PHYSICS 1050: Assignment #12

DUE: Monday April 11, 2016

Readings:

- Chapter 7 of Franklin et al.
- Chapter 8 of Franklin et al.
- Chapter 9 of Franklin et al.
- Chapter 37 of Franklin et al.
- Chapter 38 of Franklin et al.
- Chapter 39 of Franklin et al.

Problems:

- include name or PIN;
- staple your assignment;
- show all your work;
- all answers are to have three significant figures unless stated otherwise.

1. **Problem 6.2 on page 61**

2. **Problem 6.4 on page 61**

3. **Roller skating is dangerous**
   Experimental tests have shown that bone will rupture if it is subjected to a force density (i.e. pressure = force divided by area) of $1.0 \times 10^8 N/m^2$. Suppose a 70.0 daN person carelessly rollerskates into an overhead metal beam that hits his forehead and completely stops his forward motion. If the area of contact with the person's forehead is 1.5 cm^2, what is the greatest speed with which he can hit the wall without breaking any bone if his head is in contact with the beam for 10.0 ms?

4. **Rapid dance moves**
   Squids and octopuses propel themselves by expelling water. They do this by taking the water into a cavity and then suddenly contracting the cavity, forcing the water to shoot out of an opening. A 6.50 daN squid (including the water in the cavity) that is at rest suddenly sees a dangerous predator.

   (a) If this squid has 1.75 kg of water in its cavity, at what speed must it expel the water to suddenly achieve a speed of 2.50 m/s to escape the predator? Neglect any drag effects of the surrounding water.

   (b) How much kinetic energy does the squid create for this escape maneuver?

5. **Men and Women are from Earth**

   (a) Suppose 10 astronauts are sent to Mars and then back to Earth. The average power usage of each astronaut is 10,000,000 joules per day. What is the average power usage of each astronaut in watts and horsepower?

   (b) It will take approximately 2 years for the astronauts to make the round trip. The average astronaut has a mass of 70.0 kg. Assume the astronauts are on a fat-free diet. Carbohydrates and proteins on average produce approximately 17,300,000 joules of energy per kilogram. How much mass of food do the astronauts need to take with them? Note that we are assuming that 100% of the food calories that are eaten are absorbed and used by the body. This is actually not true. A person's metabolic efficiency" is the percentage of calories eaten that are actually used; the rest are eliminated by the body. Metabolic efficiency varies considerably from person to person. This means that the mass of food calculated is an underestimate of what would be needed.

   (c) 1 food calorie (Cal) = 1 kilocalorie (kcal) = 1,000 calories (cal) = 4,184.5 joules of food requires approxiamtely 0.000248 kg of oxygen for the body to metabolize the food. How many kilograms of oxygen are required for the trip?

   (d) Assume it costs $10,000,000 to send 1 kg to Mars. How much will it cost to send the astronauts, their food and oxygen to Mars?

   (e) Assume 15% of the energy goes into mechanical energy, how much mechanical work will the 10 astronauts do over the 2 years?

6. **The flying professor**
   Professor Vos was sitting on a rotating stool in front of the class. He is holding in each hand a 5.0 daN weight at a distance of 80.0 cm from the axis of rotation of the stool. He has an angular velocity of 3.00 rad/s, after which he pulls the weights in until they are only 20.0 cm from the axis of rotation. Neglect friction in the stool.

   (a) Treat the weights as point masses. Calculate the moment of inertia for the two weights while extended from the body and then when pulled in against the body.

   (b) Assume Profesor Vos has a weight of 95.0 daN, his head is a sphere with a radius of 15.0 cm and 7.00% of the body weight. What is the moment of inertia of his head?

   (c) Assume Profesor Vos has a weight of 95.0 daN, his body and legs are a solid cylinder with a radius of 25.0 cm and 80.0% of the body weight. What is the moment of inertia of his body?

   (d) Assume Profesor Vos has a weight of 95.0 daN, and his arms when extended are a rod of length 90.0 cm and 13.0% of the body weight. What is the moment of inertia of his extended arms?

   (e) Assume Profesor Vos has a weight of 95.0 daN, and his arms when pulled into the body are a hoop with a radius of 15.0 cm and 13.0% of the body weight. What is the moment of inertia of his arms when pulled in?

   (f) What is the initial angular momentum of the system?

   (g) What is Professor Vos' final angular velocity after the weights are pulled in?

   (h) Calculate the kinetic energy of the system before and after the weights are pulled in. Account for the difference, if any.