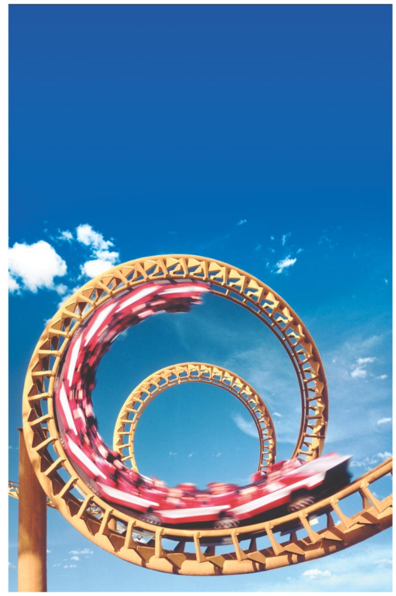
PHY131H1S - Class 13

Today:

• Dynamics in Two Dimensions
• Dynamics of Uniform Circular Motion
• Fictitious Forces



Pre-class Reading Quiz. (Chapter 8)

Last day I asked at the end of class:

- A ball is whirled on a string in a vertical circle. As it is going around, the tension in the string is

A. constant.

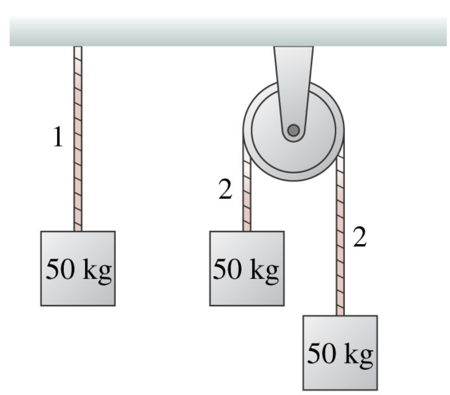
B. greatest at the top of the motion

C. greatest at the bottom of the motion

D. greatest somewhere in between the top and bottom.

ANSWER:

Chapter 7 Review Question.



Chapter 8

Dynamics in Two Dimensions

Suppose the x- and y-components of acceleration are *independent* of each other. That is, a_x does not depend on y or v_y, and a_y does not depend on x or v_x.
You can then use Newton's second law in component form:

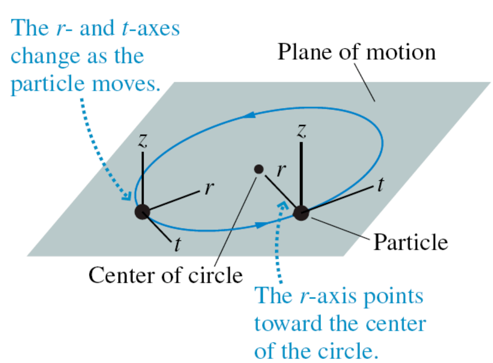
The force components (including proper signs) are found from the free-body diagram. The kinematics equations apply to the x and y components, ie:

$$x_f = x_i + v_{ix}\Delta t + \tfrac{1}{2}a_x(\Delta t)^2 \qquad y_f = y_i + v_{iy}\Delta t + \tfrac{1}{2}a_y(\Delta t)^2$$

$$v_{fx} = v_{ix} + a_x\Delta t \qquad v_{fy} = v_{iy} + a_y\Delta t$$

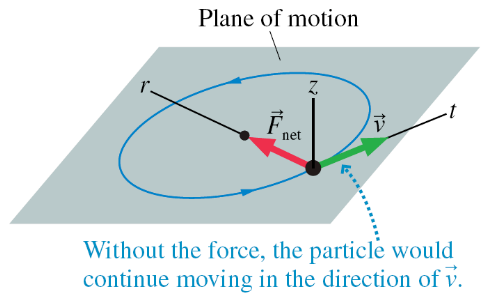
Uniform Circular Motion

FIGURE 8.3 The *rtz*-coordinate system.



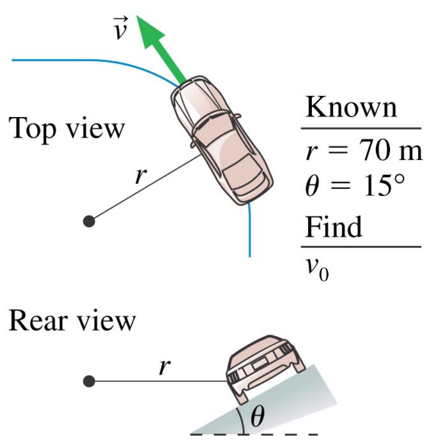
Dynamics of Uniform Circular Motion

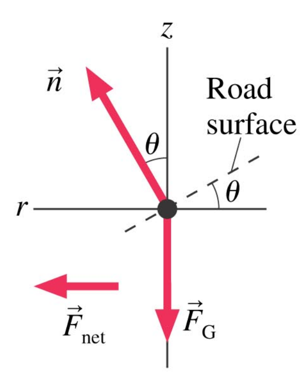
FIGURE 8.6 The net force points in the radial direction, toward the center of the circle.



Example 8.5, pg.217

- A highway curve of radius 70 m is banked at a 15° angle. At what speed v_0 can a car take this curve without assistance from friction?





A car is rolling over the top of a hill at speed *v*. At this instant,

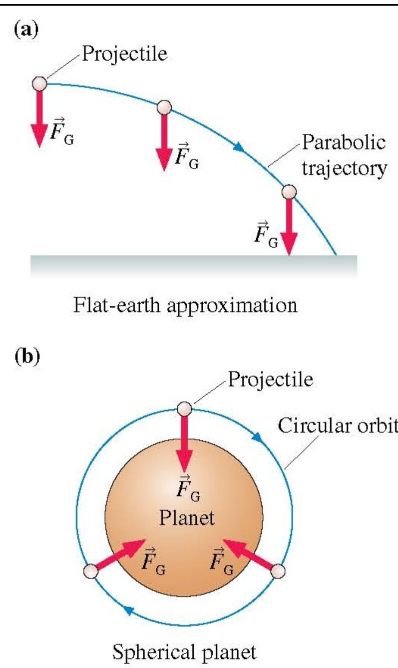
A car is driving at the bottom of a valley at speed *v*. At this instant,

Projectile Motion

In the absence of air resistance, a projectile has only one force acting on it: the gravitational force, $F_G = mg$, in the downward direction. If we choose a coordinate system with a vertical y-axis, then

$$\vec{F}_G = -mg\hat{j}$$

The vertical motion is free fall, while the horizontal motion is one of constant velocity.



Circular Orbits

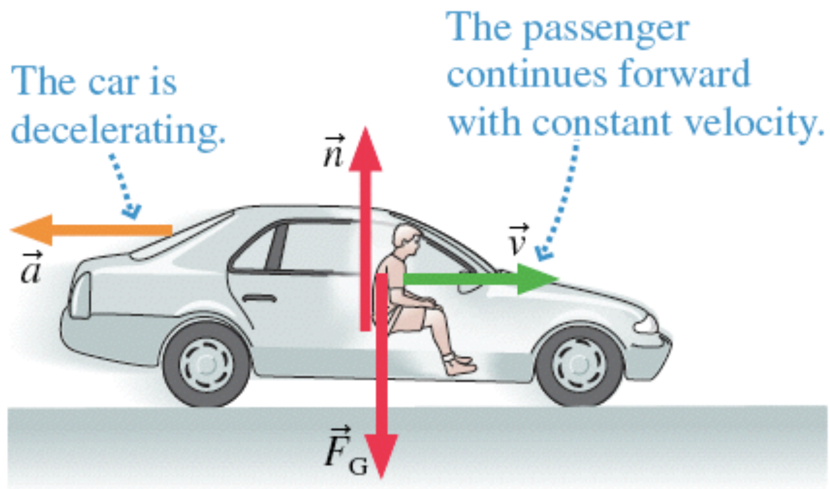
An object moving in a circular orbit of radius *r* at speed v_{orbit} will have centripetal acceleration of

That is, if an object moves parallel to the surface with the speed

then the free-fall acceleration provides exactly the centripetal acceleration needed for a circular orbit of radius *r*. An object with any other speed will not follow a circular orbit.

Fictitious Forces

- If you are riding in a car that makes a sudden stop, you may feel as if a force "throws" you forward toward the windshield.
- There really is
- Nonetheless, the fact that you seem to be hurled forward relative to the car is a very real experience!
- You can describe your experience in terms of what are called **fictitious forces**.
- These are not real forces because no agent is exerting them, but they describe your motion



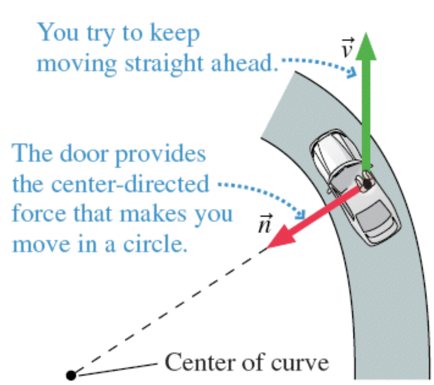
Inertial reference frame of the ground

"Centrifugal Force" (a fictitious force)

•If the car you are in turns a corner quickly, you feel "thrown" against the door.
•The "force" that seems to push an object to the outside of a circle is called the

•It describes your experience *relative to a noninertial reference frame*, but

FIGURE 8.15 Bird's-eye view of a passenger as a car turns a corner.



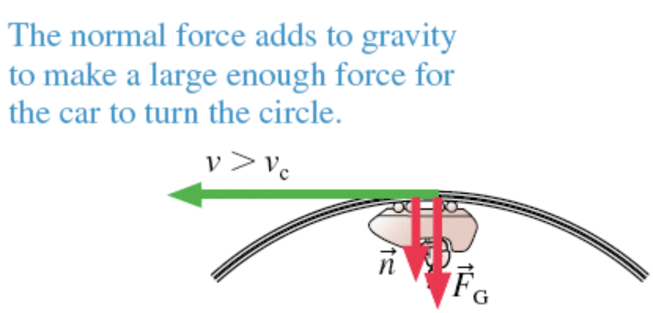
Why Does the Water Stay in my coffee cup?

• Watch Harlow swing a cup of water over his head. If he swings the cup quickly, the water stays in. But the students in the front row will get a shower if he swings too slowly.

•The critical angular velocity ω_c is that at which gravity alone is sufficient to cause circular motion at the top.

More than enough angular speed

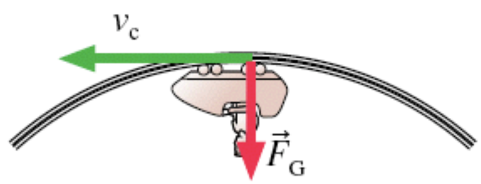
FIGURE 8.18 A roller coaster car at the top of the loop.



The point is: Normal force

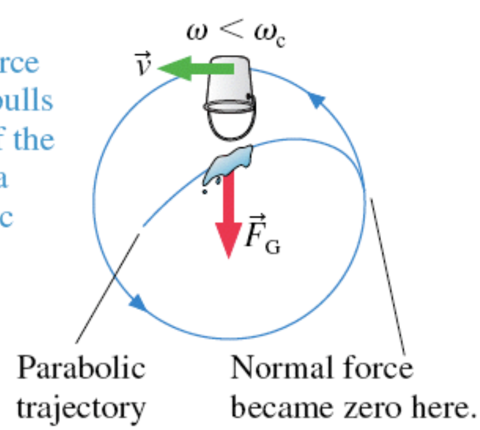
Just enough angular speed

At v_c, gravity alone is enough force for the car to turn the circle. $\vec{n} = \vec{0}$ at the top point.



Not enough angular speed

If $\omega < \omega_c$, the gravitational force is too large. It pulls the water out of the circle and into a tighter parabolic trajectory.



Before Class 14 on Wednesday

- Please read the Knight **Part II Overview**, and **Chapter 9**
- Something to think about:
- Consider a car accident in which a car, initially traveling at 50 km/hr, collides with a large, massive bridge support.
- The car comes to an abrupt stop, and so does its only occupant, the driver (who is intoxicated).
- The airbag inflates, saving the driver.
- Why is the force of the hard plastic steering wheel worse than the force of the airbag in stopping the driver?