Physics 111 Spring 2016
Final Exam Review Problems

1. **(Newton's Laws, Vectors, Friction, FBDs)** A 48-kg crate is placed on an inclined ramp. When the angle the ramp makes with the horizontal is increased to 26º, the crate just begins to slide downward.
   a. Draw a free body diagram for the crate and the ramp when the ramp is at this 26º angle.
   b. What is the coefficient of static friction between the crate and the ramp?
   c. At what angle would the crate begin to slide if the mass of the crate were doubled?

   Strategy: Draw all forces as arrows acting on a dot (FBD), choose x- and y-direction. Break up any forces into x- and y-components (vectors), then use $\Sigma F_x = 0$ and $\Sigma F_y = 0$ (Newton's laws and statics) to solve for μ in part b and θ in part c.

2. **(Torque and Statics)** A schoolyard seesaw with a total length of 5.2 m and a mass of 38 kg is pivoted at its center. A 19-kg child sits on one end of the seesaw.
   a. Where should a parent push vertically downward with a force of 210 N in order to hold the seesaw level with the ground?
   b. Where should the parent push with a force of 310 N?
   c. How would your answers to parts a. and b. change if the mass of the seesaw were doubled? Explain your reasoning.

   Strategy: Draw forces as arrows acting on a rectangle (torque FBD) and draw lever arms pointing from pivot point to where forces act. Use $\Sigma \tau = 0$ (statics) to find the lever arm in parts a and b.

3. **(Linear Kinematics and Graphs)** In heavy rush-hour traffic you drive in a straight line at 12 m/s for 1.5 minutes, then you have to stop for 3.5 minutes, and finally you drive at 15 m/s for another 2.5 minutes.
   a. Plot a v vs. t graph for this motion. Your plot should extend from t = 0 min to t = 7.5 min.
   b. Use your v vs. t graph to determine the total displacement for the whole trip.
   c. Plot an x vs. t graph for this motion. Your plot should extend from t = 0 min to t = 7.5 min.
   d. Use your x vs. t graph to determine the average velocity for the whole trip.

   Strategy: For motion plots, the x-axis represents time and the y-axis represents either x, v, or a depending on the quantity asked for. Remember that the slope of a position graph is the velocity at that time, and that the area under a velocity graph gives the total displacement during that time span.

4. **(Buoyancy)** A 3.5 kg balloon is filled with helium ($\rho_{He} = 0.179$ kg/m^3). If the balloon is a sphere with radius 5.3 m, what is the maximum weight it can lift? Assume the density of air is $\rho_{air} = 1.225$ kg/m^3.

   Strategy: Use Archimedes' principle to determine the weight of the air that the balloon displaces (recall that the volume of the balloon determines the volume of air displaced). This is the buoyant force. Draw an FBD of the balloon supporting some weight, and determine what would happen if the balloon was supporting less than the maximum weight it could lift, exactly the maximum weight it could life, or more than the maximum weight it could lift.

5. **(Rotational Kinematics)** The angular speed of a propeller on a boat increases with constant acceleration from 11 rad/s to 28 rad/s in 2.4 seconds.
   a. What is the angular acceleration of the propeller?
   b. Through what angle did the propeller turn during this time?

   Strategy: Define known quantities given in the problem, and unknowns in parts a and b. Choose which rotational kinematics equation is most appropriate given your knowns and unknowns.

6. **(Standing sound waves, harmonics, and interference)**
    a. Sketch the first three harmonic standing wave patterns for an open-open tube and an open-closed tube. Label the locations for each harmonic that are experiencing constructive interference (antinodes) and destructive interference (nodes).
    b. Assuming both tubes are 0.75m in length, find the wavelengths and frequencies for each harmonic that you sketched.

Strategy: Remember that with tubes of air with standing sound waves, the harmonics must all be experiencing either constructive interference (if the tube is open at that end) or destructive interference (if the tube is closed at that end). Use the formulae on the equation sheet to calculate the harmonic frequencies, and $\lambda \times f = v_{sound}$ to calculate the wavelengths.