Things to remember

- Use inertial reference frames
- Write physical laws (i.e. "Newton's 2nd Law" or "Work Kinetic Energy Theorem")

Kinematics Equations

Where v_0 is initial velocity, and a is acceleration. These equations can be used in any number of dimensions.

$$v_x(t) = v_{0x} + a_x t$$
$$x(t) = x_0 + v_{0x} t + \frac{1}{2} a_x t^2$$
$$v_x^2(t) = v_{0x}^2 + 2a_x \times (x(t) - x_0)$$

Newton's Laws

1. **Law of Inertia:** A body on which zero net force acts either remains at rest or moves with constant velocity $\vec{v}$ in a straight line (i.e., $\vec{a} = 0$) This would be the natural "equilibrium" state of a body that is free from external force.

2. In an *inertial reference frame*, for each body

$$\sum \vec{F}_{\text{on body}} = m\vec{a} = m\frac{d\vec{v}}{dt}$$

$$\vec{a} = \frac{d\vec{v}}{dt} = \sum \vec{F}_{\text{on body}}$$

3. Force is the agent of *interaction* between two bodies. Each interaction between 2 bodies, A and B, consists of an *interaction pair* of "3rd law partner forces," $\vec{F}_{A \text{ on } B}$ and $\vec{F}_{B \text{ on } A}$

$$\vec{F}_{B \text{ on } A} = -\vec{F}_{A \text{ on } B}$$

This holds in any reference frame, intertial or non-inertial

PHYS 1112 Game Plan for Newton's Laws

1. Work in an inertial reference frame

2. Identify relevant interactions & forces (interaction type, direction, source body, subject body). Choose bodies or systems that enable you to "access" key forces acting across their boundaries.

3. For each body, draw a carefully labeled *free body diagram* showing only external interaction forces acting on that body. Use symbols for magnitude of force. Model the body as a particle.

4. Choose a convenient coordinate system for each body. Identify $+$ and $-$ directions.

5. Write out Newton's second law in components for each body with **interaction forces on the left side only**, using symbols from your free body diagram.

$$\sum_{\text{external}} \vec{F}_{\text{on body}} = m_{\text{body}} \vec{a}_{\text{body}}$$

6. Use the resulting equations to formulate answers

7. Check to make sure that your answers make physical sense.

Gravity

Gravity is a universal non-contact force. G is the universal constant of gravitation, and g is the acceleration due to gravity on earth.

$$G = 6.67 \times 10^{-11}\,\text{N}\,\text{m}^2\,\text{kg}^{-2}$$
$$g = 9.80\,\text{N}\,\text{kg}^{-1} = 9.80\,\text{m}\,\text{s}^{-2}$$

Given two masses, m_1 and m_2, and the distance between them, r, the force of gravity is equal to

$$F_g = \frac{G \times m_1 \times m_2}{r^2} = m_1 \times g = w$$

Circular Motion

Circular motion involves two quantities, radial acceleration (a_{rad}) and tangential velocity (v_{tan}). Tangential velocity is the velocity tangent to the point on the circle that the mass is moving at, and radial acceleration is the acceleration towards the center of the circle.

$$a_{\text{rad}} = \frac{v_{\text{tan}}^2}{r}$$

Statistical Analysis

Standard deviation is the measure of the average distance from the mean of a data set:

$$\sigma = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (x_i - \bar{x})^2}$$

The standard uncertainty of the mean is defined as:

$$\delta_{\bar{x}} = \frac{\sigma}{\sqrt{N}}$$

And the t' value determines how far apart two data sets are. It can be thought of as determining if they are measuring the same physical phenomenon

$$t' = \frac{|A - B|}{\sqrt{\delta_A^2 + \delta_B^2}}$$