Circular Motion

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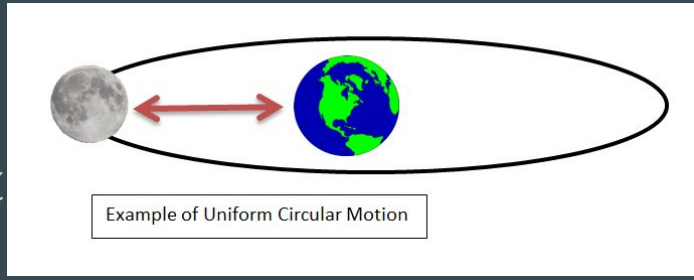
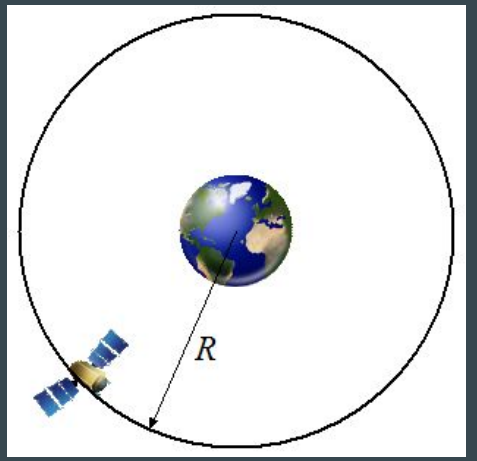
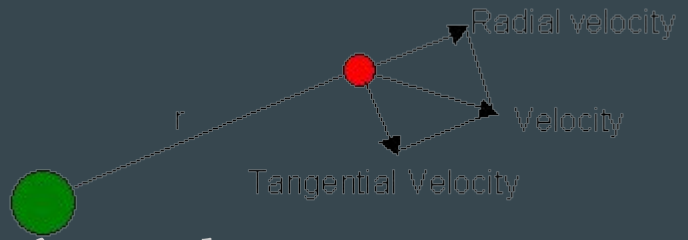
What is Circular Motion?



- An object moving in a circle at a constant speed(v) experiences uniform circular motion
- Magnitude of the velocity remains the same while the direction is constantly changing, and always accelerating.
- An external, unbalanced force has to be applied constantly in order for the object's motion to remain circular.



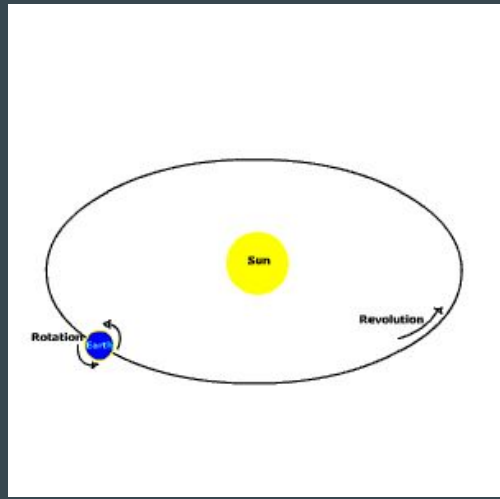
Tangential and Radial Velocity



- **Tangential:** behavior along the edge of a circle
- **Radial:** behavior away or toward the center of the circle

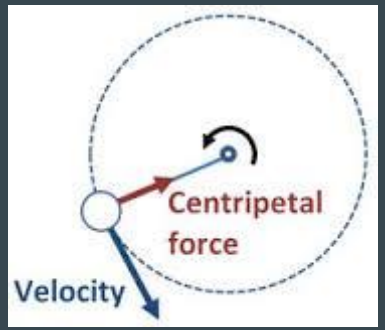
Rotations v. Revolutions

- A rotation or spin is when a body turns about an internal axis.
- A revolution is when a body turns about an external axis.



Centripetal Forces

- Forces which point to the center of rotation are called centripetal forces (F_C) meaning “center seeking” forces.
- An example of this is when a ball on a string is swung in a circle: *tension*.
- *Friction, gravity, and normal force* can also act as centripetal forces under the correct circumstances. (as perpendicular forces)
- In order to solve a centripetal force problem you must know the following: *mass, radius, and velocity.*

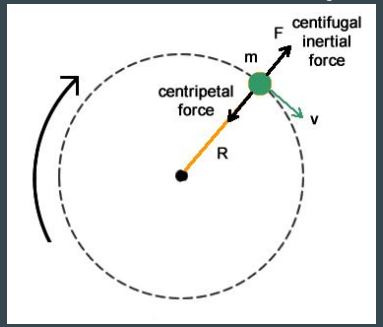


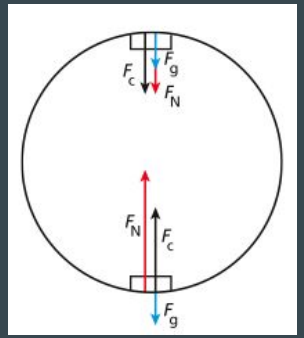
Centripetal Force Equations

- $a_c = v^2/r$
- $F_c = ma_c$
- $F_c = mv^2/r$

Fictional Centri*fugal* Force

- A centrifugal or ‘center-fleeing’ force is a made up force, used to describe forces, on an object in circular motion, that are acting away from the center of mass.
- ie. the force of gravity on a rollercoaster at the bottom of a loop.





Example 1

- A viking swings his 4,600 gram flail around his head at 4m/s, creating a circular path with a diameter of 1.5 meters.
  - What is the flail's centripetal acceleration?
  - What is its the centripetal force?
- Approach:
  - Dissect the information from the problem (ex: mass, velocity, and radius.
  - Identify what formulas you need
  - DON'T FORGET TO CONVERT TO PROPER SI UNITS

Frequency and Period

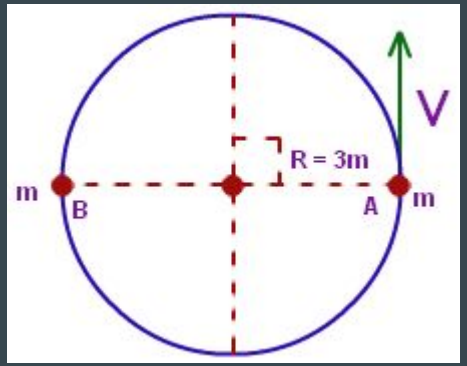
- Frequency(f) is the number of revolutions per second and is measured in Hertz(Hz)
- 1 Hz = 1 rev/s
- Period(T) is the time required to make 1 full revolution
- T = 1/f

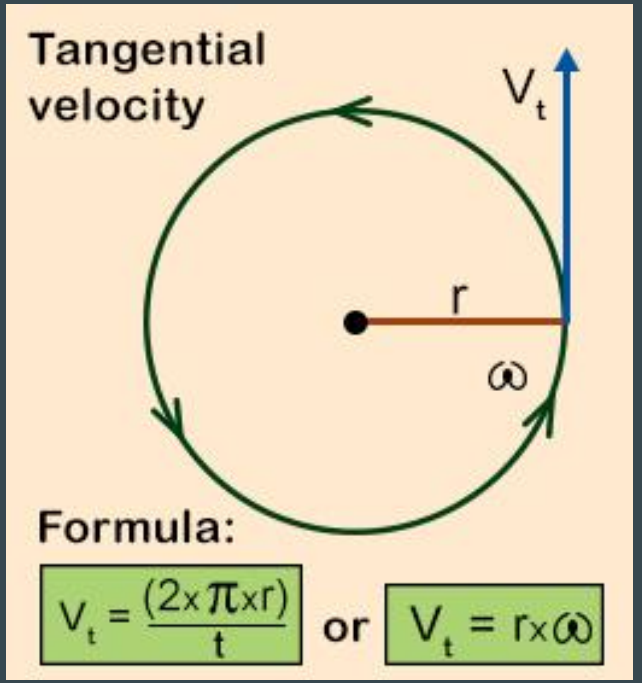
$$\text{Frequency} = \frac{1}{\text{Periodic time}} \quad \text{or} \quad f = \frac{1}{T} \text{ Hz}$$

$$\text{Periodic time} = \frac{1}{\text{Frequency}} \quad \text{or} \quad T = \frac{1}{f} \text{ sec}$$

Tangential Velocity

- Tangential velocity is the speed(v) of the object itself
- $v = 2\pi r/T$
- Measured in m/s





Example 2

- A spaceship orbits the moon 82,000 kilometers above the surface once every 12 hours.
- What is the spaceship's tangential velocity?
- Remember to:

-Convert to SI units

-Identify the factors given (ie. r = 82,000 km)

-Use the correct formula ($v = 2\pi r/T$)

WATCH OUT: Common mistakes

- Forgetting conversions: Before solving, ALWAYS check the units you're given; distance should be in meters(m), time should be in seconds(s), and mass should be in kilograms(kg). If your SI units are correct, your answer to centripetal force equations will be in Newtons(N), and tangential velocity answers will be in meters per second(m/s).
- Remember the equation for centripetal force ($F_c = mv^2/r$) and tangential force ($v = 2\pi r/T$).

WATCH OUT: Common mistakes

- Pay attention to direction! Observe what direction centripetal and centrifugal forces are pointing in regards to the center of mass and *use signs accordingly.* (Ferris wheel)
- t is time but T is Period, the time required to make one full revolution. If the time you're given in a problem suffices for more or less than one revolution(ie. The object circles the moon *twice* in one day...) take notice!
- Ignore sig figs until you have your final answer.