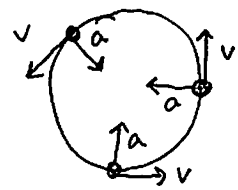
NAME: KEY

Circular Motion Review

1. Define the following terms and state the units.
   a. Frequency Hertz & rpm (remember Hz = rps)
   b. Period s & min
   c. Linear speed m/s
   d. Rotational speed - another phrase for frequency, so Hz & rpm
   e. Centripetal acceleration m/s²
   f. Centripetal force N



2. a. If you are going in a circle, what is ALWAYS true about your acceleration and your velocity?
   a to center of circle   v tangent to circle
   b. If your acceleration is ALWAYS perpendicular to your velocity, what is happening to you?
   You go in a circle with constant speed.

3. A phonograph turntable rotates at 33 rpm. Calculate the following:
   a. frequency - in both units.
   1) 33 rpm   2) $33/60 = 0.55$ Hz
   b. period - in both units.
   $\frac{1}{33} = .0303$ minutes & $\frac{1}{.55} = 1.82$ seconds
   c. The linear speed of a point 7 cm from the axis of rotation.
   $v = \frac{2\pi r}{T}$ $v = \frac{2\pi(.07)}{1.82} =$ **0.24 m/s**

4. Mary and Larry are riding on a merry-go-round. Mary is 3 m from the center and Larry is 4 m. The merry-go-round completes 3 revolutions every minute.
   a. Who has a greater rotational speed? Explain.
   The same! Both going around @ 3 rpm.
   b. Who has a greater linear speed? Explain.
   Larry, b/c he goes in a bigger circle ∴ bigger distance in same time

5. A 1500 kg car is going around in a circle of radius 25 meters. Its frequency is 2.5 rpm.
   a. How many seconds does it take the car to go around the circle once?
   $T = \frac{1}{2.5} = 0.40$ minutes ⇒ **24 seconds**
   b. How fast is the car moving, in m/s?
   $v = \frac{2\pi r}{T} = \frac{2\pi(25)}{24} =$ **6.55 m/s**
   c. What is the net force on the car?
   $F_c = \frac{mv^2}{r} = (1500)\frac{(6.55)^2}{25} =$ **2570 N**

6. A jet plane traveling at 500 m/s moves in an arc of radius 6000 m.
   a. What is the plane's acceleration?
   $a_c = \frac{v^2}{r} = \frac{(500)^2}{6000} =$ **41.7 m/s²**
   b. The mass of the plane is 17,000 kg, what is the centripetal force on the plane?
   $F = ma = (17{,}000)(41.7) =$ **708,000 N**

Note: could do $\frac{mv^2}{r}$ if you wanted.

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c. How would the centripetal force change if the radius is doubled but the speed stayed the same? What if instead the speed doubled and the radius stayed the same?

$F_c = \frac{mv^2}{r}$ if r doubled, F_c is $\frac{1}{2}$; if v doubled, F_c is 4 times bigger

7. A 1200 kg car drives around a circular track of radius 50 m. The car is traveling at a constant speed of 25 m/s.
   a. Is the car accelerating? Explain.

   Yes! Changing direction.

   b. How long does it take the car to complete one lap?

   $v = \frac{2\pi r}{T}$ $25 = \frac{2\pi(50)}{T}$ → $T = \frac{2\pi(50)}{25}$ = **12.57 sec.**

   c. What is the frequency of the car in rpm?

   $12.57/60$ = 0.21 minutes → $f = \frac{1}{T} = \frac{1}{.21}$ = **4.77 rpm**

   d. What is the centripetal force acting on the car?

   $F_c = \frac{mv^2}{r} = (1200)\frac{(25)^2}{50}$ → **F_c = 15,000 N**

   e. Where does the centripetal force come from?

   Friction between tires & road

8. Imagine you swing a 0.4 kg ball tied to the end of a string in a horizontal circle of radius 1.3 m. The tension in the string is 60 N.
   a. What is the speed the ball?

   $F_c = \frac{mv^2}{r}$ $60 = \frac{(.4)v^2}{1.3}$ → $v^2 = \frac{60(1.3)}{(.4)}$ $v^2 = 195$ **v = 13.96 m/s**

   b. In what direction is the ball accelerating?

   to the center of the circle

   c. What would happen if the string broke?

   the ball would fly off tangent to the circle

   d. What is the frequency of the swinging ball?

   $v = \frac{2\pi r}{T}$ $13.96 = \frac{2\pi(1.3)}{T}$ → $T = \frac{2\pi(1.3)}{13.96}$ = 0.59 seconds

   Then $f = \frac{1}{T} = \frac{1}{.59}$ **f = 1.71 Hz**

9. Now you swing the ball (still 0.4 kg) in a vertical circle (still radius of 1.3 m) at a constant speed of 5 m/s.
   a. What is the net force on the ball? In what direction is the net force?

   $F_c = \frac{mv^2}{r} = \frac{(.4)(5)^2}{1.3}$ = **7.7 N** always to center of circle

   b. What is the tension in the string at the top of the circle?

   @ top: ↓T ↓mg — both Tension (string) and gravity pull to center, so add them

   $T + mg = 7.7$
   $T + (.4)(10) = 7.7$
   T = 3.7 N

   c. What is the tension in the string at the bottom of the circle?

   @ bottom: ↑T ↓mg — tensions pulls up to center, gravity pulls down, so subtract.

   $T - mg = 7.7$
   $T - 4 = 7.7$ **T = 11.7 N**

   d. What would be the minimum speed needed so that the ball just barely makes the circle?

   @ top, minimum speed is when T = 0 & ALL of gravity is used to keep it in a circle, so

   $mg = \frac{mv^2}{r}$
   $(.4)(10) = \frac{(.4)v^2}{1.3}$
   $v^2 = 13$
   v = 3.61 m/s