Velocity and Acceleration

Lesson Notes

Learning Outcomes

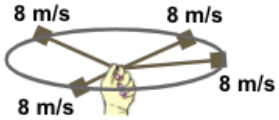
- What is the direction of the velocity and acceleration vectors for objects moving along circular paths?
- How do you calculate the velocity (or speed) and acceleration of an object moving in circles?

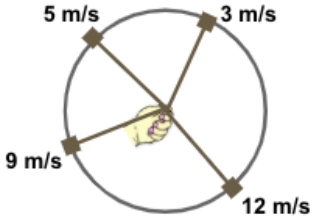
Kinematics Review

Speed: how fast an object is moving.
It's a **scalar quantity** … a direction is never associated with it.
Velocity: the rate at which the position changes. It is a **vector quantity** (has a direction). At any given instant in time, velocity is speed with a direction.
Acceleration: the rate at which the velocity changes. Acceleration is a **vector quantity** (has a direction).

Uniform vs. Non-uniform Circular Motion

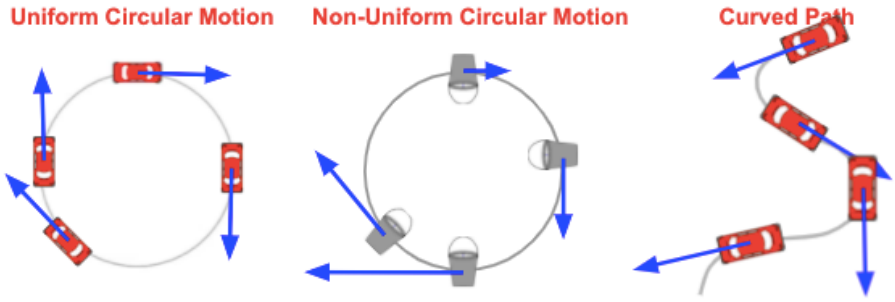
Spinning a bucket of water in a horizontal circle at a constant speed is a typical example of uniform circulat motion.
Spinning a bucket of water in a vertical circle is a sure example of non-uniform circular motion.





Tangential Velocity

For objects moving along circular or curved paths, the direction of the velocity vector at any given location is in the direction of a line drawn **tangent** to the curve.



Magnitude of Velocity

- Velocity (**v**) is a vector quantity.
- The magnitude of the velocity at any instant in time is the speed.
- Speed (**v**) = distance traveled per time of travel.
- Speed is circumference (a distance) divided by period (a time for one revolution).
- $v = 2 \cdot \pi \cdot R/T$
- If given the number of revolutions per second, the speed can also be calculated as ...

$$v = \#\ \text{revolutions} \cdot 2 \cdot \pi \cdot R/(1\ \text{sec})$$

Acceleration

- Accelerating objects are changing their velocity.
- At any given instant, velocity is the speed with a direction.
- Accelerating objects are either speeding up, slowing down, and/or changing their direction.
- An object that is moving in a circle or turning is accelerating, even if doing it at a constant speed!!

Direction of Acceleration

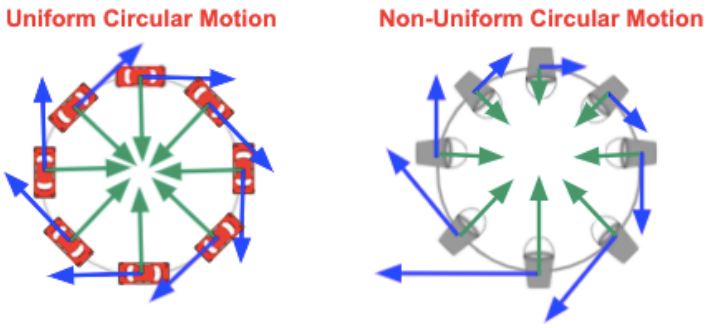
- Acceleration is a vector quantity; it has a direction.
- Objects that move in a circle are experiencing an inward acceleration.
- The adjective *centripetal* is often used to describe the inward acceleration.

Accelerometer Demonstration

- A *cork accelerometer* can be used to demonstrate the direction of acceleration for an object moving in a circle.
- On a per mL basis, the cork is less massive than the surrounding water. It offers less resistance to acceleration and thus leans in the direction of the acceleration.

Tangential Velocity, Inward Acceleration

Velocity vectors in **blue**. **Acceleration** vectors in **green**.



Acceleration Equation

For objects moving in circles, the **acceleration** (**a**) depends upon the **speed** (**v**) and the **radius** (**R**).

$$a = \frac{v^2}{R}$$

Acceleration (**a**) is …

- directly proportional to the square of the speed (**v**); doubling the **v** will quadruple the **a**.
- inversely proportional to the radius (**R**) of the circle; doubling the **R** will halve the **a**.