Mastering Physics Assignment 2

Is available on Mastering Physics website

Seven practice problems + six for credit on material from chapter 3

Due Wednesday, October 10 at 11 pm
Penalty of 25% per day late
Assignment available for practice until end of year

On Campus Machines
Use Firefox if problems with Internet Explorer!

GENERAL PHYSICS I: PHYS 10

Schedule - Fall 2007
(lecture schedule is approximate)

	W	3	12	Chapter 5	Uniform circular motion	(chapters 1, 2, 3)
	F	5	13			
6	M	8	Thanksgiving Day			Experiment 2: Measurement of g by free fall
	W	10	14	Chapter 5	Uniform circular motion	
	F	12	15	Chapter 6	Work and energy	
7	M	15	16			Tutorial and Test 2 (chapters 4, 5)
	W	17	17			
	F	19	18	Chapter 7	Impulse and momentum	
8	M	22	19			No lab or tutorial
	Tue	23	MID-TERM TEST, Ch 1-5, Tuesday, October 23, 7-9 pm			
	W	24	20	Chapter 7	Impulse and momentum	
	F	26	21	Chapter 8,		

Experiment 2: Measurement of g by free fall
Week of October 15: Tutorial and test 2: ch. 4, 5
Tuesday, October 23, 7-9 pm, midterm: ch. 1-5

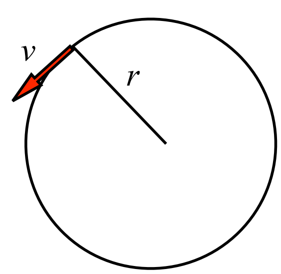
Chapter 5: Uniform Circular Motion

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

Uniform Circular Motion

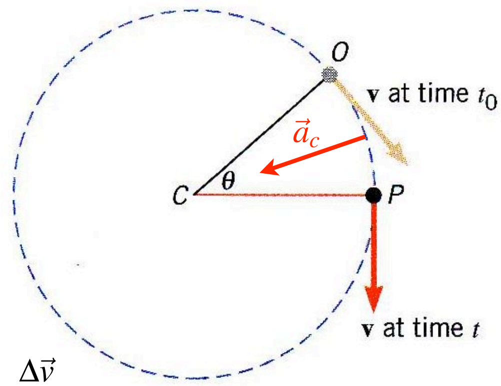
- An object is travelling at constant speed in a circular path.
- The velocity is changing because the direction of the speed is changing and so **the object is accelerated**.
- The period, T, of the motion is the time to go once around the circle.
- For an object travelling at speed v around a circle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

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



Centripetal Acceleration

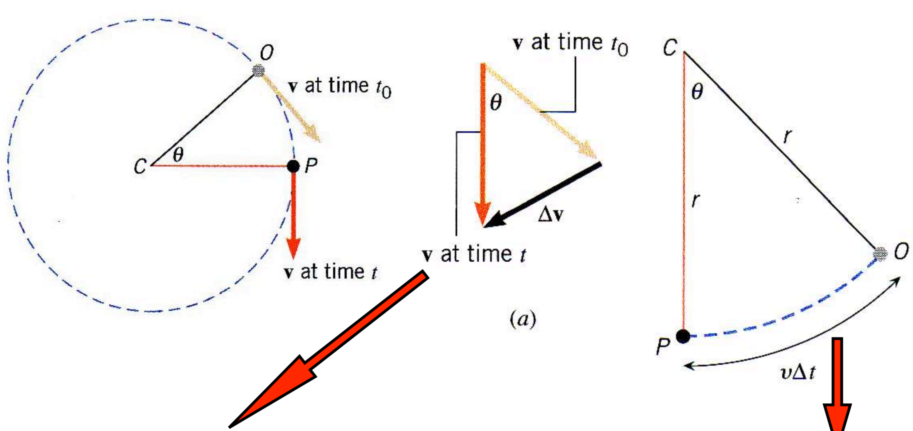
The object is accelerated toward the centre of the circle – this is the centripetal acceleration.



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

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

Centripetal Acceleration



$\dfrac{\Delta v}{v} = \theta$ radians, if time interval Δt is short

Object travels $v\Delta t$ in time Δt

$\dfrac{v\Delta t}{r} = \theta$ radians

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

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

What is the centripetal acceleration in the two turns?

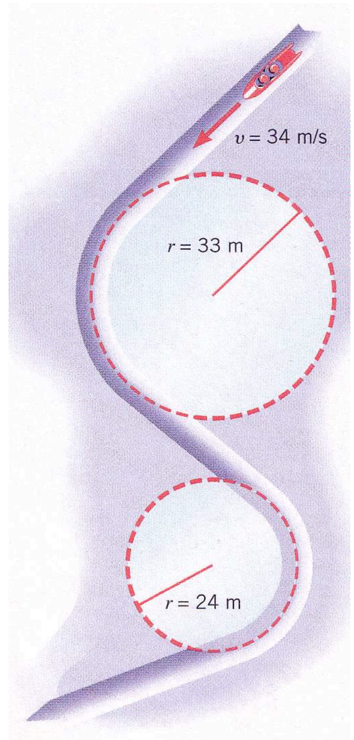
First turn: $r = 33$ m

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

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

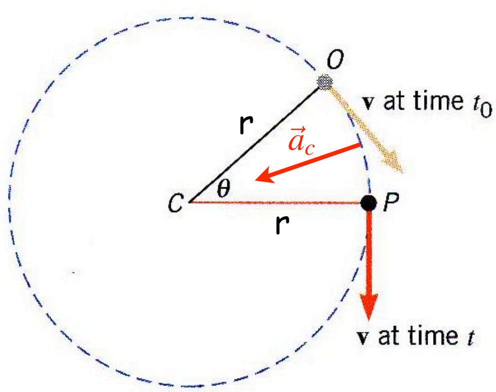
Second turn, $r = 24$ m

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



Centripetal acceleration, from last time:

For motion at speed v in a circular path of radius r:



$$\text{Centripetal acceleration, } \vec{a}_c = \frac{\Delta \vec{v}}{\Delta t} \text{ and } a_c = \frac{v^2}{r}$$

5.7/6: 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, $a_c = \dfrac{v^2}{r}$ What is v?

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

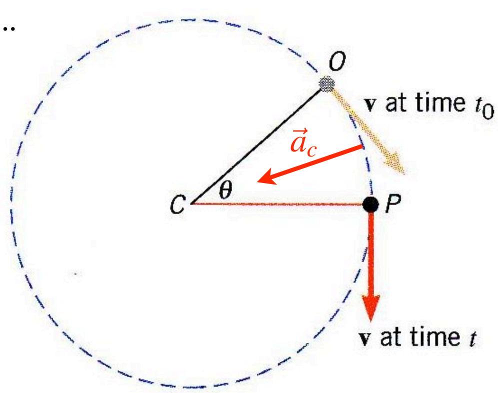
$$a_c = \frac{1.51^2}{0.12} = 18.9 \text{ m/s}^2 = 1.9g$$

Centripetal Force

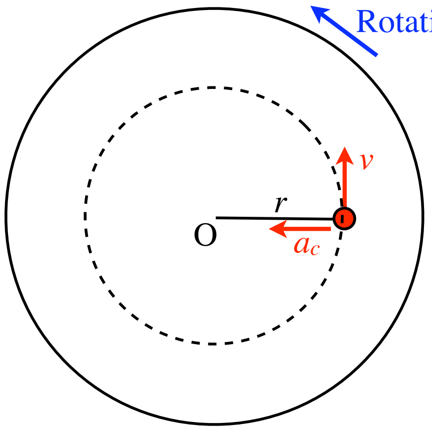
- the force that causes the centripetal acceleration
- acts toward the centre of the circular path – in the direction of the acceleration
- generated by tension in a string, gravity (planetary motion), friction (driving around a curve)...

As F = ma, centripetal force is:

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



5.C11: 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 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

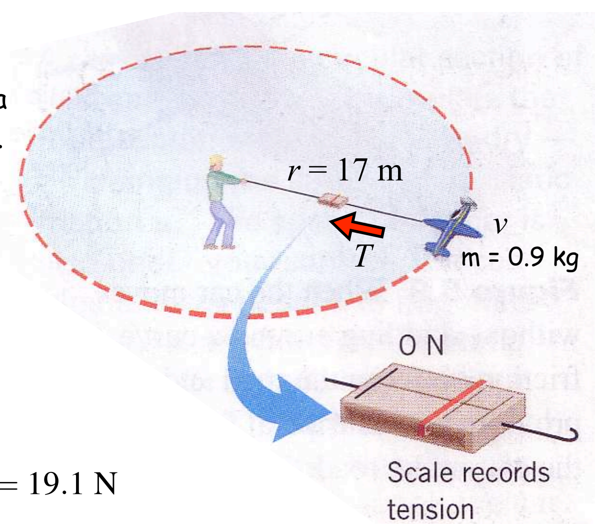
$v = 2\pi r/T$, so $v \propto r$

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 v = 19 m/s and 38 m/s.



Speed = 19 m/s,

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

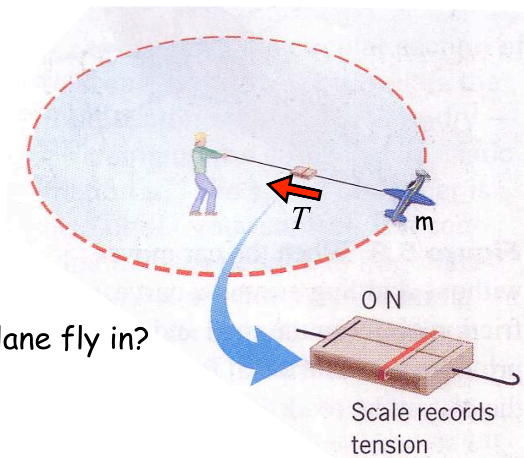
Speed = 38 m/s,

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

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?



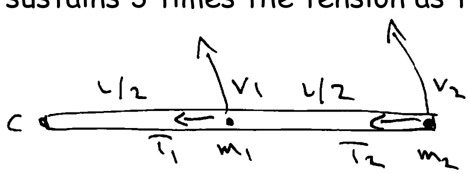
Tension in the line is $T = \dfrac{mv^2}{r}$

0.6 kg plane: $T = \dfrac{0.6v^2}{(3.5\text{ m})}$

1.2 kg plane: $T = \dfrac{1.2v^2}{r}$

If the tensions are equal: $\dfrac{0.6v^2}{3.5} = \dfrac{1.2v^2}{r} \quad \rightarrow r = 3.5 \times 1.2/0.6 = 7\text{ m}$

5.19/53: 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.



$T_2 = \dfrac{m_2 v_2^2}{L}$

$T_1 = \dfrac{m_1 v_1^2}{L/2} + T_2 = 3T_2$

$T_1 = 3T_2$

$\therefore \dfrac{m_1 v_1^2}{L/2} = 2\dfrac{m_2 v_2^2}{L}$

$v_2 = 2v_1$ (2x radius)

What is v_2 in terms of v_1 ?

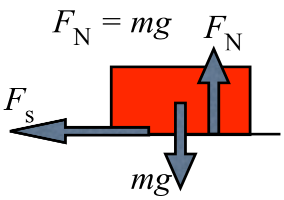
$\therefore 2m_1 = 2m_2(2)^2$

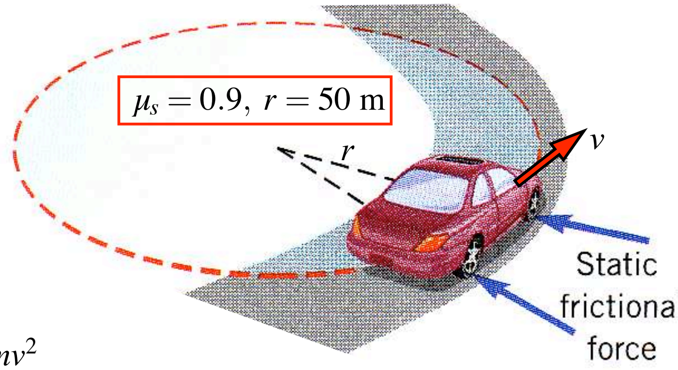
$m_1 = 4m_2$

$\dfrac{m_2}{m_1} = \dfrac{1}{4}$

How fast can you go around a curve?

Forces on the car:





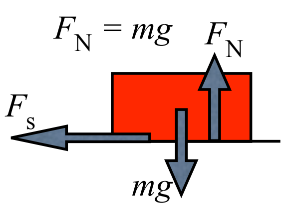
Centripetal force $= \dfrac{mv^2}{r}$

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)

5.14/-: 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: $\mu_s = 0.85$, $v_B = ?$

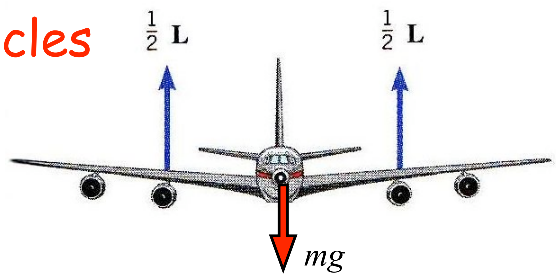
From previous page, $v = \sqrt{\mu_s rg}$, proportional to $\sqrt{\mu_s}$

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

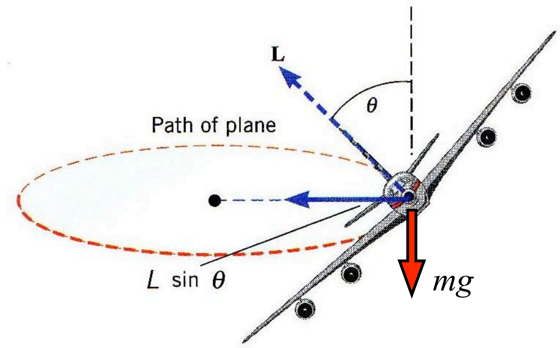
so, $v_B = 0.879 \times 25 = 22$ m/s

Flying around in circles

Lift: L/2 + L/2 = mg



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



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

$$L\cos\theta = mg$$

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

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

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

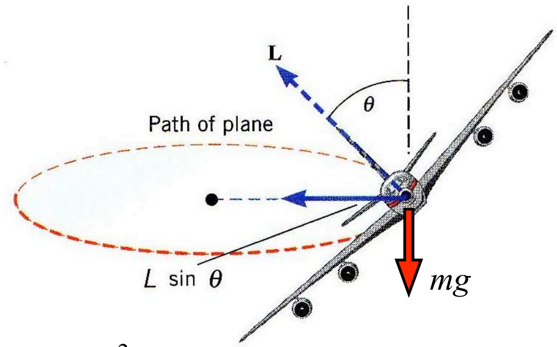
→ angle of banking needed to make the turn without gaining or losing height

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

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

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

5.25: 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.



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

$$L\cos\theta = mg$$

Trigonometry:

$$\sin^2\theta + \cos^2\theta = 1$$

So, $(L\sin\theta)^2 + (L\cos\theta)^2 = L^2 = (\frac{mv^2}{r})^2 + (mg)^2$

$$\rightarrow\ L = m\sqrt{\left(\frac{v^2}{r}\right)^2 + g^2}$$

$$L = 2.11 \times 10^6\ \text{N}$$