- Kinematics
  - We are often interested in the position x of a particle at a time t: $x(t)$
  - The rate of change of $x(t)$ is velocity, $v(t)$. In calculus, $x'(t) = v(t)$.
  - The rate of change of $v(t)$ is acceleration, $a(t)$. Another derivative: $x''(t) = v'(t) = a(t)$
  - The following are mathematical consequences of constant acceleration:

    $$v = \frac{\Delta x}{t} \qquad v_f = v_0 + at \qquad v_f^2 = v_0^2 + 2a\Delta x \qquad x_f = x_0 + v_0 t + \frac{1}{2}at^2$$

  - These equations can be generalized to two dimensions (or 3 or 4, for that matter). 2-dimensional kinematics are used to understand the path of projectiles.
- Conservation of Momentum
  - A mass, m, moving at a velocity, v, has a momentum defined as $\rho = mv$.
  - Momentum is conserved in the universe in all cases. We use this law to understand collisions.
  - Collisions can happen in 1 or more dimensions. For each dimension, $\rho_\circ = \rho_f$.
- Mechanical Energy
  - A mass in motion has energy associated with that motion; Kinetic Energy (KE)
  - A mass in a gravitational field has an energy associated with its position;
    Potential Energy (PE)
  - These two scalar quantities together comprise the mechanical energy of an object.
    $$\text{KE} = \frac{1}{2}mv^2 \qquad \text{PE} = mgh$$
  - Under ideal conditions (conservative forces, no friction) we can use conservation of mechanical energy to understand some things about the motion of a mass.
  - Conservation of mechanical energy:

    $$\text{KE}_\circ + \text{PE}_\circ = \text{KE}_f + \text{PE}_f$$

  - Energy is always conserved in the universe, but mechanical energy may not always be conserved. Energy can be transformed into heat, work, light, or other forms.
  - In more advanced formulations of mechanics (like you would see in advanced undergraduate physics), the motion of a body is determined by minimizing the function $L(x(t), x'(t), x''(t), m) = \text{KE} - \text{PE}$. In other words, the path a particle will take in nature minimizes the difference of kinetic and potential energies.

Homework:
Who was Isaac Newton and what are his three laws? 1 page max *IN YOUR OWN WORDS*.