This Week

Edition 8	Edition 7
3:10	3:11
3:33	3:27
3:63	3:57
4:17	4:15
4:16	n/a

Tutorial and Test 2

Need to know all of chapter 3 and up to and including sect 4.5 (Newton's 3rd law): average velocity, average acceleration, displacement, the four equations of kinematics, relative motion, Newton's laws of motion.

WileyPLUS Assignment 2

Due Monday, October 19 at 11:00 pm

Chapters 4 & 5

WileyPLUS Assignment 1

Marks are up on the web

Only 412 out of ~470 have valid U of M student IDs!

Make sure WileyPLUS has your U of M student ID if you want to be sure to get any credit!

Go to Profile and add U of M student number

Only the central 7 digits - example: 7654321
- what you enter on exam bubble sheets

NOT the 22212... at the beginning or the trailing digit at the end

Scientific Notation for WileyPLUS

Enter 2.1×10^{20} as 2.1E20

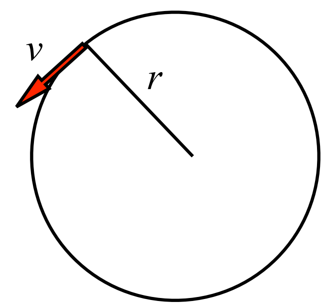
Chapter 5: Uniform Circular Motion

- Motion at constant speed in a circle
- Centripetal acceleration
- Banked curves
- Orbital motion
- Weightlessness, artificial gravity
- Vertical circular motion

Uniform Circular Motion

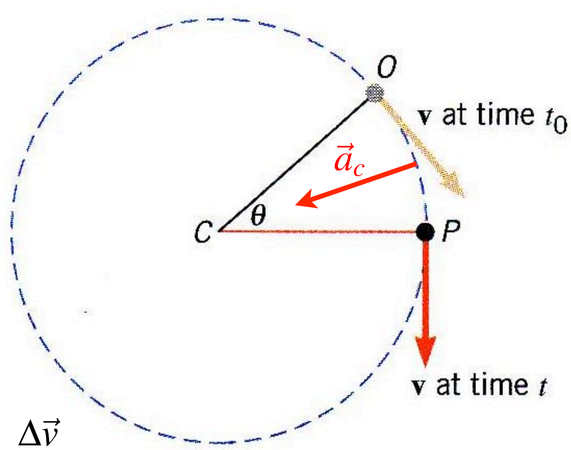
- An object is travelling at constant speed in a circular path.
- The velocity is changing because the direction of the speed is changing and so **the object is accelerated**.
- The period, T, of the motion is the time to go once around the circle.
- For an object travelling at speed v around a circle of radius r –

$$T = \frac{\text{circumference}}{\text{speed}} = \frac{2\pi r}{v}$$



Centripetal Acceleration

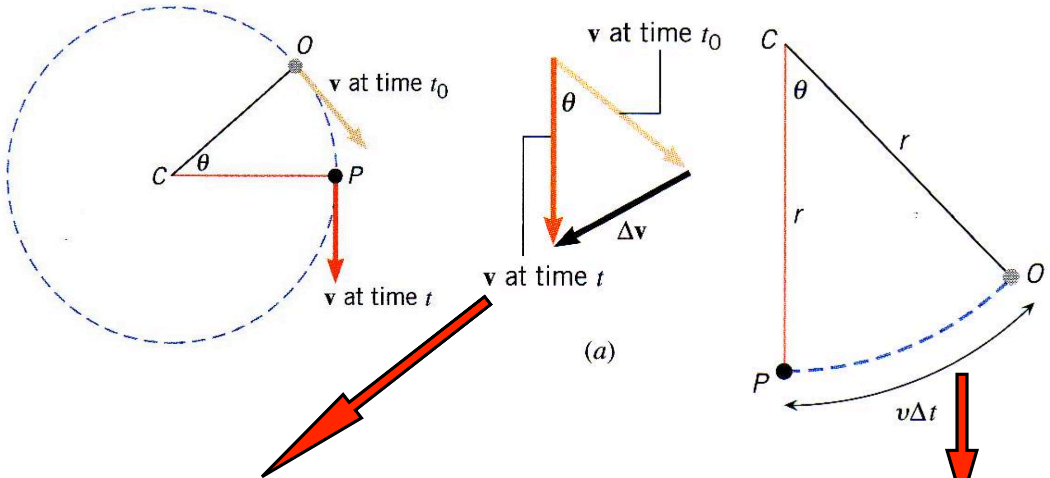
The object is accelerated toward the centre of the circle – this is the centripetal acceleration.



$$\text{Centripetal acceleration, } \vec{a}_c = \frac{\Delta\vec{v}}{\Delta t}$$

Work out the change in velocity in a short time interval...

Centripetal Acceleration



$$\frac{\Delta v}{v} = \theta \text{ radians, if time interval } \Delta t \text{ is short}$$

Object travels $v\Delta t$ in time Δt

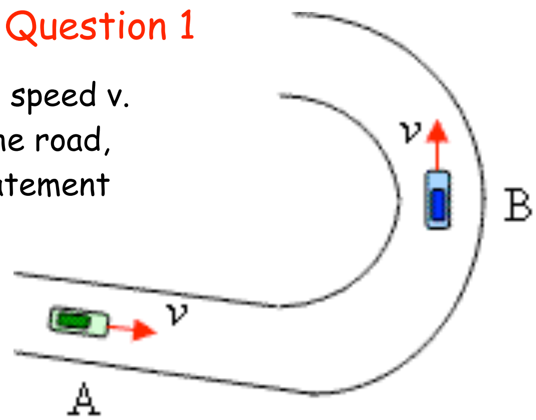
$$\frac{v\Delta t}{r} = \theta \text{ radians}$$

$$\text{So, } \theta = \frac{\Delta v}{v} = \frac{v\Delta t}{r} \qquad a_c = \frac{\Delta v}{\Delta t} = \frac{v^2}{r} = \text{centripetal acceleration}$$

toward centre of circle

Clicker Question: Focus on Concepts, Question 1

Two cars are travelling at the same constant speed v. Car A is moving along a straight section of the road, while B is rounding a circular turn. Which statement is true about the acceleration of the cars?



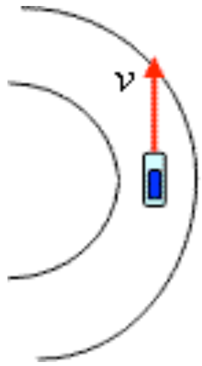
A) The acceleration of both cars is zero, since they are travelling at a constant speed.
B) Car A is accelerating, but car B is not accelerating.
C) Car A is not accelerating, but car B is accelerating.
D) Both cars are accelerating.

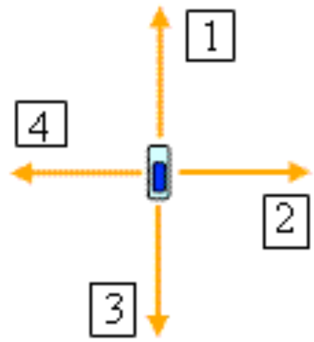
C) Car A has zero acceleration, car B is accelerated toward the centre of the curve

Clicker Question: Focus on Concepts, Question 2

The car in the left drawing is moving counterclockwise with a constant speed v around a circular section of the road. The drawing at the right shows the car and four possible directions for the centripetal acceleration that it experiences. Which one (if any) depicts the correct direction for the centripetal acceleration?

A) 4
B) 2
C) 3
D) 1





A) The car is accelerated toward the centre of the curve

A car is driven at a constant speed of 34 m/s (122 km/h).

What is the centripetal acceleration in the two turns?

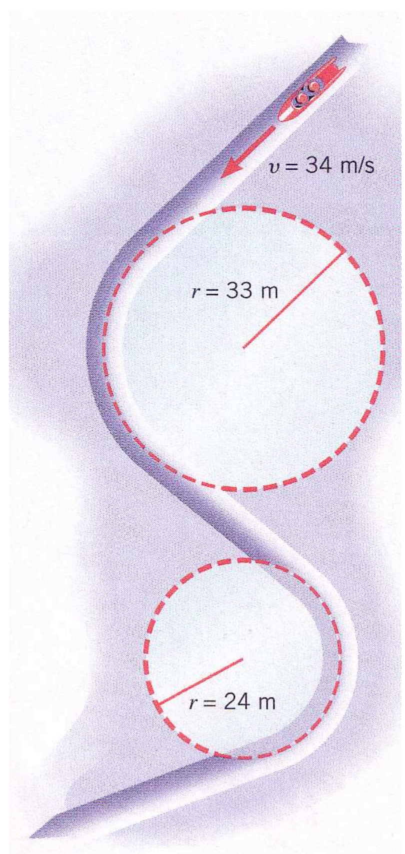
First turn: $r = 33$ m

$$\text{Centripetal acceleration, } a_c = \frac{v^2}{r} = \frac{34^2}{33}$$

$$a_c = 35.0 \text{ m/s}^2 = 3.6 \times g = 3.6g$$

Second turn, $r = 24$ m

$$a_c = \frac{34^2}{24} = 48.2 \text{ m/s}^2 = 4.9g$$



5.8/7: Lettuce drier: spin a container containing the lettuce, water is forced out through holes in the sides of the container.

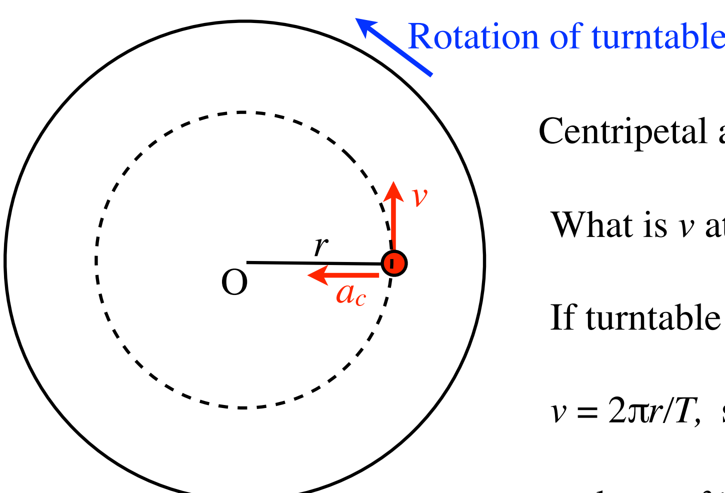
Radius = 12 cm, rotated at 2 revolutions/second. What is the centripetal acceleration of the wall of the container?

Centripetal acceleration, $a_c = \frac{v^2}{r}$ What is v?

$$v = 2 \times 2\pi r \text{ m/s } = 1.51 \text{ m/s}$$

$$a_c = \frac{1.51^2}{0.12} = 18.9 \text{ m/s}^2 = 1.9g$$

A penny is placed on a rotating turntable. Where on the turntable does the penny require the largest centripetal force to remain in place? Centripetal force is supplied by friction between the penny and the turntable.



$$F_c = \frac{mv^2}{r} = ma_c$$

Centripetal acceleration, $a_c = \frac{v^2}{r}$

What is v at radius r?

If turntable rotates once in T seconds

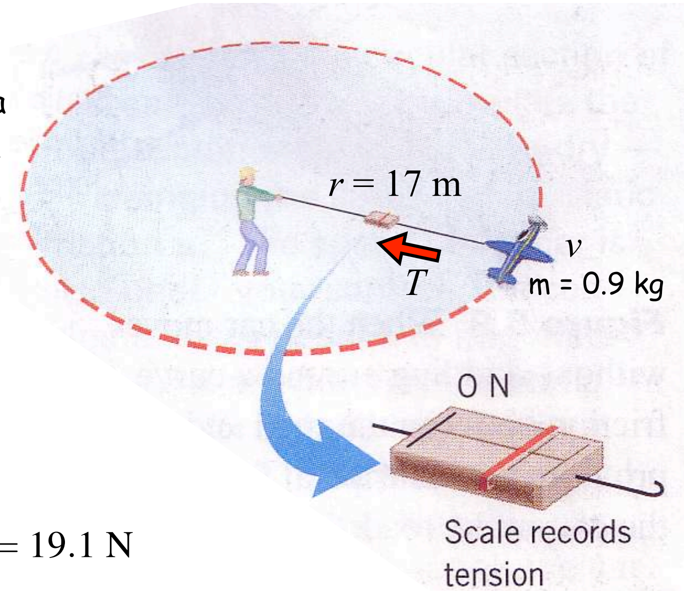
$v = 2\pi r/T$, so $v \propto r$

and $a_c = v^2/r \propto r^2/r = r$

The greatest centripetal acceleration is at the outer edge of the turntable

A 0.9 kg model airplane moves at constant speed in a circle parallel to the ground.

Find the tension in the guideline if r = 17 m and
a) v = 19 m/s and
b) v = 38 m/s.



a) Speed = 19 m/s,

$$T = F_c = \frac{mv^2}{r} = \frac{0.9 \times 19^2}{17} = 19.1 \text{ N}$$

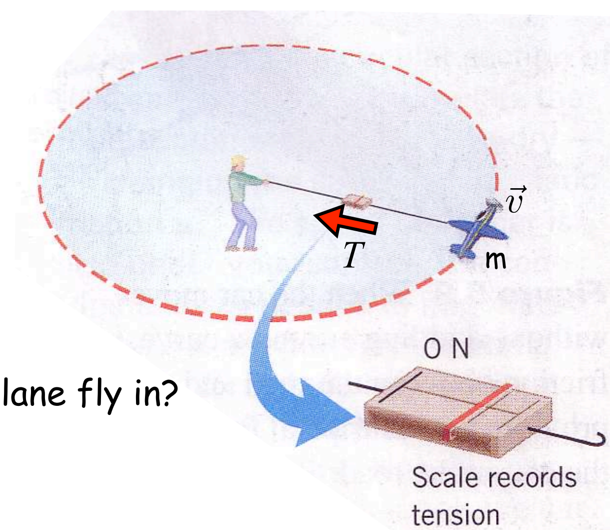
b) Speed = 38 m/s,

$$T = F_c = \frac{mv^2}{r} = \frac{0.9 \times 38^2}{17} = 76.4 \text{ N}$$

A 0.6 kg and a 1.2 kg airplane fly at the same speed using the same type of guideline.

The smallest circle the 0.6 kg plane can fly in without the line breaking is 3.5 m

How small a circle can the 1.2 kg plane fly in?

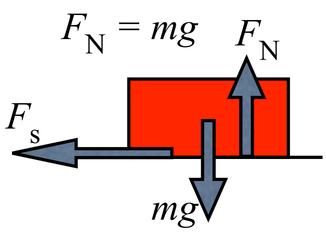


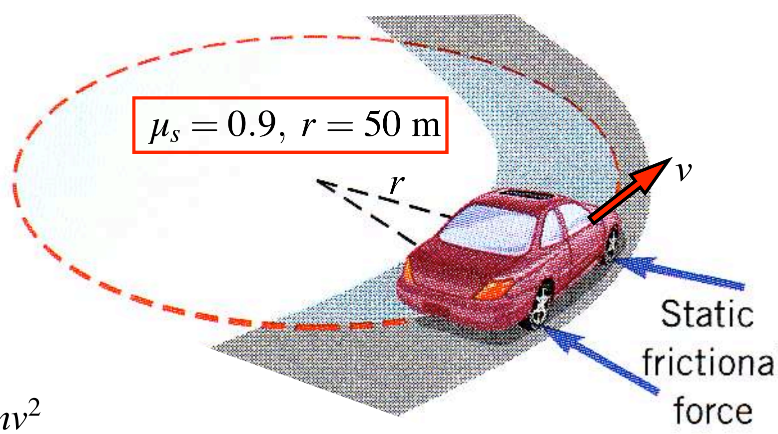
5.-/19: A rigid massless rod is rotated about one end in a horizontal circle. There is a mass m_1 attached to the centre of the rod and a mass m_2 attached to the end. The inner section of the rod sustains 3 times the tension as the outer section. Find m_2/m_1.

How fast can you go around a curve?

Forces on the car:
(velocity into screen)

$F_N = mg$





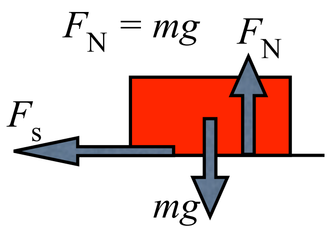
Centripetal force $= \dfrac{mv^2}{r}$

Provided by static friction force, $F_s = \mu_s F_N = \mu_s mg$

So, $\dfrac{mv^2}{r} = \mu_s mg \ \rightarrow v = \sqrt{\mu_s rg} \ = \sqrt{0.9 \times 50 \times 9.8} = 21$ m/s (76 km/h)

On ice $\mu_s = 0.1 \rightarrow v = 7$ m/s (25 km/h)

5.16/14: Car A uses tires with coefficient of static friction 1.1 with the road on an unbanked curve. The maximum speed at which car A can go around this curve is 25 m/s. Car B has tires with friction coefficient 0.85. What is the maximum speed at which car B can negotiate the curve?



A: $\mu_s = 1.1$, $v_A = 25$ m/s
B: $\mu_s = 0.85$, $v_B = ?$

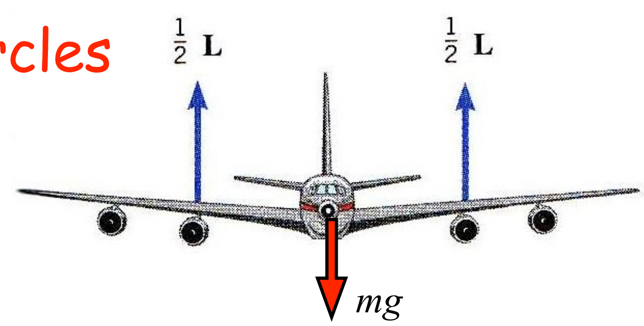
From previous page, $v = \sqrt{\mu_s r g}$, proportional to $\sqrt{\mu_s}$

$$\text{Therefore, } \frac{v_B}{v_A} = \sqrt{\frac{0.85}{1.1}} = 0.879$$

$$\text{so, } v_B = 0.879 \times 25 = 22 \text{ m/s}$$

Flying around in circles

Lift: L/2 + L/2 = mg



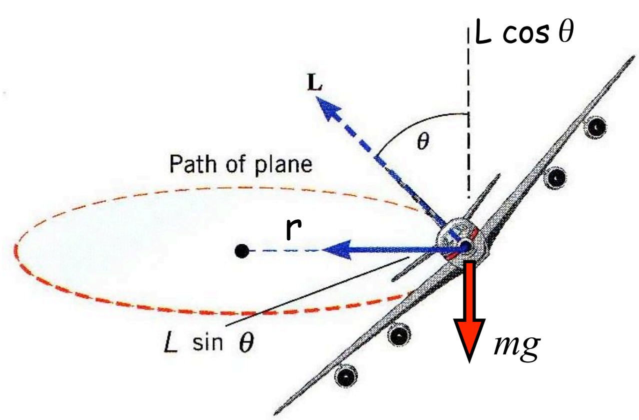
Plane banking to turn in a horizontal circular path of radius r:

$$L \sin\theta = \frac{mv^2}{r}$$ Centripetal force

$$L\cos\theta = mg$$

$$\tan\theta = \frac{v^2}{rg}$$

→ angle of banking needed to make the turn without gaining or losing height



$$\tan\theta = \frac{v^2}{rg}$$ → angle of banking needed to make the turn without gaining or losing height

Example: v = 100 m/s (360 km/h), r = 3,000 m

$a_c = v^2/r$ = 3.33 m/s^2

$\tan\theta = a_c/g = 0.340$, → $\theta = 19^0$

5.28/25: A jet (m = 200,000 kg), flying at 123 m/s, banks to make a horizontal turn of radius 3810 m. Calculate the necessary lifting force.

$$L\sin\theta = \frac{mv^2}{r}$$

from previous slide

$$L\cos\theta = mg$$