Did this in place of BW1

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AP Physics 1: UCM Problems 100 cm = 1 m

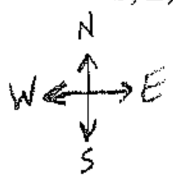
1. A cyclist goes around a level, circular track at constant speed. Do you *agree or disagree* with the following statement: "Because the cyclist's speed is constant, her acceleration is zero." Explain your answer. $\vec{a} \neq 0$!

   Disagree... as the cyclist moves at a constant speed while constantly changing direction, the cyclist's velocity is changing (b/c of direction changing), ∴ accelerating.

2. You are driving your car in a circular path on level ground at a constant speed of 20 mi/hr. At the instant you are driving north, and turning left, are you accelerating?

   Yes... you are changing direction ∴ accelerating!

3. Continuation of #2... If so, toward what direction is your acceleration vector pointing (N, S, E, W)? If not, why not? Hint: draw a picture of this scenario.



   Turning Left ↑Velocity is North and as you turn left from a position facing North, your acceleration vector is directed West.

4. When you go around a corner in your car, your car follows a path that is a segment of a circle. To turn safely, you should keep your car's acceleration below some safe upper limit. If you want to make a "tighter" turn—that is, turn in a circle with a smaller radius—how should you adjust your speed? Explain.

   Reduce your speed.

   $$\vec{a}_c = \frac{v^2}{r} = \frac{(\frac{1}{2}v)^2}{(\frac{1}{4}r)}$$

   If $\vec{a}_c$ is to stay the same, if r is 4x smaller, v needs to be cut in half.

5. Riders on a Ferris wheel move in a circle with a speed of 4.0 m/s. As they go around, they experience a centripetal acceleration of 2.0 m/s^2. What is the diameter of this particular Ferris wheel?

   $v = 4\ m/s$

   $\vec{a}_c = 2\ m/s^2$

   diameter = 2r = ?

   $\vec{a}_c = \frac{v^2}{r}$

   $$r = \frac{v^2}{a_c} = \frac{(4\ m/s)^2}{2\ m/s^2} = \frac{16\ m^2/s^2}{2\ m/s^2} = 8\ m = r$$

   ∴ diameter = 2(8 m) = **16 m**

6. A typical hard disk in a computer spins at 5400 rpm (rpm = revolutions per minute).
   a) What is the frequency, in revolutions per second (rev/s)?
   b) What is the period, in seconds (s/rev)?

   $$f = \frac{5400\ rev}{1\ min} \cdot \frac{1\ min}{60\ sec} = 90\ \frac{rev}{s}$$

   $$T = \frac{1\ min}{5400\ rev} \cdot \frac{60\ sec}{1\ min} = 0.011\ sec$$

7. Racing greyhounds are capable of rounding corners at very high speeds. A typical greyhound track has turns that are 45-m-diameter semicircles. A greyhound can run around these turns at a constant speed of 15 m/s (almost as fast as Pelizabeth Aschal! ☺). What is the greyhound's acceleration?

diameter = 45m → $r = \frac{45m}{2} = 22.5m$ ← change each year

$v = 15$ m/s

$\vec{a}_c = ?$

$a_c = \frac{v^2}{r} = \frac{(15\text{ m/s})^2}{22.5\text{m}} = 10\text{ m/s}^2 = \vec{a}_c$

8. A CD-ROM drive in a computer spins the 12-cm diameter disks at 10,000 rpm.
   a) What are the disk's period (in seconds) and frequency (in rev/sec)?
   b) What would be the speed (in m/s) of a speck of dust on the outside edge of this disk?
   c) What is the acceleration (in m/s^2) of the disk?

$r = 6\text{cm} = 0.06\text{m}$

a) $f = \frac{10000\text{rev}}{1\text{min}} \cdot \frac{1\text{min}}{60\text{sec}} = 166.7\frac{\text{rev}}{\text{sec}} = f$ $T = \frac{1}{f} = \frac{60\text{sec}}{10{,}000\text{rev}} = T = 0.006\text{ sec}$

b) $v = \frac{2\pi r}{T} = \frac{2\pi(0.06\text{m})}{0.006\text{ sec}} = 62.8\frac{\text{m}}{\text{s}} = v$

c) $\vec{a}_c = \frac{v^2}{r} = \frac{(62.8\text{ m/s})^2}{0.06\text{m}} = 65{,}797\text{ m/s}^2 = \vec{a}_c$

9. A particle rotates in a circle with centripetal acceleration of 8.0 m/s^2. What is the *acceleration* if…
   a) The radius is doubled without changing the particle's speed? Explain w/words or math.
   b) The speed is halved without changing the circle's radius? Explain w/words or math.

a) $\vec{a}_{original} = \frac{v^2}{r}$ $?\vec{a}_{new} = \frac{v^2}{2r} \Rightarrow \vec{a}_{new} = \frac{1}{2}\vec{a}_{original} = 4\frac{\text{m}}{\text{s}^2}$

b) $\vec{a}_{original} = \frac{v^2}{r}$ $?\vec{a}_{new} = \frac{(\frac{1}{2}v)^2}{r} \Rightarrow \vec{a}_{new} = \frac{1}{4}\vec{a}_{original}$

$\vec{a}_{new} = 2\text{ m/s}^2$

10. Entrance and exit ramps for freeways are often circular stretches of road. (Think about the entrance to I-205 N from Willamette Drive down below the school.) As you go around one of these circular stretches of road at a constant speed, you will experience a constant acceleration. Suppose you drive through such an entrance ramp at a modest speed and your centripetal acceleration is 3.0 m/s^2. What will be the acceleration if you double your speed? Explain.

$\vec{a}_{original} = 3\text{ m/s}^2 = \frac{v^2}{r}$

$\vec{a}_{new} = ? = \frac{(2v)^2}{r} = 4\frac{v^2}{r} = 4\vec{a}_{original} = 4(3\text{ m/s}^2) =$

$12\text{ m/s}^2 = \vec{a}_{new}$

11. In uniform circular motion (UCM), which of the following quantities are constant: speed, instantaneous velocity, centripetal acceleration, the magnitude of the net force?

UCM constant: speed, $\vec{a}_c$, ΣF

12. Give an everyday example of circular motion for which the centripetal acceleration is mostly or completely due to a force of the type specified;
   a) Static Friction Force:

   b) Tension Force:

   c) Gravitational Force:

   d) Normal Force:

13. A ball on a string moves around a complete circle, once every second, on a frictionless, horizontal table. The tension in the string is measured to be 6.0 N. What would be the tension if the ball went around in only half a second?

$T_{original} = 1\,sec \Rightarrow \vec{F}_{T_o} = 6N = \frac{m4\pi^2 r}{T^2}$

$? \vec{F}_T = m \cdot \frac{4\pi^2 r}{(\frac{1}{2}T)^2} = \frac{m4\pi^2 r}{T^2} \cdot \frac{1}{(\frac{1}{2})^2} = \frac{m4\pi^2 r}{T^2}\left(\frac{1}{\frac{1}{4}}\right) = 6N \cdot (4) = 24N = F_{New}$

14. Suppose you and a friend, each of mass 60 kg, go to the park and get on a 4.0-m-diameter merry-go-round. You stand on the outside edge of the merry–go-round, while your friend pushes so that it rotates once every 6.0 s. What is the magnitude of the (apparent) outward force that you feel? (But we all know that there is NO force pushing you outward.)

$m = 60\,kg$

$r = \frac{4m}{2} = 2m$

$T = 6\,sec$

$\vec{F}_c = ?$

$F_c = m \cdot \frac{4\pi^2 r}{T^2}$

$F_c = (60kg)\frac{4\pi^2(2m)}{(6s)^2} = 131.6N = \vec{F}_c$

this force could be provided by friction and/or the person holding on to a bar ($F_{applied}$).

15. A 200-g block on a 50-cm-long string swings in a circle on a horizontal, frictionless table at 75 rpm (rpm = revolutions per minute).
    a) What is the speed of the block?
    b) What is the tension in the string?

$m = 0.2\,kg$

$r = 0.5\,m$

$f = \frac{75\,rev}{min}\cdot\frac{1\,min}{60\,sec} = 1.25\,\frac{rev}{sec}$

$T = \frac{1}{f} = \frac{60\,sec}{75\,rev} = 0.8\,\frac{sec}{rev}$

a) $V = \frac{2\pi r}{T} = \frac{2\pi(0.5\,m)}{0.8\,sec}$

$V = 3.93\,m/s$

b) $\vec{F}_T = m\cdot\frac{v^2}{r}$

$\vec{F}_T = \frac{(0.2\,kg)(3.93\,m/s)^2}{0.5\,m}$

$\vec{F}_T = 6.17\,N$

16. A 1500 kg car drives around a flat 200-m-diameter circular track at 25 m/s. What are the magnitude and direction of the net force on the car? What causes this force?

$m = 1500\,kg$

$r = \frac{200\,m}{2} = 100\,m$

$V = 25\,\frac{m}{s}$

$\Sigma\vec{F} = m\cdot\vec{a}_c = m\cdot\frac{v^2}{r} = F_{friction}$

$\vec{F}_f = \frac{(1500\,kg)(25\,\frac{m}{s})^2}{100\,m} = 9375\,N = \vec{F}_f$

17. A baseball pitching machine works by rotating a light and stiff rigid rod about a horizontal axis until the ball is moving toward the target. Suppose a 144-g baseball is held 85 cm from the axis of rotation and released at the major league pitching speed of 85 mph. (1 km = 0.621 miles, and 1000 m = 1 km)
    a) What is the ball's centripetal acceleration just before it is released?
    b) What is the magnitude of the net force that is acting on the ball just before it is released?

$m = 0.144\,kg$

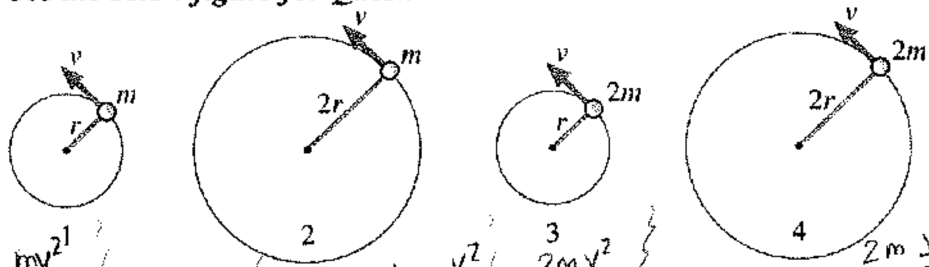
$r = 0.85\,m$

$V = \frac{85\,mi}{hr}\cdot\frac{1\,hr}{3600\,sec}\cdot\frac{1000\,m}{0.621\,mi} = 38.02\,\frac{m}{s}$

$\vec{a}_c = \frac{v^2}{r} = \frac{(38.02\,m/s)^2}{0.85\,m} = 1701\,\frac{m}{s^2} = \vec{a}_c$

$\Sigma\vec{F} = m\cdot a = (0.144\,kg)(1701\,m/s^2) = 245\,N = \vec{F}_c = \Sigma\vec{F}$

***Use the below figure for Question #18*:**



$\frac{mv^2}{r}$ $\quad$ $\frac{mv^2}{2r} = \frac{1}{2}m\frac{v^2}{r}$ $\quad$ $2m\frac{v^2}{r}$ $\quad$ $2m\frac{v^2}{2r} = \frac{mv^2}{r}$

18. The above figure is a bird's eye view of particles on a string moving in horizontal circles on a tabletop. Rank in order, from largest to smallest, the tensions T_1 to T_4.

$$\vec{F}_T = m \cdot \frac{v^2}{r}$$

$$F_{T_3} > F_{T_1} = F_{T_4} > F_{T_2}$$

$$3 > 1 = 4 > 2$$

$$\frac{2mv^2}{r} > \frac{mv^2}{r} = \frac{2mv^2}{2r} > \frac{mv^2}{2r}$$