Recitation - Exam 3 Guide

Week 11 Day 2

During today's recitation, you will revisit problems from Exam 3. Despite the things we have done that are similar, it seems that many students did not know how to approach these problems.

Thus, we want to spend some extra time on this material, mixing in another idea from rotational motion as we do.

To begin with, we want you to do at least two of the questions from Exam 3 with your group during this recitation. We will help you; this is not an exam any more.

In the future, we want you to be able to figure out how to analyze situations on your own. However, to aid you, here is a brief guide to the situations on your exam. Note that none of the steps should take you more than 3-4 lines of algebra; if they do, it is an indication that you're doing something "the hard way".

1. **Problem 1 (Dog and Boat: Techniques in Combination)**
   (a) You know the kinetic energy of the dog once he jumps off the boat. From this you can determine his velocity.
   (b) You want to determine the dog's trajectory to see where he lands in the water. You should use 2D kinematics to do this.
   (c) Since the dog jumping off of the boat is an "explosion" (one object separating into two), you should use the conservation of momentum to determine the relationship between the dog's velocity and the boat's velocity. With that relationship, and knowing the combined kinetic energy, you can determine what the dog's velocity is. It should be less than in (a), since some of the kinetic energy goes into moving the boat.
   (d) This is just like part (b), but with a different starting velocity for the dog.

2. **Problem 2 (Electric Car: Energy, Work, and Power)**
   (a) You know that γv^2 gives you a force. You know the units of force and velocity; determine what units γ must have to make both sides of the equation have the same units.
   (b) You know that at top speed, the motor is producing 180 kW of power – doing positive work at the same rate that the drag force does negative work. Since you know that power is $\vec{F} \cdot \vec{v}$, and you know the relationship between the drag force and velocity, you can determine γ.
   (c) You know the total amount of work that the motor can do before the batteries are drained. Since work is force dot distance, and since the force depends on velocity, you can determine the velocity. Note that the power here is not the maximum power of the engine.
   (d) You know power is force dot velocity. Since you know how the force depends on velocity, you can determine the power required.

3. **Problem 3 (Skateboarder: Work-Energy Theorem)**
   (a) Use the work-energy theorem from the starting point on the left to the highest point reached on the right. You may either think about gravity as a force that does work or as a force associated with a potential energy. You will need to determine the work done by friction, which is the dot product of the frictional force with the displacement during the part of the motion where friction applies.

(b) Use the work-energy theorem to relate the starting point on the left to the ending point back on the left side. You will need to determine the total work done by friction as the skateboarder crosses the sand both ways.

(c) This is easiest if you think about energy conversion. The only nonconservative force here is friction. You can determine the starting gravitational potential energy (in joules) and how many joules of energy are lost each time the skateboarder crosses the sandy region with friction.

4. **Problem 4 (Astronaut: Conservation of Momentum)**

   This is a collision, so you should use the conservation of momentum.

   Use conservation of momentum in the x-direction to determine the x-component of the tool's initial velocity, then do the same in the y-direction to determine its y-component.

   Then, once you know the tool's initial velocity in the x- and y-directions, use trigonometry to convert the vector to an angle-and-magnitude representation.