1206 - Concepts in Physics

Wednesday, September 23

NOTES

- Additional Tutorial available: THURSDAY 16:30 to 18:00 F536 this is for all first year physics students, so bring specific questions you have
- Tutorial specific for our course is still on MONDAY
 16:30 to 18:00 F055

Circular uniform motion



Uniform circular motion can be described as the motion of an object in a circle at a constant speed. As an object moves in a circle, it is *constantly changing its direction*.

At all instances, the object is moving tangent to the circle. Since the direction of the velocity vector is the same as the direction of the object's motion, the velocity vector is directed tangent to the circle as well.

An object moving in a circle is *accelerating*. Accelerating objects are objects which are *changing their velocity* - either the speed (i.e., magnitude of the velocity vector) or the direction. An object undergoing uniform circular motion is moving with a constant speed. Nonetheless, it is accelerating due to its *change in direction*. The direction of the acceleration is inwards.



Calculation of the Average Speed

An object moving in uniform circular motion will cover the same linear distance in each second of time (constant speed). When moving in a circle, an object traverses a distance around the perimeter of the circle. So if your car were to move in a circle with a constant speed of 5 m/s, then the car would travel 5 meters along the perimeter of the circle in each second of time. The distance of one complete cycle around the perimeter of a circle is known as the **circumference**.

The circumference of any circle can be calculated using from the radius according to the equation **Circumference = 2*pi*Radius**

The average speed is then given by:

Average Speed =
$$\frac{\text{distance}}{\text{time}} = \frac{\text{circumference}}{\text{time}}$$

Combining these two equations above leads to a new equation relating the speed of an object moving in uniform circular motion to the radius of the circle and the time to make one cycle around the circle - called **period**.

Average Speed =
$$\frac{2 * \pi * R}{T}$$
 wit

with R radius and T period.

YOUR TURN:

1.) A tube is been placed upon the table and shaped into a three-quarters circle. A golf ball is pushed into the tube at one end at high speed. The ball rolls through the tube and exits at the opposite end. Describe the path of the golf ball as it exits the tube.



 2.) The moon orbits the earth in an approximately circular path (mean radius= 3.84 x 10⁵ km) every 27.3 days.
Calculate the moon's average speed - assuming a circle for it's path. The final motion characteristic for an object undergoing uniform circular motion is the net force. The net force acting upon such an object is directed towards the center of the circle. The net force is said to be an inward or **centripetal** force. Without such an inward force, an object would continue in a straight line, never deviating from its direction. Yet, with the inward net force directed perpendicular to the velocity vector, the object is always changing its direction and undergoing an **inward acceleration**.

Or in other words: The fact that the centripetal force is directed perpendicular to the tangential velocity means that the force can alter the direction of the object's velocity vector without altering its magnitude.

YOUR TURN:

An object is moving in a clockwise direction around a circle at constant speed. Use your understanding of the concepts of velocity, acceleration and force to answer the next five questions. Use the diagram shown at the bottom right.

1. Which vector below represents the direction of the force vector when the object is located at point A on the circle?

2. Which vector below represents the direction of the force vector when the object is located at point C on the circle?

3. Which vector below represents the direction of the velocity vector when the object is located at point B on the circle?

4. Which vector below represents the direction of the velocity vector when the object is located at point C on the circle?

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5. Which vector below represents the direction of the acceleration vector when the object is located at point B on the circle?

Angular displacement is equal to the difference of angular positions at two instants of rotational motion.



$\Delta \theta = \theta_2 - \theta_1$

The angular displacement is measured in radian like angular position. In case our measurement of angular position coincides with the reference direction, we can make substitution as given here:

$\theta_1 = 0$ and $\theta_2 = \theta$

With these substitution, we can simply express angular displacement in terms of angle as :

 $\Rightarrow \Delta \theta = \theta_2 - \theta_1 = \theta - 0 = \theta$

Now some more exercises:

1.) A car is travelling at a constant speed of 72 km/h and passes a stationary police car. The police car immediately gives chase, accelerating uniformly to reach a speed of 90 km/h in 10 s and continues at this speed until he overtakes the other car. Find:

(a) the time taken by the police to catch up with the car,

(b) the distance travelled by the police car when this happens.

- 2.) Draw free body diagrams for the following situations. Neglect friction.
 - a) A pendulum bob at it's highest point
 - b) 1 kg apple falling through the air
 - c) 2 kg ball tossed into the air, moving upwards

3.) A 2.0 kg mass swinging at the end of a 0.50 m string is traveling 3.0 m/s. What is the

- a) centripetal acceleration of the mass?
- b) centripetal force on the mass?

Friction

Friction is a very useful force, without friction life would be very difficult.

Try the following: Rub your hands together. Now press them hard to together and rub. What do you notice? Was it easy to do? Your hands got hot and it is quite hard to do. The reason is that your hands are rough and when you rub them together the friction between them causes heat.

Rough surfaces have more friction.

Now run your hand over a smooth surface. Is it easy to do? The answer is yes.

Smooth surfaces have less friction.

In short friction is the force that slows moving objects and it causes things to get hot.

You are walking on the street and you walk onto ice. Does the friction between your shoes and the ice increase or decrease?

When you slide your book on floor, it will come to stop because of the **force of friction**. Friction is the force that acts between two objects in contact because of action-reaction.

Force of friction can be calculated by the formula $F_f = \mu F_N$

where:

- F_f is the force of friction in N,
- μ is the coefficient of friction, and
- F_N is the normal force in N.

The value of depends on surface you are dealing with. The following table shows some example of .

Surface	Value of µ
rubber on dry asphalt	~1
rubber on wet asphalt	0.95
steel on steel	0.18
steel on ice	0.010
rubber on ice	0.005

For example, if you throw a 500 g book on floor where $\mu = 0.1$, the force of friction would be: F_f = μ F_N = (0.1)(0.5 * 9.8) = 0.49 N

QUESTION: What is the value of if the force of friction on a 300 g book was 0.5 N?

YOUR TURN:

A book has a mass of 400 g. When you slide the book against the floor with 5 N, it accelerated at the rate of -1.5 m/s². What would the coefficient of friction between the book and the floor be?