AP Physics Study Guide

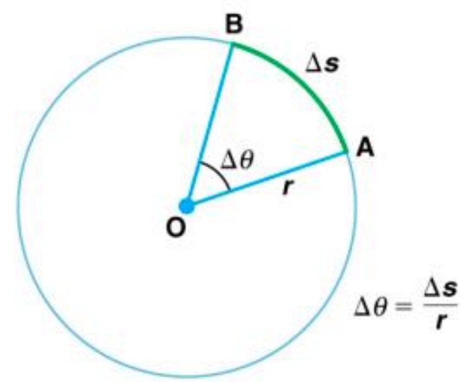
Uniform Circular Motion and Gravitation

From Simple Studies, https://simplestudies.edublogs.org & @simplestudiesinc on Instagram

All images are from the Openstax college physics textbook

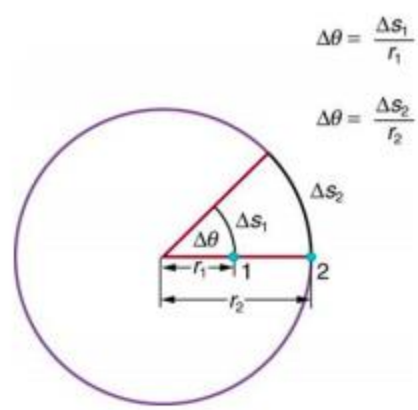
When objects rotate about some axis, each point in the object follows a circular arc

- The **rotation angle** is the ratio of the arc length to the radius of curvature
    - $\Delta\theta = \Delta s / r$
        - The **arc length** is the distance traveled along a circular path
        - r is the **radius of curvature** of the circular path
- The result is the basis for defining the units to measure rotation angles, $\Delta\theta$ to be **radians**
    - 2πradians = 1 revolution



Angular velocity is the rate of change of an angle

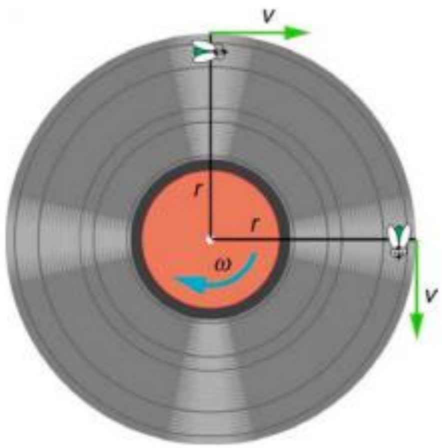
- $w = \Delta\theta / \Delta t$
    - The greater the rotation angle in a given amount of time, the greater the angular velocity
    - The unit for angular velocity is radians per second



Angular velocity is analogous to linear velocity

- $v = \Delta s / \Delta t$

- $v = \frac{r\Delta\theta}{\Delta t} = rw$
    - $w = v/r$



Centripetal acceleration is the acceleration of an object moving in uniform circular motion (resulting from a net external force)

- Centripetal means “toward the center” or “center seeking”
- $a_c = v^2/r = rw^2$
- A **centrifuge** is a rotating device used to separate specimens of difference densities
    - High centripetal acceleration significantly decreases the time it takes for separation to occur

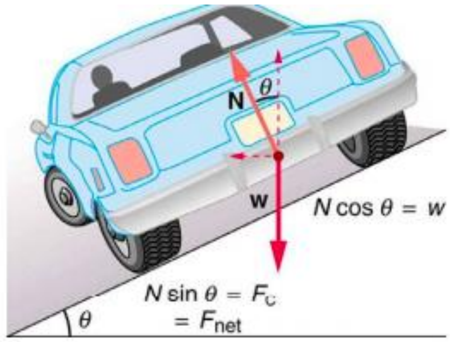
Centripetal force is any net force causing uniform circular motion

- The direction of a centripetal force is toward the center of curvature (the same as the direction of centripetal acceleration)
- It is always perpendicular to the path
- $F_c = ma_c = m\frac{v^2}{r} = mrw^2$
    - For a given mass and velocity, a large centripetal force causes a small radius of curvature (a tight curve)

In **banked curves**, the slope of the road helps negotiate the curve

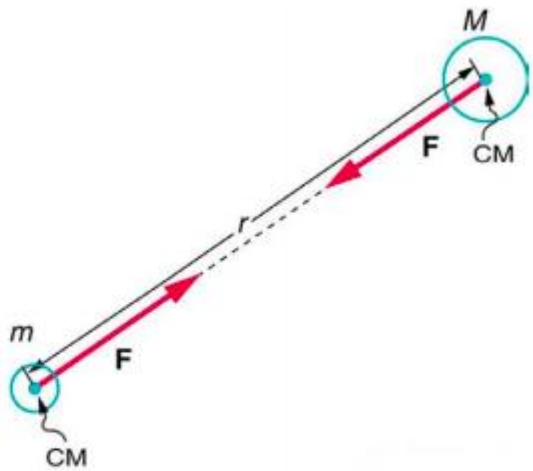
- The greater the angle, the faster you can take the curve

- For **ideal banking**, the net external force equals the horizontal centripetal force in the absence of friction



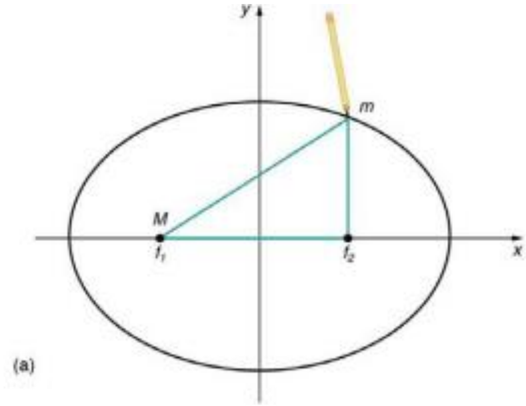
Newton's universal law of gravitation states that every particle in the universe attracts every other particle with a force along a line joining them

- The force is directly proportional to the product of their masses and inversely proportional to the square of the distance between them
- We assume that the body acts as if its entire mass is concentrated at one specific point called the **center of mass**
- $F = G\frac{mM}{r^2}$
    - $g = G\frac{M}{r^2}$
        - G is a proportionality factor called the **gravitational constant**(it is given on your reference sheet)

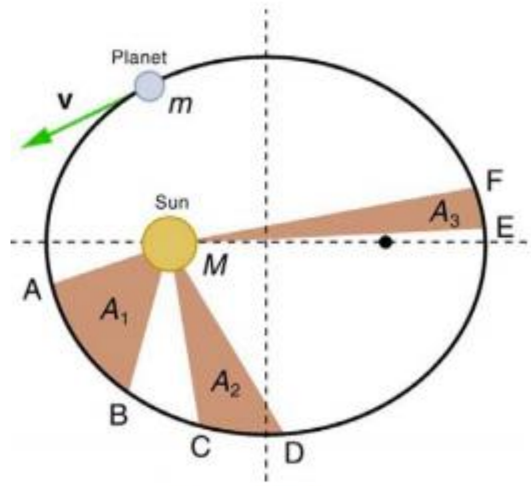


These are **Kepler's three laws of planetary motion**:

- The orbit of each planet about the Sun is an ellipse with the sun at one focus



- Each planet moves so that an imaginary line drawn from the sun to the planet sweeps out equal areas in equal times



- The ratio of the squares of the periods of any two planets about the Sun is equal to the ratio of the cubes of their average distances from the Sun