Study Guide for 2nd Midterm for Calculus-Based Physics-1: Mechanics (PHYS150-01)

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1 Vectors and Newton's Laws

1. Practice the following skills with vectors: a) calculating the magnitude when the vector is given in algebraic form b) Summing vectors (as when obtaining net force) c) calculating the angle between two vectors using the dot product.

   The dot product for vectors $\vec{f_1} = f_{1\mathrm{x}}\hat{i} + f_{1\mathrm{y}}\hat{j}$ and $\vec{f_2} = f_{2\mathrm{x}}\hat{i} + f_{2\mathrm{y}}\hat{j}$ is $\vec{f_1} \cdot \vec{f_2} = f_{1\mathrm{x}}f_{2\mathrm{x}} + f_{1\mathrm{y}}f_{2\mathrm{y}}$. The magnitude $|\vec{f_1}|$ of a vector $\vec{f_1}$ is $\sqrt{\vec{f_1} \cdot \vec{f_1}}$ (Pythagorean theorem). If θ is the angle between two vectors $\vec{f_1}$ and $\vec{f_2}$, then $\vec{f_1} \cdot \vec{f_2} = |\vec{f_1}||\vec{f_2}|\cos\theta$

2. Practice drawing a free-body diagram that includes all *external* forces on the *system*. Understand that centripetal force is not an *external* force, but a force that describes circular motion and is supplied by some external effect like gravity.

3. Practice drawing a free-body diagram that describes an object on an incline plane.

2 Restoring Forces and Young's Modulus

1. The Young's Modulus of a material, Y is given in the following form:

   $$\frac{x}{L} = \frac{p}{Y} \tag{1}$$

   The *pressure*, p, is the applied force (either squeezing or stretching in a linear fashion) to a material, divided by the cross-sectional area of the material:

   $$p = \frac{F}{A} \tag{2}$$

   The resulting change in length is x, and the original length is L. The ratio x/L is known as the *strain*, or the fractional change in length of an object. The units of pressure are *Pascals* or N/m^2, and strain has no units. We can remember the helpful phrase:

   $$stress = Y \times strain \tag{3}$$

   Stress is pressure, and Y has units of pressure.

3 Frictional Forces

1. Practice drawing free-body diagrams that include frictional forces. What should be the direction of the frictional force?

2. Let N be the magnitude of the normal force. If a frictional force is *static*, then the magnitude of that force is $f_{\mathrm{f,s}} = \mu_{\mathrm{s}}N$. If the frictional force is *kinetic*, then the magntidue of that force is $f_{\mathrm{f,k}} = \mu_{\mathrm{k}}N$. Usually, $\mu_{\mathrm{k}} < \mu_{\mathrm{s}}$.

3. We encountered two forces of friction not associated with surface contact: drag forces. One drag force was given by Stoke's Law: $F_{\mathrm{D}} = 6\pi r\eta v$.

   - r is the radius of the object moving through the medium in meters.
   - η is the *viscosity* of the fluid in kg/(m s).
   - v is the velocity of the object in m/s.
   - The force points in the opposite direction of velocity.

4. One other drag force was given by the following: $F_{\mathrm{D}} = \frac{1}{2} C \rho A v^2$.
    - C is a dimensionless empirical constant (usually close to 1).
    - ρ is the density of the fluid or gas through which the system moves, in kg/m^3.
    - A is the cross-sectional area of the system moving through the fluid or gas, in m^2.
    - v is the system velocity in m/s.