**What phenomena are we seeing?**

* Single mass
  + On a flat surface
  + On inclined plane
  + Moving in a circle
    - Horizontal circle
    - Vertical circle
* Multiple interacting masses
  + connected by ropes & pulleys
    - Massless approximation on pulley
    - Non-negligible mass of pulley
  + directly in contact with each other
  + directly in contact with each other & connected by ropes & pulleys
* Extended rigid rotating object
  + About a fixed point
  + About a moving point

**What are the relevant variables/quantities?**

* Forces
  + Contact Forces
* Friction
* Magnitude & direction of Force of Static friction depends on initial conditions of masses involved
* Magnitude & direction of Force of Kinetic friction is always = ukFN, and always opposes direction of motion
* Normal Force
* Force exerted on an object by the surface supporting it, perpendicular to the plane of the surface
* Also known as “apparent weight”
* FN >mg ?
* FN = mg ?
* FN < mg ?
* Tension
* Tension force always acts along direction of the string
* For massless string approximation, magnitude of tension is the same all along the length of the string
* Drag
* Always opposite the direction of velocity
* Applied Force
* Long Range Forces
* Gravity
* Always points towards the center of the earth
* Electrostatic
* Magnetic
* Net Force
* Vector sum of all the forces
* Directly proportional to acceleration
* ΣFx = 0?
* ΣFy = 0?
* ΣFr = ?
* Mass
* Measure of resistance to translation
* Acceleration
* Equal to derivative (slope) of velocity
* Horizontal
* Horizontal acceleration is zero
* Horizontal acceleration is non-zero but constant
* Vertical
* Vertical acceleration is zero
* Vertical acceleration is non-zero but constant
* Radial Acceleration
* Always towards the center of the circle
* Equal to v2/R
* Tangential Acceleration
  + - Equal to the rate of change of tangential speed
* Angular Acceleration
  + - Equal to derivative (slope) of angular velocity
* Object is slowing
* Direction of acceleration and velocity are opposite
* Object is speeding up

Direction of acceleration and velocity are parallel

* Moment of Inertia
* Depends on distribution of mass about axis of rotation
* Torque
* Cross product of radial vector and force

**What are the relevant physical laws?**

Newton’s First Law

* Applies to a single object
* If Fnet = 0, an object’s velocity doesn’t change
* If τnet = 0, a rotating object’s angular velocity doesn’t change

Newton’s Second Law

* Applies to a single object
* Describes behavior of a single mass in response to external forces
* The acceleration and the net force always point in the same direction
* The angular acceleration is the always in the direction of the net torque
* The acceleration is inversely proportional to the net force
* The angular acceleration is inversely proportional to the net torque

Newton’s Third Law

* Applies to a pair of interacting objects
* For every force that is exerted on an object by an agent, that object exerts an equal force, but in the opposite direction, back onto that agent.