"The 8th Day Sun Song"

Homework Wk #4 Due Today 9/19/19

Homework Wk #5 Due Tuesday 9/24/19

Exam #1 Tuesday 9/24/19

Today's Topics

1. Rotational Motion
2. Centripetal Acceleration
3. Review

Figure: 8.1 audio example of circular motion

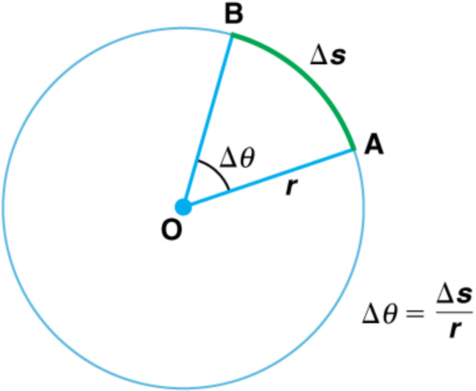

Figure: 8.2 full revolution: $v = 2\pi r/T$

Translational vs Rotational Motion

Translational Velocity

$$v = \frac{ds}{dt} \rightarrow \frac{\Delta s}{\Delta t}$$

Translational Acceleration

$$a = \frac{dv}{dt} \rightarrow \frac{\Delta v}{\Delta t}$$

Angular Velocity

$$\omega = \frac{d\theta}{dt} \rightarrow \frac{\Delta \theta}{\Delta t}$$

Angular Acceleration

$$\alpha = \frac{d\omega}{dt} \rightarrow \frac{\Delta \omega}{\Delta t}$$

A Geometric Derivation

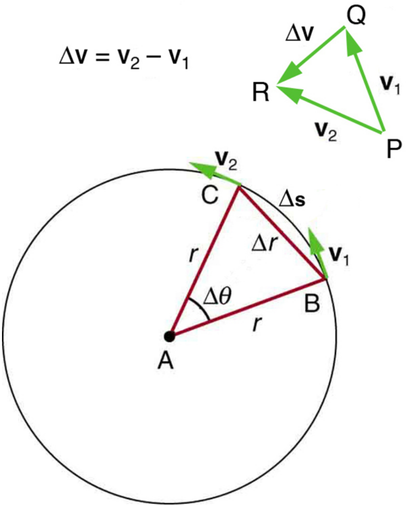

Figure: 8.3 Deriving centripetal acceleration from similar triangles

UCM Derivation

$$a \equiv \frac{\Delta v}{\Delta t}$$

$$\frac{\Delta v}{v} = \frac{\Delta r}{r}$$

$$\frac{\Delta v}{v} = \frac{\Delta s}{r}$$

$$\Delta s = r\Delta\theta$$

$$\Delta v = v\Delta\theta$$

$$a_c = \frac{v\Delta\theta}{\Delta t} = v\frac{\Delta\theta}{\Delta t}$$

Centripetal Acceleration

$$a_c = v\frac{\Delta\theta}{\Delta t}$$

$$\omega = \frac{\Delta\theta}{\Delta t}$$
$$v = r\omega$$

$$a_c = \frac{v^2}{r}$$

$$a_c = r^2\omega$$

Exercise #1

C&J 5.2.2 The following data for the speed and radius of three examples of uniform circular motion is given below. Find the magnitude of the centripetal acceleration for each example.

radius (m)	**speed (m/s)**
0.50	12
infinitely large	35
1.8	2.3

Exercise #2

C&J 5.2.7 The blade of a windshield wiper moves through an angle of $\pi/4\ rads$ in 0.40 s. The tip of the blade moves on the arc of a circle that has a radius of 0.45 m. What is the magnitude of the centripetal acceleration of the tip of the blade? How about the part of the blade halfway to the tip?

Laws of Motion Big Picture

1. **Changes in motion are caused by forces. No force, no change in velocity.**
2. **Net acceleration is directly caused by net force.**
3. **Forces arise from interactions. "It takes two to tango."**

Exercise #3

C&J 4.8.43 A car that has a mass $m = 1700\ kg$ is parked on a road that rises 15° above the horizontal. What are the magnitudes of

a. the normal force and

b. the static frictional force that the ground exerts on the tires?

C&J 4.8.57 A worker stands still on a roof sloped at an angle of 36° above the horizontal. He is prevented from slipping by a static frictional force of $390\ N$. Find the mass of the worker.

Relative Velocity

- Relative velocities allow us to compare measurements from different references.
- Technique applies to almost every physical vector quantity.
- Start with the version that makes most sense and rewrite as needed:

$$\mathbf{v}_{AG} = \mathbf{v}_{AB} + \mathbf{v}_{BG}.$$

$$\downarrow$$

$$\mathbf{v}_{AB} = \mathbf{v}_{AG} - \mathbf{v}_{BG}.$$

$$\mathbf{v}_{BG} = \mathbf{v}_{AG} - \mathbf{v}_{AB}.$$

2D Constant Acceleration

$$s(t) = s_o + v_o t + \frac{1}{2} a t^2$$

$$v(t) = v_o + at$$

$$v_f^2 = v_o^2 + 2a\Delta s$$

C&J 2.7.67 What is the average acceleration during each of the segments A, B, and C?

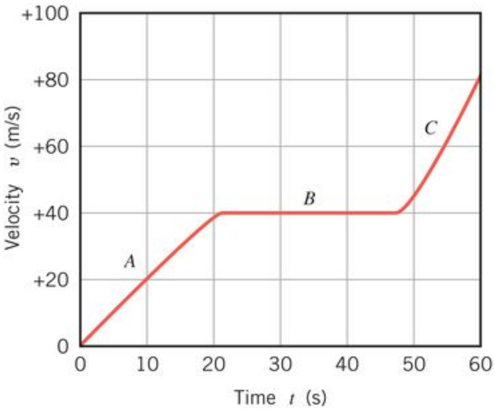

Figure: 3.8 Velocity vs Time for Non-Constant Acceleration

C&J 2.7.68 What is the average velocity (magnitude and direction) during each of the segments A, B, and C? Express your answers in km/h.

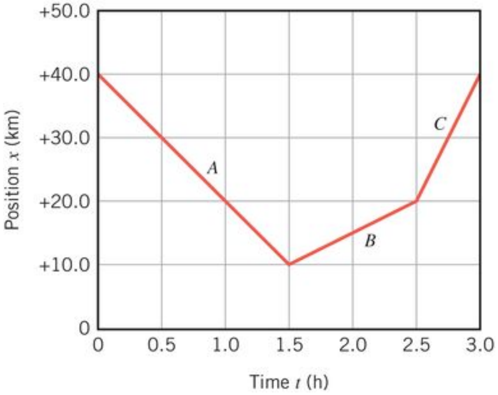

Figure: 3.10 Bus Trip Data for C&J 2.7.68

Exercise #7

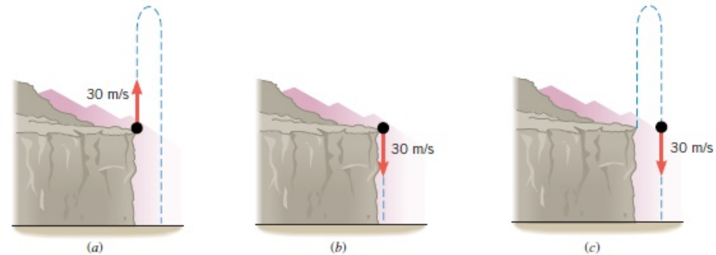

Figure: 3.5 Lauch anything straight up with a "slow" speed. $a_y = -g$

Exercise #8

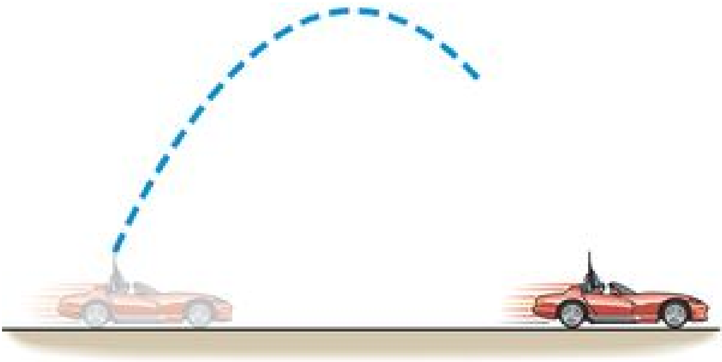

Figure: 3.5 Lauch & land at same height