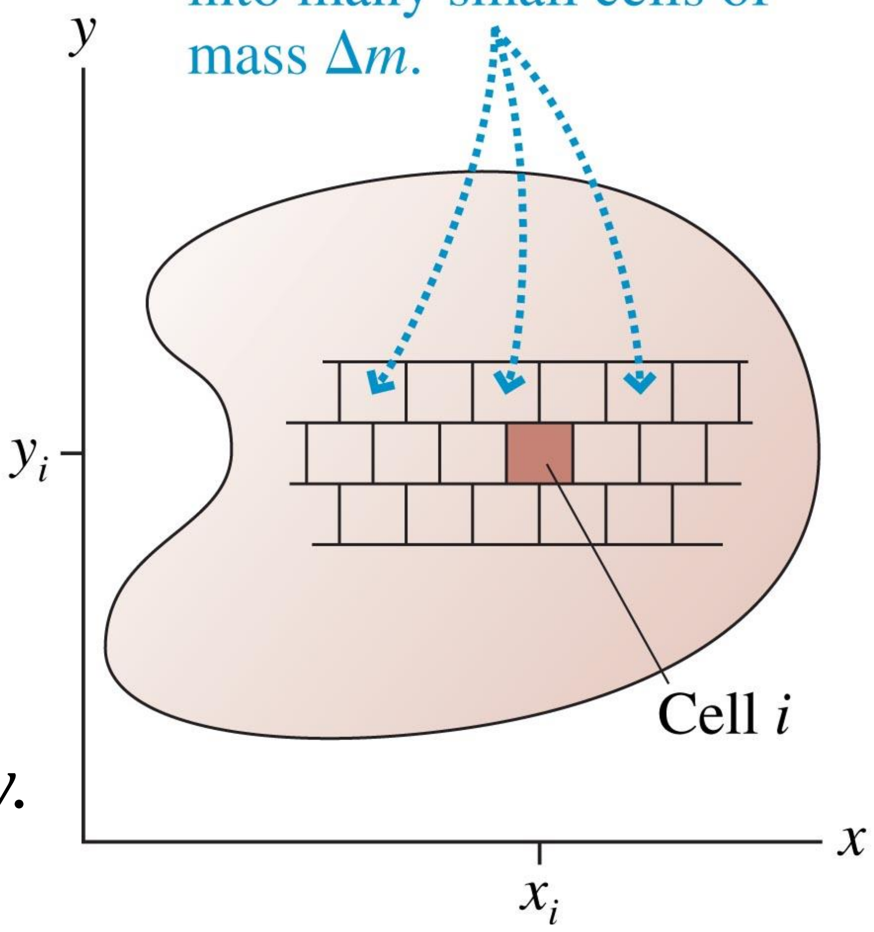


Calculating center of mass is much like calculating your grade-point average. Marks in full-courses count twice as much as marks in half-courses. Particles of *higher mass* count *more* than particles of lower mass.

Center of Mass of a Solid Object

Divide a solid object into many small cells of mass Δm. As $\Delta m \to 0$, and is replaced by dm, the sums become

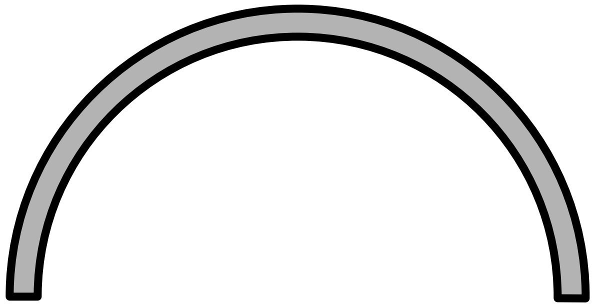
$$x_{cm} = \frac{1}{M}\int x\,dm \qquad \text{and} \qquad y_{cm} = \frac{1}{M}\int y\,dm$$



Before these can be integrated:

- *dm* must be replaced by expressions using *dx* and *dy*.
- Integration limits must be established.

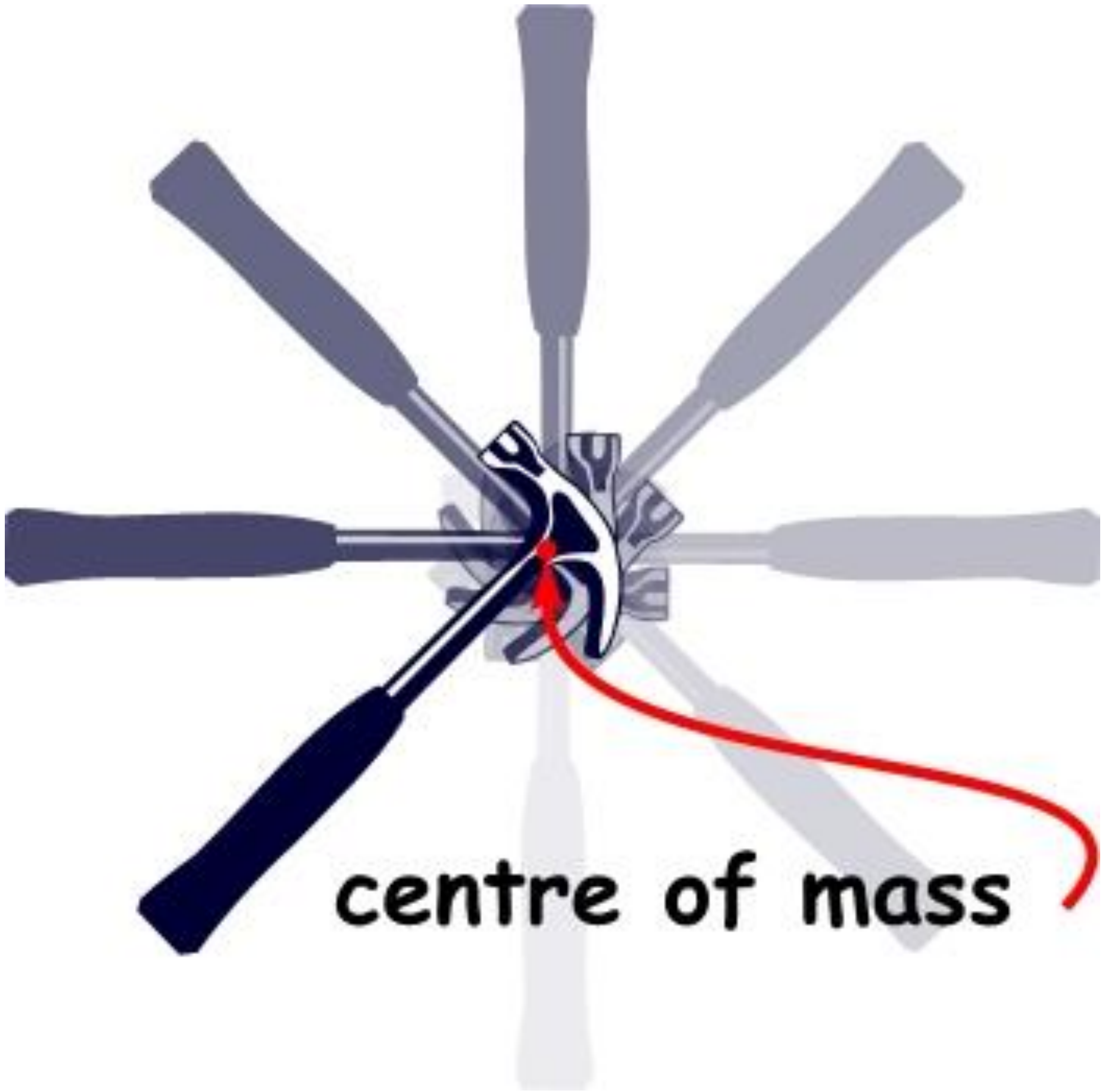
Where is the centre of mass of a semicircular ring?



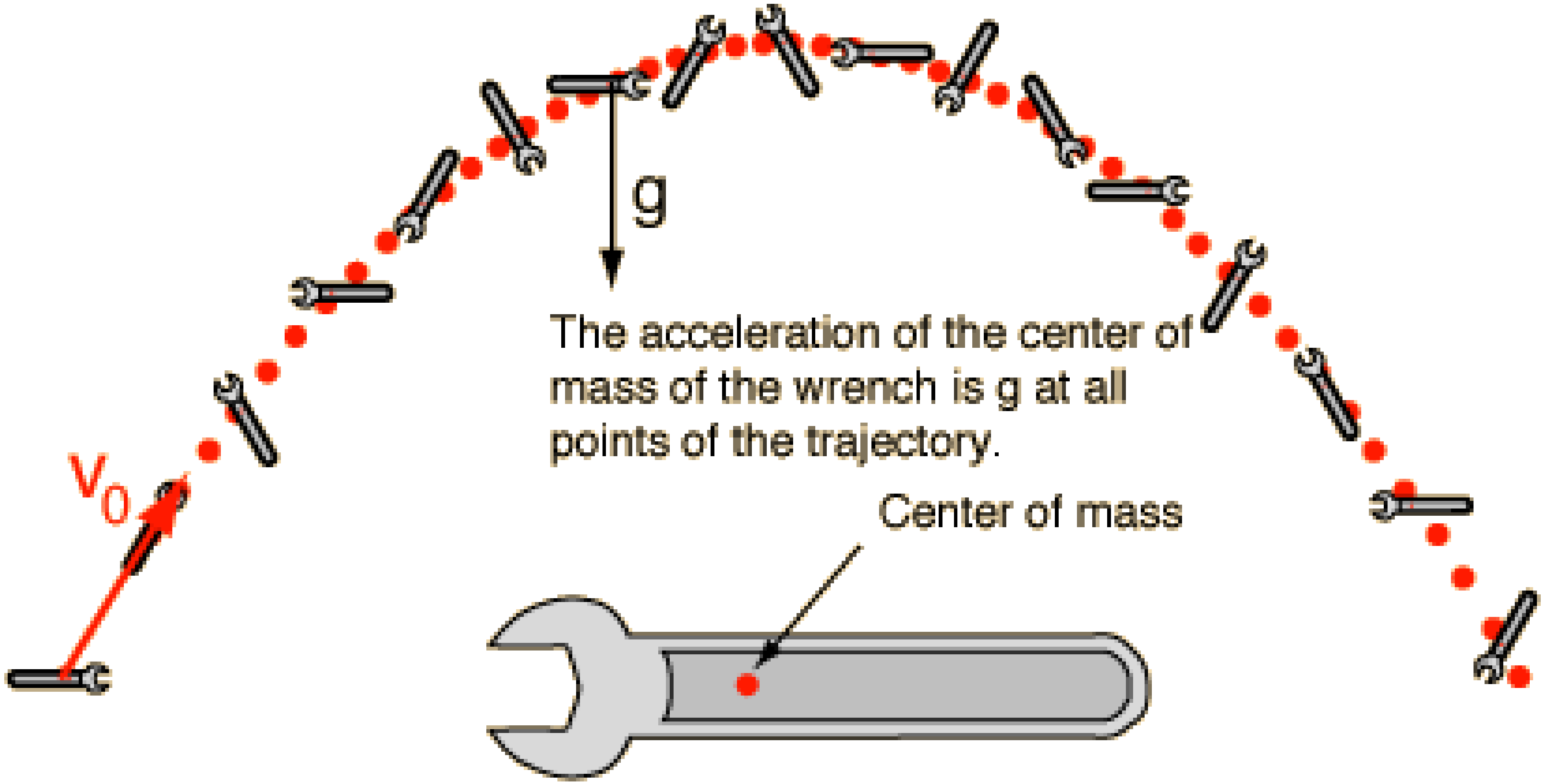
Rotation About the Center of Mass

An unconstrained object (i.e., one not on an axle or a pivot) on which there is no net force rotates about a point called the center of mass.

The center of mass remains motionless while every other point in the object undergoes circular motion around it.

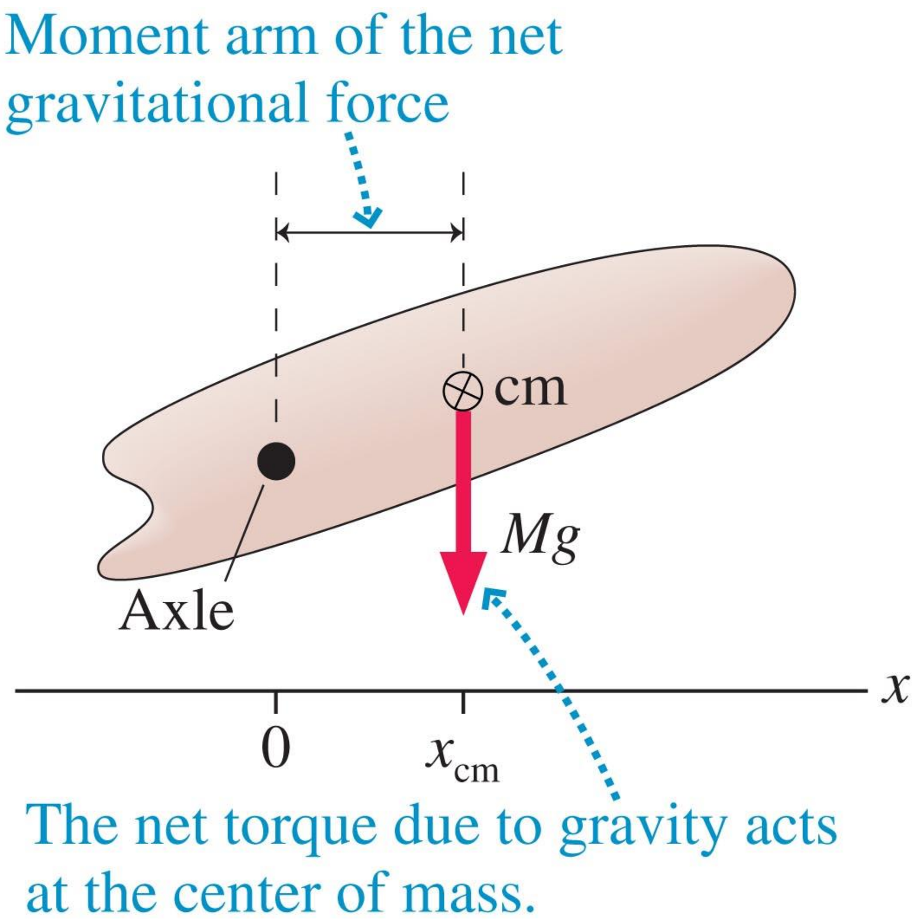


[Image from http://resources.yesican-science.ca/discover_2006_2/images/hammer2.jpg]



[image from http://hyperphysics.phy-astr.gsu.edu/hbase/mechanics/n2ext.html]

Gravitational Torque



- When calculating the torque due to gravity, you may treat the object as if all its mass were concentrated at the centre of mass.
- More about this in Chapter 10!

Chapter 9 big idea:
"Conservation of Momentum"

- A system of particles has a total momentum, $\vec{P}$
- If the system is isolated, meaning that there is no external net-force acting on the system, then:

$$\vec{P}_f = \vec{P}_i$$

- This means the momentum is "conserved"; it doesn't change over time.

Chapter 9 summary:

Law of Conservation of Momentum

The total momentum $\vec{P} = \vec{p}_1 + \vec{p}_2 + \cdots$ of an isolated system is a constant. Thus

$$\vec{P}_f = \vec{P}_i$$

Newton's Second Law

In terms of momentum, Newton's second law is

$$\vec{F} = \frac{d\vec{p}}{dt}$$

Learning Catalytics Question 2

- Two particles collide, one of which was initially moving, and the other initially at rest. Is it possible for *both* particles to be at rest after the collision? [Assume no outside forces act on the particles.]

A. Yes

B. No

Learning Catalytics Question 3

- Two particles collide, one of which was initially moving, and the other initially at rest. Is it possible for *one* particle to be at rest after the collision? [Assume no outside forces act on the particles.]

A. Yes

B. No

A yellow Hummer (m_H = 3900 kg) was driving South and collided with a blue Toyota (m_T = 1200 kg) which was driving East. The speed limit on both roads is 50 km/hr.

After the collision, the two cars stuck together and the combined mass skidded along the ground.

The police measure that the skid marks are a line 10 m long, angled 32° East of South.

The coefficient of kinetic friction between rubber and road is 0.8.

How fast were the cars going before the collision? Who is at fault?

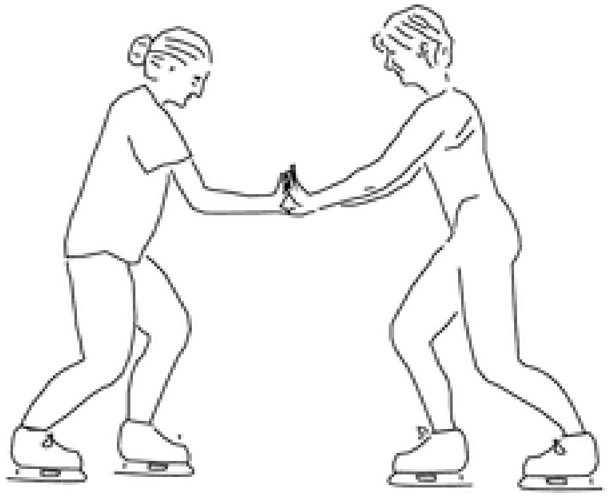
Learning Catalytics Question 4

- Two ice skaters, Paula and Ricardo, push off from each other. They were both initially at rest. Ricardo has a greater mass than Paula. Which skater has the greater magnitude of momentum after the push-off?

A. Ricardo

B. Paula

C. neither



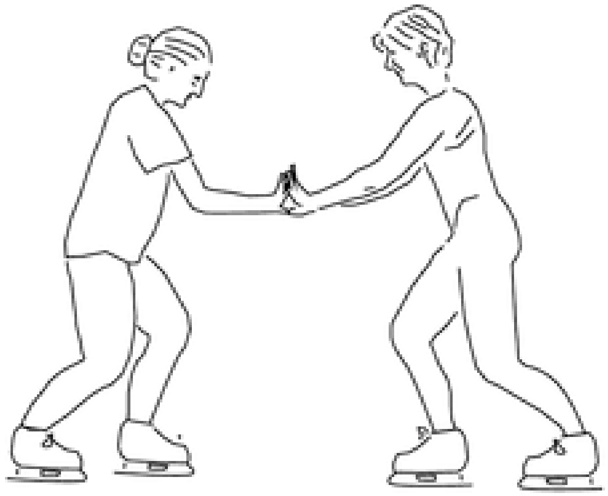
Learning Catalytics Question 5

- Two ice skaters, Paula and Ricardo, push off from each other. They were both initially at rest. Ricardo has a greater mass than Paula. Which skater has the greater speed after the push-off?

A. Ricardo

B. Paula

C. neither



Before Class 15 on Wednesday

- Remember MasteringPhysics.com **Problem Set 6** on Ch.7 is due **tonight** by 11:59pm!!
- Please finish reading Chapter 9 and/or watch Preclass 15 Video:
- Something to think about:
- Consider the two integrals below. What's the difference? [Hint: one is the change in **energy** of an object, and one is the change in **momentum** of an object.]

$$\vec{J} = \int \vec{F} dt$$

$$W = \int \vec{F} \cdot d\vec{r}$$