Particle F=ma: Curved Paths and n-t Coordinates

Last Class, Particle Straight Line Motion: We solved F=ma problems in which particles moved along straight line paths. We wrote particle F=ma equations in x and/or y directions (or along rotated x-y coordinates).

Last Class

$$\Sigma F_x = ma_x$$
$$\Sigma F_y = ma_y$$

or

$$\Sigma F_n = ma_n$$
$$\Sigma F_t = ma_t$$

Today

Today, Particles moving along curved paths: We'll work with circular and non-circular paths, in vertical and horizontal planes. Lots of interesting, practical problems!

We'll use normal and tangential (n-t) coordinates.

Various n-t coordinate problems…

We will investigate a number of basic F=ma problems, using n-t coordinates, in which particles move in curves.

A. Problems where the curve is in a vertical plane.
   1. Pendulum
   2. Car cresting hill or in dip
   3. Airplane or space shuttle

B. Problems where the curve is in the horizontal plane.
   4. Weight swung in circle (tetherball problem).
   5. Car in banked curve on track.

C. Additional n-t problem(s)
   6. Non-constant radius of radius of curvature.

Procedure for solving F = ma particle problems:

1. Draw a complete Free Body Diagram (FBD) showing all forces acting on the body.
2. Draw a complete Kinetic Diagram (KD) which shows the ma (kinetic) terms and their assumed directions.
3. Write the equations of motion, using coordinates appropriate to the problem:

$$\begin{array}{l} \sum F_x = ma_x \\ \sum F_y = ma_y \end{array} \quad \text{or} \quad \begin{array}{l} \sum F_n = ma_n \\ \sum F_t = ma_t \end{array} \quad \text{or} \quad \begin{array}{l} \sum F_r = ma_r \\ \sum F_\theta = ma_\theta \end{array}$$

4. You may need to write an additional equation, such as a pulley kinematics relationship, a friction equation ($F = \mu N$), and/or others.
5. Solve the equations.