Study Guide for Test 2

Newton's first law: An isolated object (with no outside influences acting on it) moves in a straight line at constant speed.

Newton's second law: The acceleration of an object is determined by the vector sum of all the forces acting on it. More precisely,

$$\sum F_x = ma_x \qquad \sum F_y = ma_y \qquad \sum F_z = ma_z$$

Newton's third law: When two objects, A and B, interact, the forces they exert on each other are always equal in magnitude and opposite in direction:

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

Newton's laws work only in an inertial reference frame, that is, when we measure all velocities and accelerations with respect to a reference frame that is not itself accelerating.

Every force on an object arises from an interaction with some other nearby object (called the "agent" of the force). If a force has no agent, it's not a real force.

Types of forces:

- Contact forces
  1. compression (including "normal")
  2. tension (same at each end of an ideal string)
  3. friction (gripping, $|\vec{F}_f| \le \mu_{\text{gr}}|\vec{F}_N|$; slipping, $|\vec{F}_f| = \mu_{\text{sl}}|\vec{F}_N|$; also air resistance, etc.)
- Long-range forces
  1. gravity or "weight", $|\vec{F}_g| = mg$, where $g = 9.8$ N/kg near earth's surface
  2. electromagnetic

$$(\text{Center of mass of a system}) = \vec{r}_{\text{cm}} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + \cdots}{m_1 + m_2 + \cdots} \qquad \text{(weighted average of the positions)}$$

Motion of center of mass: $\sum \vec{F}_{\text{external}} = M_{\text{total}}\,\vec{a}_{\text{cm}}$

Momentum $= \vec{p} = m\vec{v}$

Momentum conservation: $\sum \vec{p}_f = \sum \vec{p}_i$ (for any isolated system) *Note*: This is a vector equation, so it must be broken into components in solving problems: $\sum p_{f,x} = \sum p_{i,x}$, and similarly for y, z.

You should be able to do the following:

- Draw qualitatively accurate force diagrams, identify the type and agent of each force, identify third-law partners.
- Solve "constrained motion" problems involving straight-line or circular motion of a single object or multiple interacting objects.
- Recognize non-inertial reference frames (accelerating cars, elevators, etc.) and instead analyze problems from the viewpoint of an inertial reference frame.
- Solve momentum-conservation problems in one or two dimensions.

Although this test will cover mainly the ideas listed here (and covered on Problem Sets 4–6), you are still responsible for material covered on the first test (Problem Sets 1–3). Note that the equations for constant acceleration and for uniform circular motion tend to come up frequently in constrained motion problems.