

Concepts this Week

Relevant Lectures for Discussion:

- Relative and Uniform Circular Motion
 1. Reference frames and relative motion
 2. Uniform circular motion
- Newton's Laws
 1. More on centripetal acceleration
 2. Newton's Laws

Key concepts this week:

- Reference Frames & Relative Motion
 - $\vec{v}_{A,B} = \vec{v}_{A,C} + \vec{v}_{C,B}$
- Uniform Circular Motion
 - Centripetal acceleration
 - Angular velocity
- Newton's Laws
 - Inertial reference frames
 - Velocities (or, more generally, momenta) don't change spontaneously
 - $\vec{a} = \frac{\vec{F}_{\text{Net}}}{m}$
 - $\frac{d\vec{p}}{dt} = \vec{F}_{\text{Net}}$
 - Forces come in pairs of equal strength and opposite direction ($\vec{F}_{A \text{ on } B} = -\vec{F}_{B \text{ on } A}$)

Heading North

You are the navigator of an AA flight scheduled to fly from New Orleans due north to St. Louis, a distance of 673 miles. Your instruments tell you that there is a steady wind from the northwest with a speed of 105 mph. The pilot sets the air speed at 575 mph and asks you to find the estimated flying time. What do you tell her?

Against the Grain

You are on the west bank of a river which flows due south and want to swim to the east bank. You have told your friends to meet you on the east bank directly opposite your starting point. Before starting out you realize that, since the river is flowing swiftly at a speed of 12 ft/s and your fastest swimming speed in still water is only 5 ft/s, you will inevitably be carried downstream. Nevertheless, you want to minimize the effort expended by your friends in walking downstream to meet you. Your guide book to the region tells you that the width of the river is 300 ft. After a quick calculation, you call your friends on your cellular phone and tell them to start walking to a new meeting point. How far downstream of the original meeting point should you tell them to walk?

Review: Which Way Is Up?

Tilted Land is flat, much like central Illinois, but in Tilted Land gravity does not point straight down! It points down at an angle of 75 degrees with respect to the ground. (In central Illinois gravity points straight down at an angle of 90 degrees with respect to the ground.) This circumstance causes major changes in everyday life, but people manage. Suppose that a person in Tilted Land throws a ball straight up at 20 m/s. Where does the ball hit the ground?

HAL - 2001

A Hollywood producer has decided to film a remake of the movie **2001: A Space Odyssey**. You have been hired as a consultant for the movie to make sure the science is correct. The producer wanted to have an Illinois physics student for the job since HAL was invented in Urbana (January 12, 1997!). Part of the movie takes place on a space station very far from any gravitating body.

This space station is a large wheel-like structure where people live and work on the rim. In order to create “artificial gravity,” the space station rotates about its axis. It is desired that the gravity at a person’s feet should be equal to 0.85 times that of the Earth. Since centripetal acceleration depends on the distance to the axis of rotation, it is not possible for the “artificial gravity” to be the same at the head and the feet of a standing person (~1.8 m). In order to minimize any possible discomfort, suppose that the difference in the “artificial gravity” can only be 1%. The special effects department wants to know the diameter and the rate of rotation of a space station that meets these specifications.

Kinematics

$$\mathbf{v} = \mathbf{v}_0 + \mathbf{a}t$$

$$\mathbf{r} = \mathbf{r}_0 + \mathbf{v}_0t + \mathbf{a}t^2/2$$

$$v^2 = v_0^2 + 2a(x-x_0)$$

$$g = 9.81 \text{ m/s}^2 = 32.2 \text{ ft/s}^2$$

$$\mathbf{v}_{A,B} = \mathbf{v}_{A,C} + \mathbf{v}_{C,B}$$

Uniform Circular Motion

$$a = v^2/r = \omega^2r$$

$$v = \omega r$$

$$\omega = 2\pi/T = 2\pi f$$

Dynamics

$$\mathbf{F}_{\text{net}} = m\mathbf{a} = d\mathbf{p}/dt$$

$$\mathbf{F}_{A,B} = -\mathbf{F}_{B,A}$$

$$F = mg \text{ (near earth's surface)}$$

$$F_{12} = -Gm_1m_2/r^2 \text{ (in general)}$$

$$\text{(where } G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2\text{)}$$

$$\mathbf{F}_{\text{spring}} = -k \Delta \mathbf{x}$$