# Physics 111 - Class 7A
# Force Applications

October 17, 2022

# Class Outline

- Logistics / Announcements
- Mid-course Feedback Results
- Introduction to Chapter 6
- Clicker Questions
- Activity: Worked Problems

# Logistics/Announcements

- Lab this week: Lab 4
- HW6 due this week on Thursday at 6 PM
- Learning Log 6 due on Saturday at 6 PM
- HW and LL deadlines have a 48 hour grace period
- Test/Bonus Test: Bonus Test 2 available this week (Chapters 3 & 4)
- Additional Student Hours from Tutorial TAs for more 1:1 help via Zoom

# Changes moving forward...

- **Full worked solutions posted after class (Started in Week 5)**
- **Adjustment to Learning Logs**
  - Question 2 will not be required (though I still encourage you to do it)
- **Review HW problems in class**
  - In Tutorials, I will ask Ishanka and Siddharth to do a quick poll before every tutorial and spend 5 minutes with the strategy on one HW problem
  - In class, I will **try** to give some hints on one HW problem (may not happen every week)

# Changes moving forward...

- **More opportunities for 1:1 help:** Three hours of additional time/week on Zoom
    - Siddharth (TA): Tuesdays 3:00 - 4:30 PM on Zoom
    - Ishanka (TA): Thursdays 2:00 - 3:30 on Zoom

## Contact Us

| Team Member | Pronounce as | Contact | Student Hours |
| --- | --- | --- | --- |
| Dr. Firas Moosvi (he/his/him); Instructor | Fur-az Moose-vee | Contact via Ed Discussion | Wednesdays and Fridays 3:30-4:00 PM and 5:00 - 5:30 in COM 201 |
| Siddharth Perera | Pronunciation | Contact via Ed Discussion | Tuesdays 3:00 - 4:30 on Zoom |
| Ishanka Banerjee | Pronunciation | Contact via Ed Discussion | Thursdays 2:00 - 3:30 on Zoom |
| Skyler Alderson | Pronunciation | Contact via Ed Discussion | N/A |

# Wednesday’s Class

6.3 Centripetal Force
6.4 Drag force and Terminal Speed

# Centripetal Motion

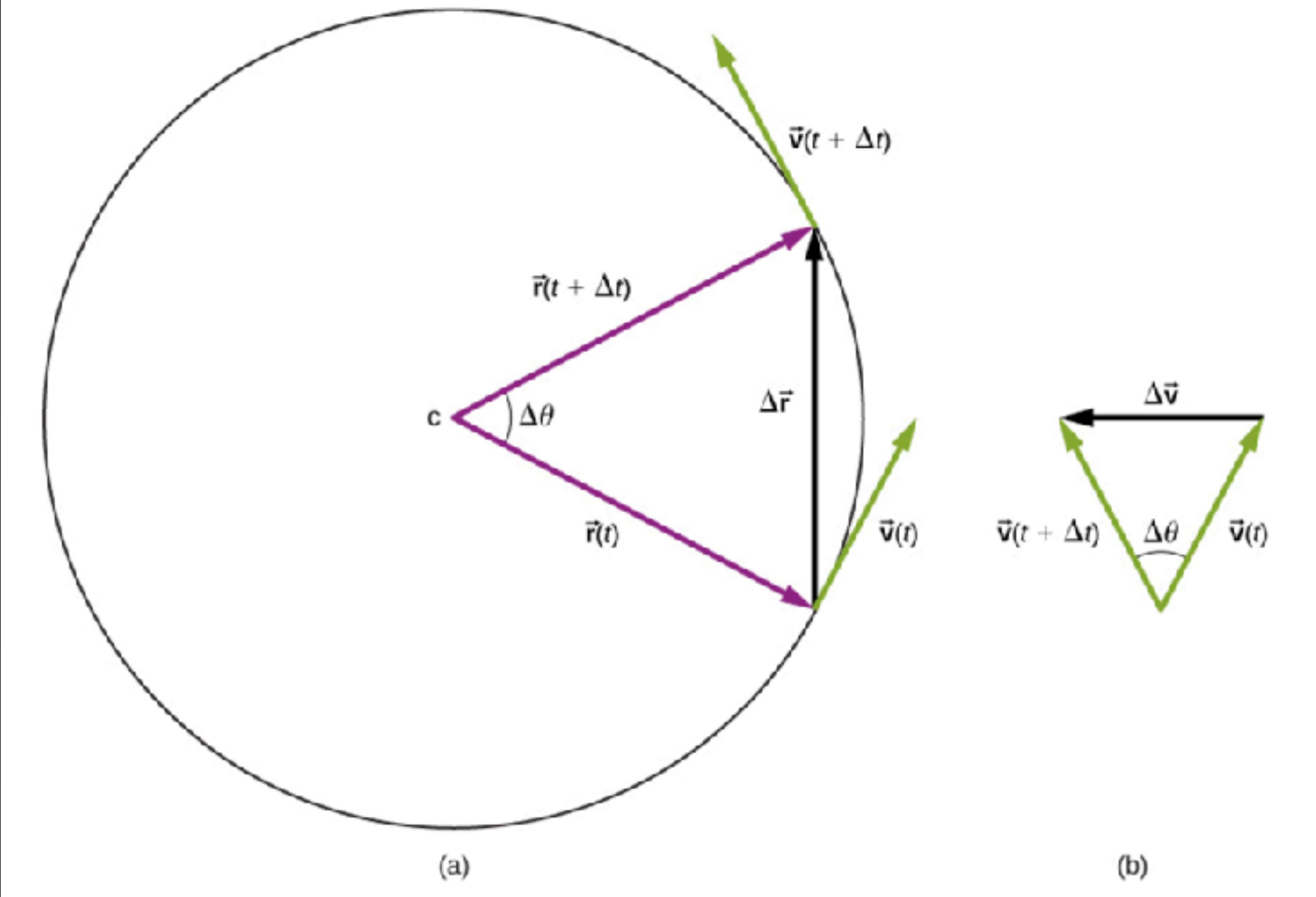



**Figure 4.18** (a) A particle is moving in a circle at a constant speed, with position and velocity vectors at times $t$ and $t + \Delta t$. (b) Velocity vectors forming a triangle. The two triangles in the figure are similar. The vector $\Delta\vec{v}$ points toward the center of the circle in the limit $\Delta t \to 0$.

We can find the magnitude of the acceleration from

$$a = \lim_{\Delta t \to 0}\left(\frac{\Delta v}{\Delta t}\right) = \frac{v}{r}\left(\lim_{\Delta t \to 0}\frac{\Delta r}{\Delta t}\right) = \frac{v^2}{r}.$$

The direction of the acceleration can also be found by noting that as $\Delta t$ and therefore $\Delta\theta$ approach zero, the vector $\Delta\vec{v}$ approaches a direction perpendicular to $\vec{v}$. In the limit $\Delta t \to 0, \Delta\vec{v}$ is perpendicular to $\vec{v}$. Since $\vec{v}$ is tangent to the circle, the acceleration $d\vec{v}/dt$ points toward the center of the circle. Summarizing, a particle moving in a circle at a constant speed has an acceleration with magnitude

$$a_c = \frac{v^2}{r}. \qquad \boxed{4.27}$$

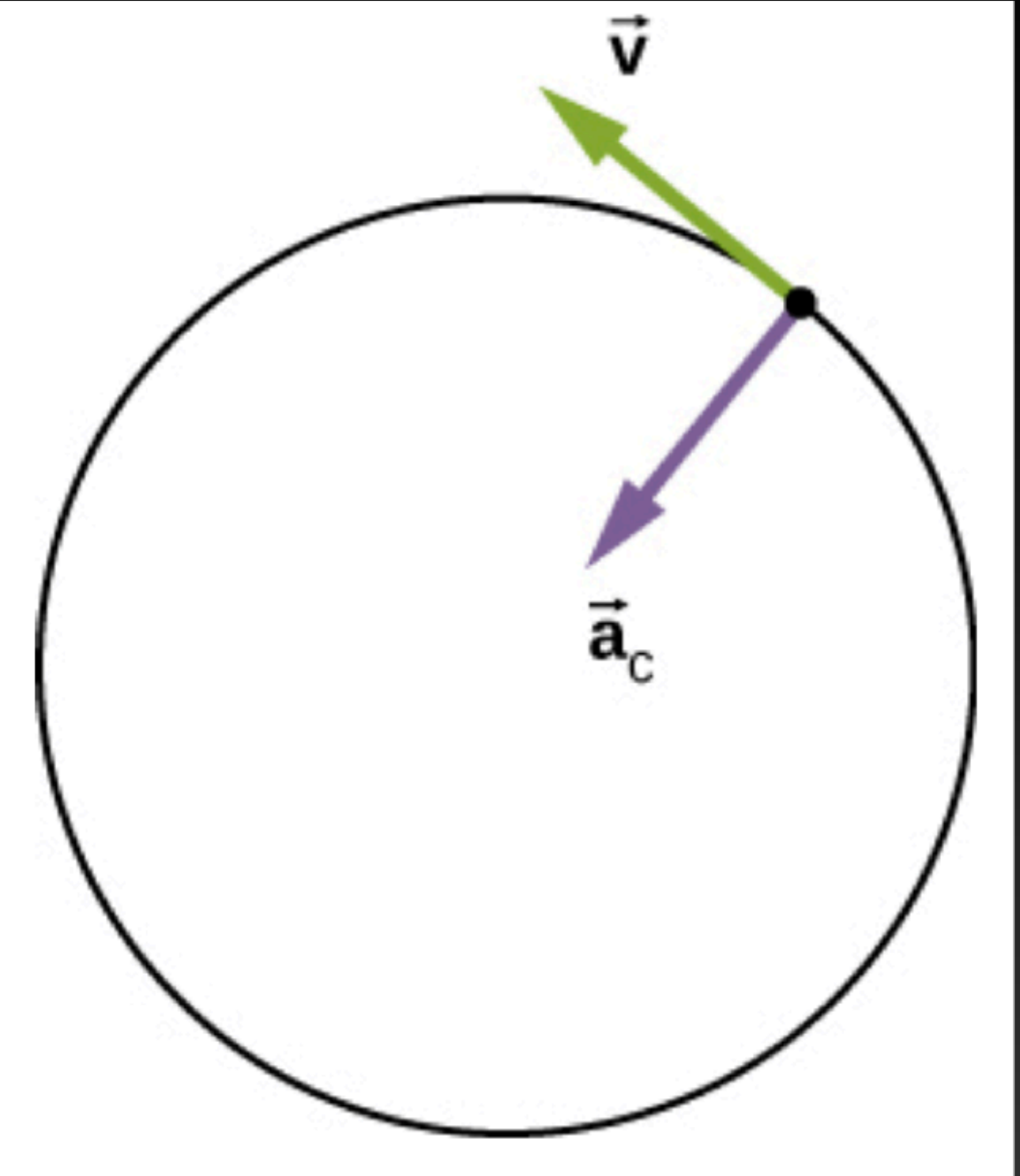



**Figure 4.19** The centripetal acceleration vector points toward the center of the circular path of motion and is an acceleration in the radial direction. The velocity vector is also shown and is tangent to the circle.

# Centripetal Motion

By substituting the expressions for centripetal acceleration $a_c$ ($a_c = \frac{v^2}{r}$; $a_c = r\omega^2$), we get two expressions for the centripetal force $F_c$ in terms of mass, velocity, angular velocity, and radius of curvature:

$$F_c = m\frac{v^2}{r}; \quad F_c = mr\omega^2. \tag{6.3}$$


arc of projectile motion

# Drag Force

**DRAG FORCE**

Drag force $F_D$ is proportional to the square of the speed of the object. Mathematically,

$$F_D = \frac{1}{2} C \rho A v^2,$$

where $C$ is the drag coefficient, $A$ is the area of the object facing the fluid, and $\rho$ is the density of the fluid.

# Drag Force

**DRAG FORCE**

Drag force $F_D$ is proportional to the square of the speed of the object. Mathematically,

$$F_D = \frac{1}{2} C \rho A v^2,$$

where $C$ is the drag coefficient, $A$ is the area of the object facing the fluid, and $\rho$ is the density of the fluid.

## Rank the drag force on these specimens from highest (1) to lowest (7)

# Terminal Velocity

# Terminal Velocity

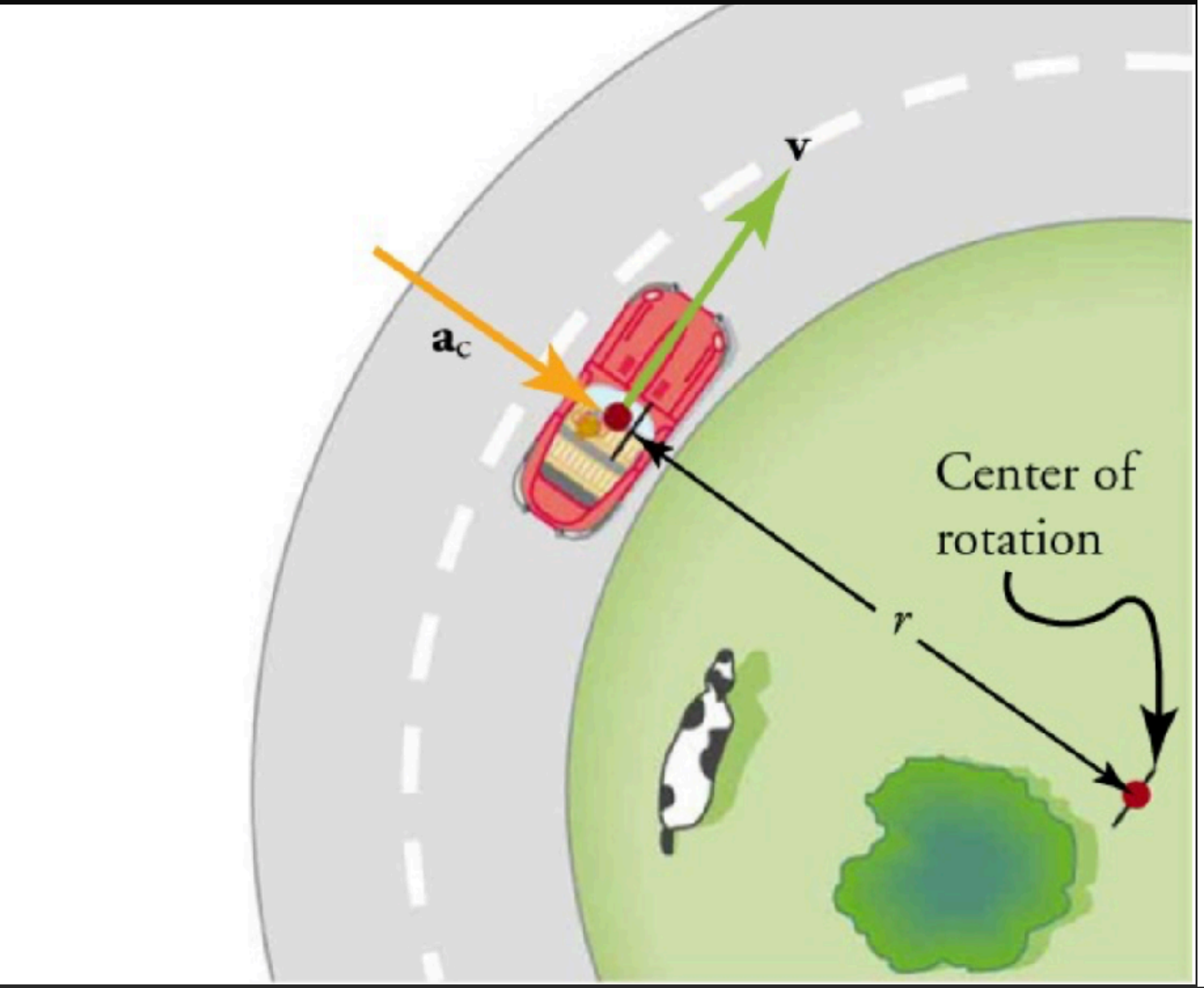
Parachute

# Key Equations

| | |
|---|---|
| Magnitude of static friction | $f_s \leq \mu_s N$ |
| Magnitude of kinetic friction | $f_k = \mu_k N$ |
| Centripetal force | $F_c = m\frac{v^2}{r}$ or $F_c = mr\omega^2$ |
| Ideal angle of a banked curve | $\tan\theta = \frac{v^2}{rg}$ |
| Drag force | $F_D = \frac{1}{2}C\rho A v^2$ |
| Stokes' law | $F_s = 6\pi r\eta v$ |

# Clicker Questions

# CQ.7.6




**A car follows a curve of radius $500\ \mathrm{m}$ at a speed of $25.0\ \mathrm{m/s}$ (about $90\ \mathrm{km/h}$). What is the magnitude of the car's centripetal acceleration? Compare the centripetal acceleration for this fairly gentle curve taken at highway speed with acceleration due to gravity $g$.**

a) The centripetal acceleration is $0.1\ \mathrm{m/s}$ and is $0.1$ times the acceleration due to gravity.

b) The centripetal acceleration is $1.25\ \mathrm{m/s^2}$ and is $0.1$ times the acceleration due to gravity.

c) The centripetal acceleration is $0.1\ \mathrm{m/s}$ and is $0.01$ times the acceleration due to gravity.

d) The centripetal acceleration is $1.25\ \mathrm{m/s^2}$ and is $0.01$ times the acceleration due to gravity.

A

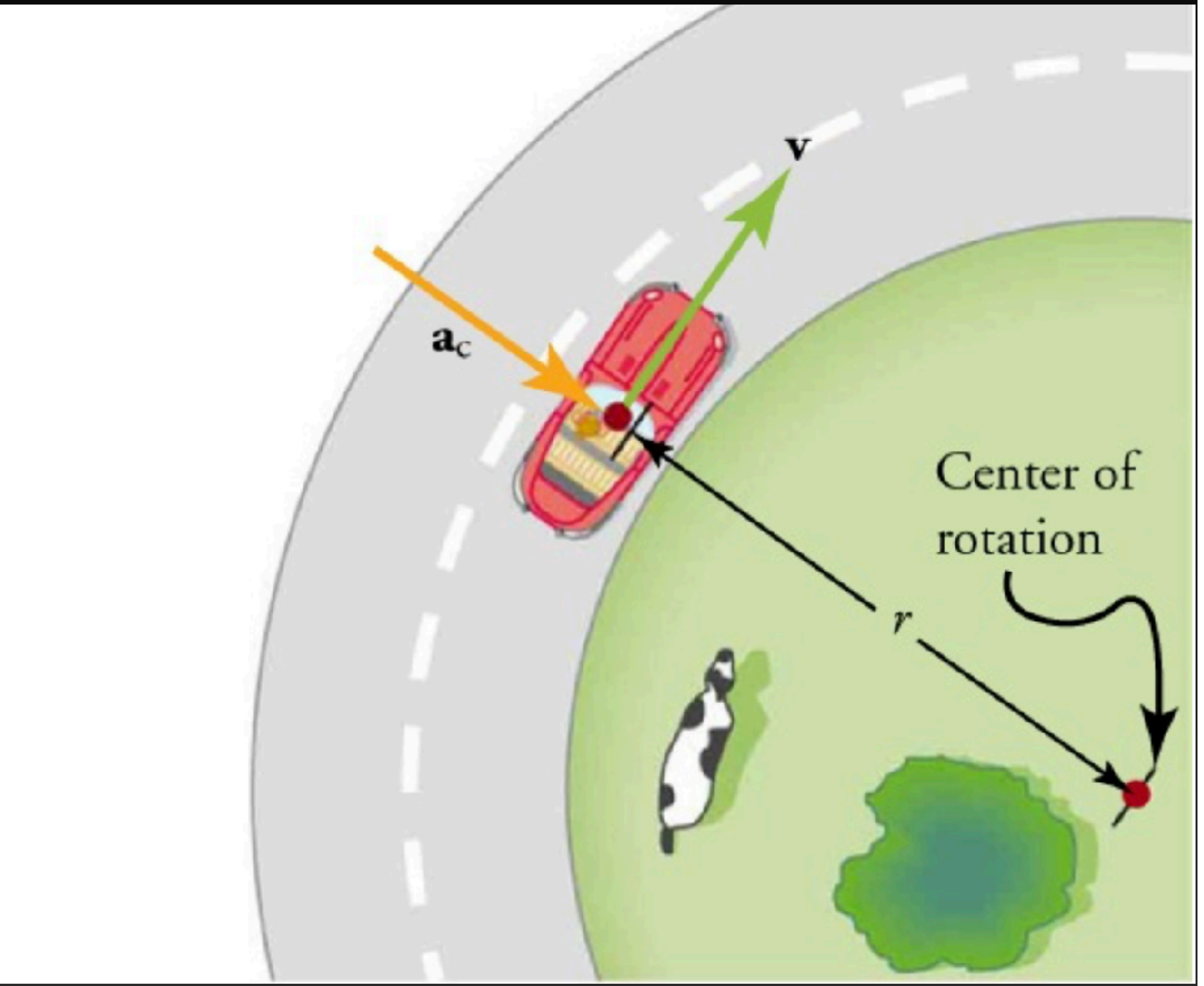
B

C

D

E

# CQ.7.6




**A car follows a curve of radius $500\ \mathrm{m}$ at a speed of $25.0\ \mathrm{m/s}$ (about $90\ \mathrm{km/h}$). What is the magnitude of the car's centripetal acceleration? Compare the centripetal acceleration for this fairly gentle curve taken at highway speed with acceleration due to gravity $g$.**

a) The centripetal acceleration is $0.1\ \mathrm{m/s}$ and is $0.1$ times the acceleration due to gravity.

The centripetal acceleration is $a_c = \frac{v^2}{r}$, where $v$ is tangential velocity and $r$ is the radius of curvature of th
circular path. It is incorrect that the centripetal acceleration is $a_c = \frac{v}{r}$.

✔ b) The centripetal acceleration is $1.25\ \mathrm{m/s^2}$ and is $0.1$ times the acceleration due to gravity.

The centripetal acceleration can be obtained by using the relation $a_c = \frac{v^2}{r}$, where $v$ is tangential velocity and $r$ is the radius of curvature of the circular path. Also, the comparison is done by taking the ratio of centripetal acceleration to the acceleration due to gravity.

c) The centripetal acceleration is $0.1\ \mathrm{m/s}$ and is $0.01$ times the acceleration due to gravity.

It is incorrect that $a_c = \frac{v}{r}$. The centripetal acceleration is $a_c = \frac{v^2}{r}$, where $v$ is tangential velocity and $r$ is t
radius of curvature of the circular path.

d) The centripetal acceleration is $1.25\ \mathrm{m/s^2}$ and is $0.01$ times the acceleration due to gravity.

It is correct that the centripetal acceleration is $a_c = \frac{v^2}{r}$, but you have compared the centripetal acceleratio
with the acceleration due to gravity incorrectly. The comparison is done by taking the ratio of centripetal acceleration to the acceleration due to gravity.

| A | B | C | D | E |
|---|---|---|---|---|
| | | | | |

# CQ.7.7

**Is an object in uniform circular motion accelerating? Why or why not?**

a) Yes, because the velocity is not constant.

b) No, because the velocity is not constant.

c) Yes, because the velocity is constant.

d) No, because the velocity is constant.

A

B

C

D

E

# CQ.7.7

**Is an object in uniform circular motion accelerating? Why or why not?**

✓ a) Yes, because the velocity is not constant.

b) No, because the velocity is not constant.

c) Yes, because the velocity is constant.

d) No, because the velocity is constant.

A B C D E

# CQ.7.8

**An object is in uniform circular motion. Suppose the centripetal force was removed. In which direction would the object now travel?**

a) in the direction of the centripetal force

b) in the direction opposite to the direction of the centripetal force

c) in the direction of the tangential velocity

d) in the direction opposite to the direction of the tangential velocity

A B C D E

# CQ.7.8

**An object is in uniform circular motion. Suppose the centripetal force was removed. In which direction would the object now travel?**

a) in the direction of the centripetal force

b) in the direction opposite to the direction of the centripetal force

✔ c) in the direction of the tangential velocity

d) in the direction opposite to the direction of the tangential velocity

A B C D E

# CQ.7.9

**A 50 kg bicyclist starts his ride down the road with an acceleration of $1 m/s^2$ in air with a density of $1.2 kg/m^3$. If his velocity at a given moment is $2 m/s$, how much force is he exerting? Assume the area of his body is $0.5 m^2$.**

a) The bicyclist is exerting 1.1 N of force.

b) The bicyclist is exerting 49 N of force.

c) The bicyclist is exerting 50 N of force.

d) The bicyclist is exerting 51 N of force.

A B C D E

# CQ.7.9

**A 50 kg bicyclist starts his ride down the road with an acceleration of $1 m/s^2$ in air with a density of $1.2 kg/m^3$. If his velocity at a given moment is 2m/s, how much force is he exerting? Assume the area of his body is $0.5m^2$.**

a) The bicyclist is exerting 1.1 N of force.

b) The bicyclist is exerting 49 N of force.

c) The bicyclist is exerting 50 N of force.

✓ d) The bicyclist is exerting 51 N of force.

**Detailed solution:** The $F_{NET}$ of the bicyclist is calculated as ma = 50 kg x 1 $m/s^2$ = 50 N. Since $F_{NET} = F_{CYC} - F_D$ we can solve the equation to find $F_{CYC}$. The drag force can be calculated using the equation $F_D = ½ C\rho Av^2$ where C = 0.9, $\rho$ = $1.2kg/m^3$, A = $0.5m^2$, and v = 2m/s. $F_D$ is calculated to be 1.08 N, so $F_{CYC}$ must be 51.08 N. Then, adjust for significant figures.

A B C D E

# CQ.7.10

**A 2.20 kg toy plane takes off with an acceleration of 3.30 m/s$^2$. The engine supplies a force of 8.15 N. Determine the magnitude of drag force acting on the plane as it accelerates.**

a) 7.26 N

b) 15.4 N

c) 0.89 N

d) 0.0 N

A

B

C

D

E

# CQ.2.1

**A 2.20 kg toy plane takes off with an acceleration of 3.30 m/s$^2$. The engine supplies a force of 8.15 N. Determine the magnitude of drag force acting on the plane as it accelerates.**

a) 7.26 N

b) 15.4 N

✔ c) 0.89 N

d) 0.0 N

**Detailed solution:** Without any drag force the airplane would accelerate at **3.7 m/s$^2$**. The drag force opposes a little bit of the force supplied by the motor. If you chose **15.4 N** you may have added a number that should have been subtracted. **7.26 N** is the net force acting on the plane. You'll need this to calculate the drag force.

A

B

C

D

E

# Activity:
# Worked Problems

# WP 7.3 - Rotor Ride: Friction & Centripetal Motion

# WP 7.3 - Rotor Ride: Friction & Centripetal Motion

# WP 7.3

See you next class!

# Attribution