Plan:

1. Talk about the test
2. Chapter 8 circular motion

An object moves in a straight line with a position given by the function $s(t) = B\,t^5$ where B is an unknown constant. At time t = 1 second the object is moving 0.60 m/s. What is the average speed of the object during the first 1 second of motion (from t = 0 seconds to t = 1 second)?

$$s = B\,t^5$$

$$v(t=1) = 0.60 \text{ m/s}$$

$$\text{find } v_{avg} = \frac{s(1) - s(0)}{1 - 0}$$

First find B:

$$v = \frac{ds}{dt} = \frac{d}{dt}\left(B\,t^5\right) = B\,\frac{d\,t^5}{dt}$$

$$0.6 = 5\,B\,t^4 = 5B(1)^4$$

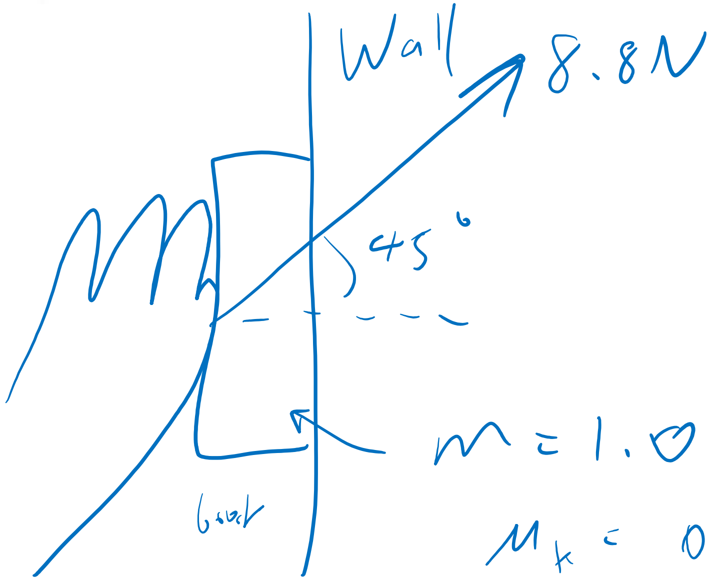
$$B = \frac{0.6}{5} = 0.12$$

$$s = 0.12\,t^5$$

$$v_{avg} = \frac{0.12(1)^5 - 0}{1 - 0}$$

$$\boxed{v_{avg} = 0.12 \text{ m/s}}$$

You push a 1.0 kg book into a wall. Your push has a force of 8.8 N at an angle of 45 degrees (up and toward the wall). The book starts at rest. The coefficients of friction between the book and the wall are $\mu_s = 0.60$ and $\mu_k = 0.40$. Find the acceleration of the book.



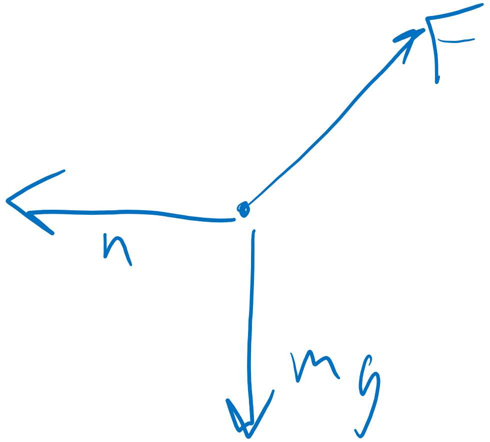
$m = 1.0$ kg

$\mu_k = 0.40$

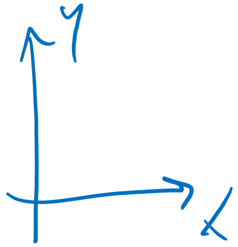
$\mu_s = 0.60$

FBD of book:

friction?



Define:



Let's find the unbalanced force when frictionless. f_s will oppose this.

$$\Sigma F_x = 0 = 8.8\cos 45^\circ - n$$

$$\Rightarrow n = 8.8\cos 45^\circ = 6.22254\text{ N}$$

$$\Sigma F_y = 8.8\sin 45^\circ - mg$$

$$= 6.22254 - 9.8(1.0) = -3.57746\text{ N}$$

↑ down.

So f_s must be up.

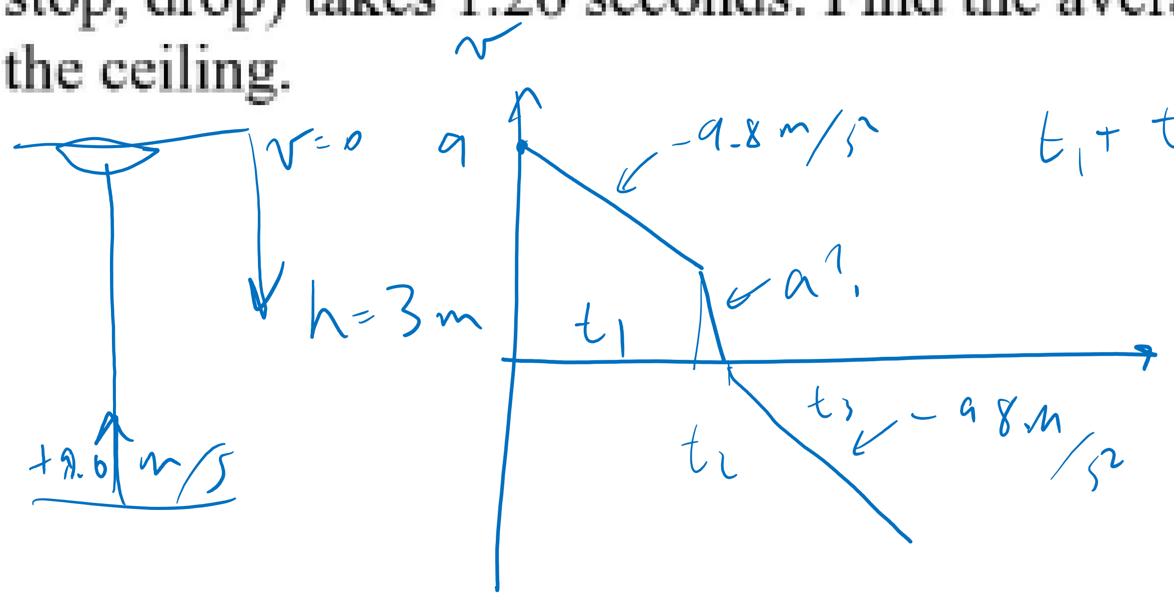
Needed: $f_s = +3.57746$ N to stop sliding.

$$f_{s\,max} = \mu_s n = 0.6(6.22254) = 3.7335\text{ N}$$

$f_s < f_{s\,max}$, so no sliding

$$\boxed{a = 0}$$

A pillow is thrown upward from the floor at a speed of 9.0 m/s. The pillow momentarily stops (it does not bounce) at the ceiling, 3.0 m above the floor, and then falls to the ground. The entire process (throw, stop, drop) takes 1.26 seconds. Find the average acceleration of the pillow while it was in contact with the ceiling.



$t_1 + t_2 + t_3 = 1.26\text{ s}$

$t_1 = \dfrac{3}{v_{avg}} = 0.43758\text{ s}$

On the way up:

$v_f^2 = v_i^2 - 2gh$

$v_f = \sqrt{9^2 - 2(9.8)3}$

$v_f = 4.71169\text{ m/s}$

$v_{avg} = \dfrac{v_i + v_f}{2} = \dfrac{9 + 4.71169}{2} = 6.85584$

On the way down: $v_{initial} = 0$

$t_3 = \sqrt{\dfrac{2h}{g}} = \sqrt{\dfrac{2 \times 3}{9.8}}$

$t_3 = 0.78246\text{ s}$

$t_2 = t_{tot} - t_1 - t_3 = 1.26 - 0.43758 - 0.78246$

$= 0.03996$

$a_{avg} = \dfrac{4.71169 - 0}{0.03996} = \boxed{118\text{ m/s}^2\text{, down}}$

Turn to your neighbour… 5 minutes to reflect.

- Were you surprised by anything that was on the test?
  - If so, what? And why did it surprise you?

- Did your aid sheet help you?
  - How can you make it better?

- When/how did you study?
  - Cramming, or slow and steady?
  - Reading and reviewing, or solving problems?

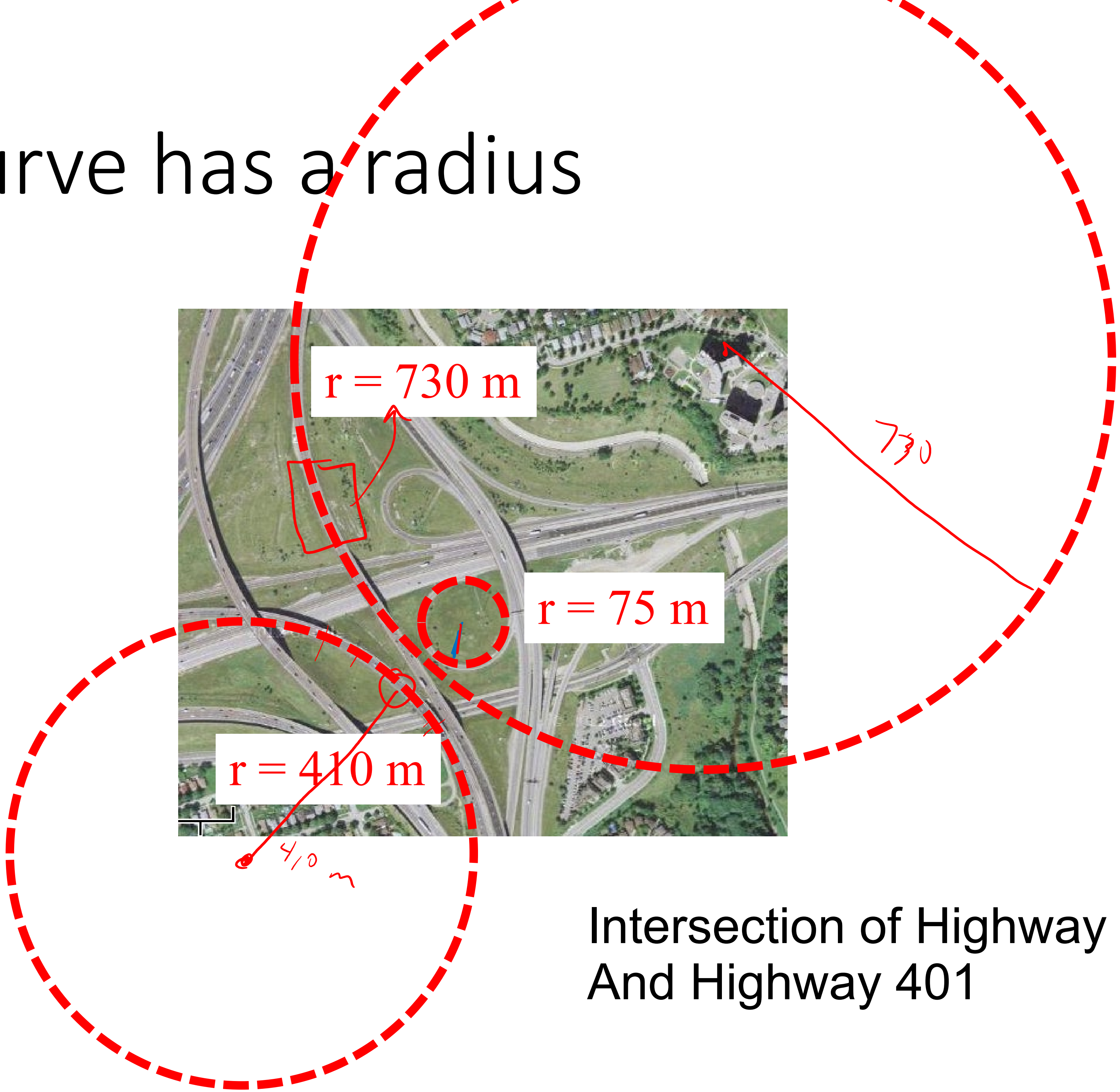
- What do your notes look like for this course?
  - Do you transcribe (take dictation) or summarize (reword)?
  - Do you take notes from the videos? The textbook? Classes?
  - When do you review your notes?

- Do you feel physics (or Prof. Wilson) is too hard?
  - Or do you feel that university is meant to be a challenge?
  - What is the point of learning to solve pillow throwing problems?

Chapter 8 – Dynamics in 2D

- Uniform/Nonuniform Circular Motion
- Centrifugal (fictitious) force (next class)

Every curve has a radius



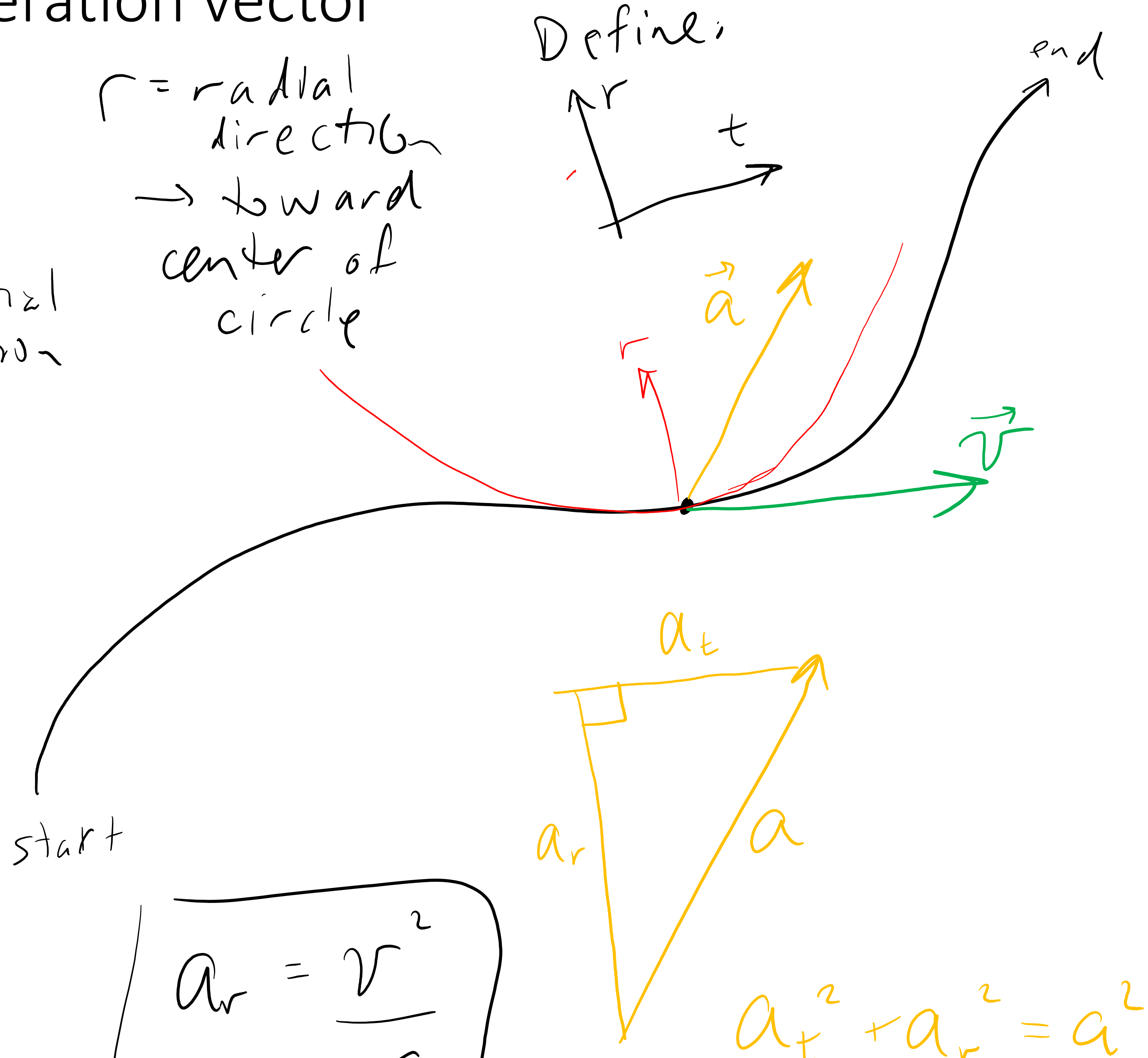
Intersection of Highway 427
And Highway 401

Analyzing the acceleration vector

- An object's acceleration can be decomposed into components parallel and perpendicular to the velocity.
- If you set the t-axis to be in the direction of $\vec{v}$, then:] tangential direction
- a_t is the component of the acceleration that causes the object to change **speed**
- a_r is the component of the acceleration that causes the object to change **direction**
- An object changing direction *always* has a component of acceleration perpendicular to the direction of motion.

r = radial direction → toward center of circle

Define:



$$a_t^2 + a_r^2 = a^2$$

$$\boxed{a_r = \frac{v^2}{r}}$$

a_t does not have an equation.

PROBLEM-SOLVING STRATEGY 8.1

Circular-motion problems

MODEL Model the object as a particle and make other simplifying assumptions.

VISUALIZE Draw a pictorial representation. Use *rtz*-coordinates.

- Establish a coordinate system with the r-axis pointing toward the center of the circle.
- Show important points in the motion on a sketch. Define symbols and identify what the problem is trying to find.
- Identify the forces and show them on a free-body diagram.

SOLVE Newton's second law is

$$(F_{net})_r = \sum F_r = ma_r = \frac{mv_t^2}{r} = m\omega^2 r$$

$$(F_{net})_t = \sum F_t = ma_t$$

$$(F_{net})_z = \sum F_z = 0$$

- Determine the force components from the free-body diagram. Be careful with signs.
- The tangential acceleration for uniform circular motion is $a_t = 0$.
- Solve for the acceleration, then use kinematics to find velocities and positions.

REVIEW Check that your result has the correct units and significant figures, is reasonable, and answers the question.

Exercise 11

$$\omega = \frac{v_t}{r}$$

$$\Rightarrow v_t = \omega r$$

ω is angular velocity in $\frac{rad}{s}$.

$$a_r = \frac{v_t^2}{r} = \frac{(\omega r)^2}{r} = \frac{\omega^2 r^{\cancel{2}}}{\cancel{r}}$$

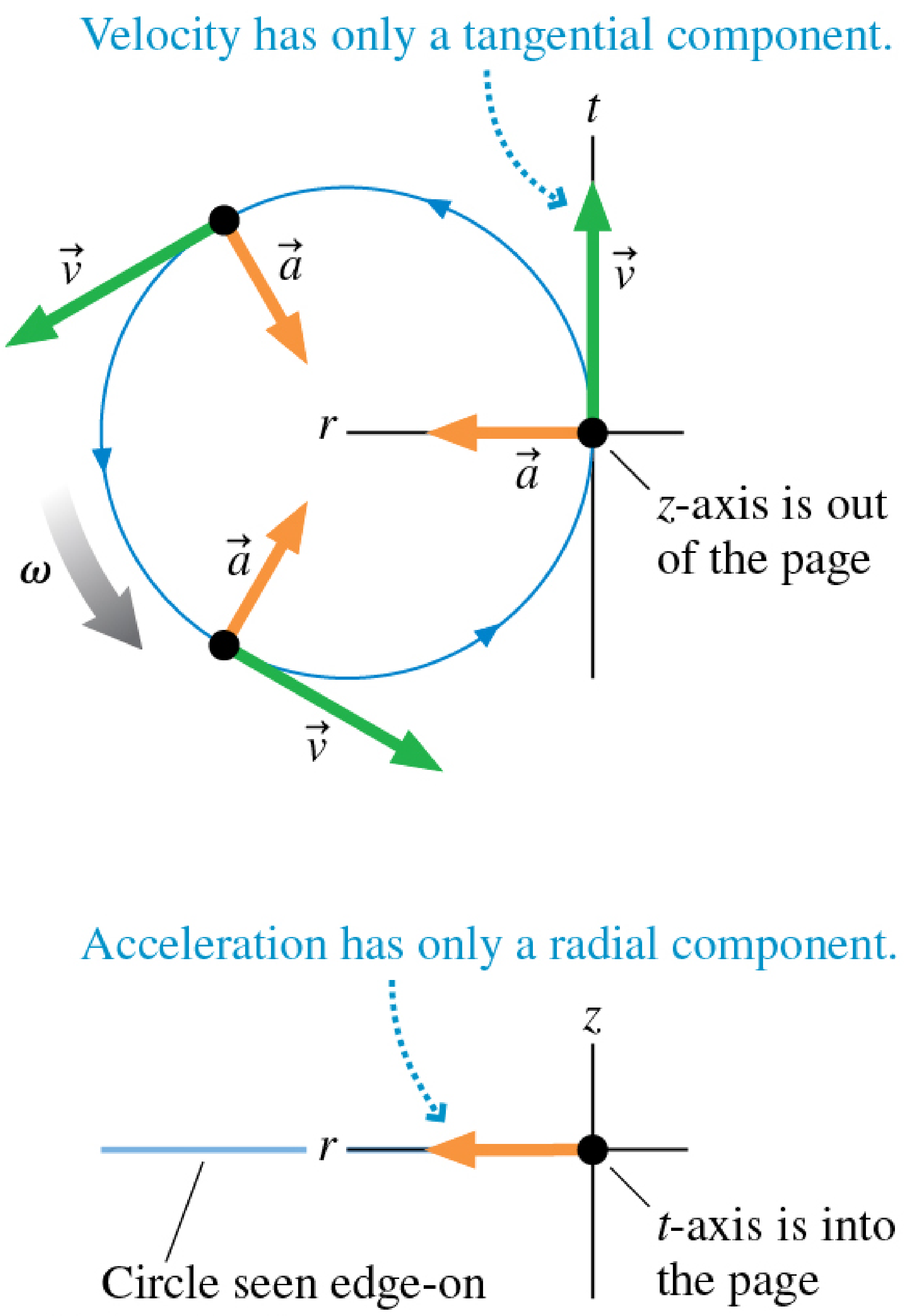
$$a_r = \omega^2 r$$

$$a_t = r\frac{d\omega}{dt}$$

Uniform Circular Motion:

Speed is **constant**.

How can something have a constant speed but be accelerating?



Team Up Oct.12: Circular Motion Ranking

STOP TO THINK 8.2 A block on a string spins in a horizontal circle on a frictionless table. Rank in order, from largest to smallest, the tensions T_A to T_E acting on blocks a to e.

Tension provides centripetal acceleration. $\boxed{a_r = \omega^2 r}$

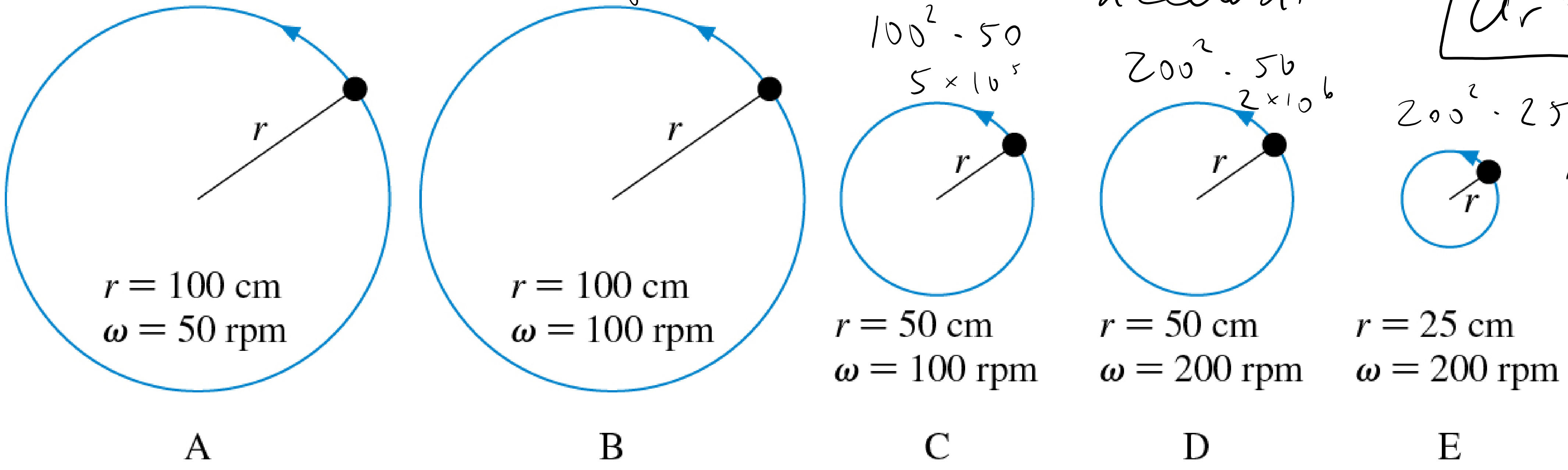
$50^2 \cdot 100$ 2.5×10^5

$100^2 \cdot 100$ 10^6

$100^2 \cdot 50$ 5×10^5

$200^2 \cdot 50$ 2×10^6

$200^2 \cdot 25$ 10^6

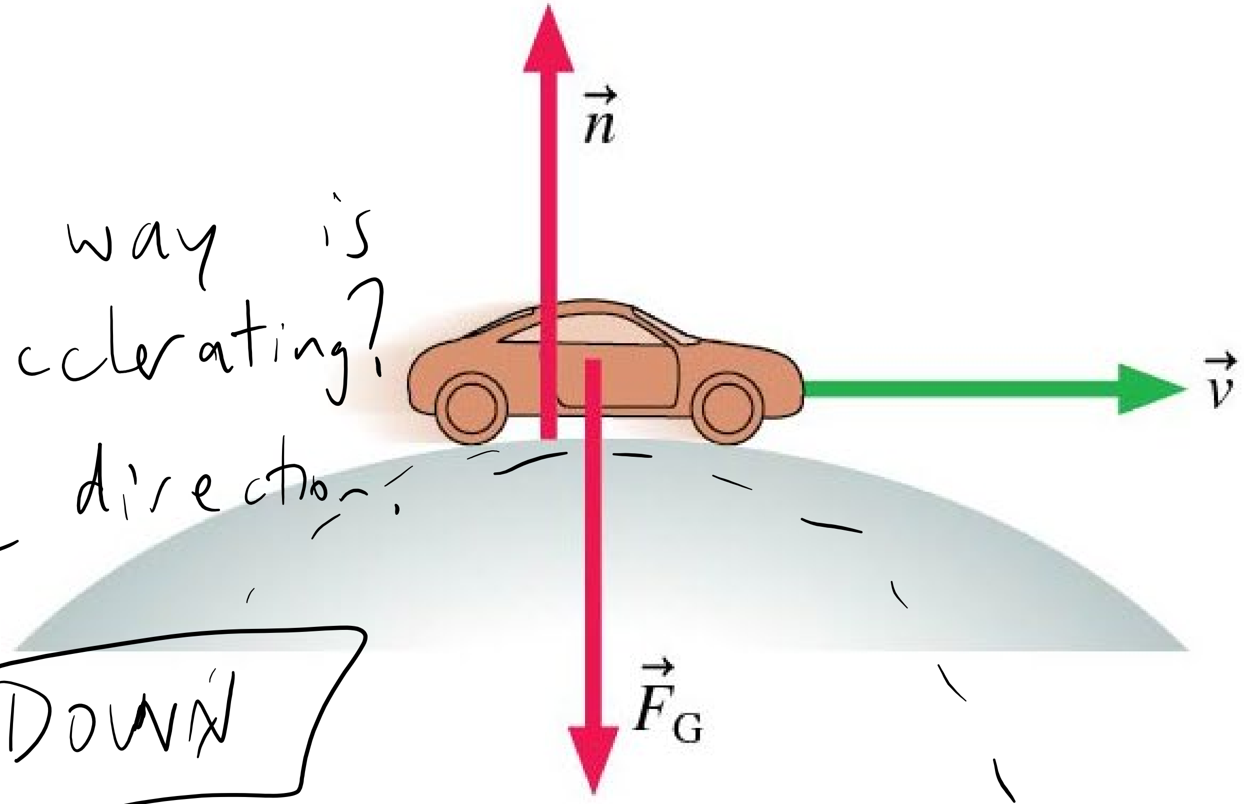


$T_D > T_B = T_E > T_C > T_A$?

Team Up Oct.12: Car on a hill

STOP TO THINK 8.3 An out-of-gas car is rolling over the top of a hill at speed *v*. At this instant,

a. $n > F_G$
b. $n < F_G$
c. $n = F_G$
d. We can't tell about *n* without knowing *v*.



Which way is car acclerating?

+r direction

Which way is that?

$\boxed{\text{DOWN}}$

Down is POSITIVE!

$$n = mg - \frac{mv^2}{r}$$

$$\sum F_r = \frac{mv^2}{r} = mg - n$$

Team Up Oct.12: Circular motion, string breaks!

STOP TO THINK 8.4 A ball on a string is swung in a vertical circle. The string happens to break when it is parallel to the ground and the ball is moving up. Which trajectory does the ball follow?