Duke University
Department of Physics

Physics 361 Spring Term 2020

WUN2K FOR LECTURE 1

These are notes summarizing the main concepts you need to understand and be able to apply.

- **Newton's Laws**

  Concisely, in their most quantitatively useful form, Newton's three laws are as follows:

  > I. A particle maintains constant velocity if there are no external forces on it (the "law of inertia"; it follows from the second law).
  >
  > II. $\vec{F} = \frac{d\vec{p}}{dt} = m\vec{a}$, where $\vec{p} = m\vec{v}$ is *momentum*.
  >
  > III. $\vec{F}_{1,2} = -\vec{F}_{2,1}$, i.e., the force on particle 1 due to particle 2 is equal in magnitude and opposite in direction to the force on particle 2 due to particle 1 (the "law of action and reaction").

- The **equation of motion** for a particle is a *differential equation* following from Newton's second law, $\vec{F} = m\ddot{\vec{x}}$, with the relevant forces applied. The solution to the equation of motion describes the motion of the particle ($\vec{r}(t)$, $\vec{v}(t) = \dot{\vec{r}}$, $\vec{a}(t) = \dot{\vec{v}}(t) = \ddot{\vec{r}}(t)$). The equations are typically solved for each component separately. We can solve many problems by appropriate setup and solution of the equations of motion.

- The law of **conservation of momentum** states that *if* the net external force on a system of particles is zero, then the system's total momentum $\vec{P}$ is constant. This principle is equivalent to Newton's third law.

- **Inertial mass** is the mass determining the acceleration of a body under the action of a given force. **Gravitational mass** is the mass determining gravitational forces between a body and other bodies. (The

principle of equivalence is the assertion that these are the same, which is subject to experimental test; so far, it's passed the tests.)

- A reference frame (coordinate system) is an **inertial frame** if Newton's laws are valid in it.