Physics 2211 GPS Week 11

Problem #1

After watching "The Big Lebowski" for the first time this summer, you and a friend get into an argument about how much ice to add when making the perfect white russian cocktail. You both agree that, for optimum taste, the cocktail should be enjoyed at 10 degrees Celsius. The two ingredients for the cocktail, cream and a "vodka & kahlua" mix, both leave the fridge at 15 degrees Celsius. Ice from a standard freezer is at a temperature of -10 degrees Celsius. If typical white russian calls for 0.06 L of cream and 0.14 L of the "vodka & kahlua" mix, how much ice is needed to bring the drink down to its optimum temperature?

Ice: density = 0.91 kg/L, C = 4.18 J/(Cg)
Mix: density = 0.8 kg/L, C = 2.44 J/(Cg)
Cream: density = 1 kg/L, C = 3.77 J/(Cg)

Problem #2

During 3 hours one winter afternoon, when the outside temperature was 11° C, a house heated by electricity was kept at 25° C with the expenditure of 58 kwh (kilowatt·hours) of electric energy.

(a) What was the average energy leakage in joules per second (watts) through the walls of the house to the environment (the outside air and ground)?

(b) The rate at which energy is transferred between two systems due to a temperature difference is often proportional to their temperature difference. Assuming this to hold in this case, if the house temperature had been kept at 28° C (82.4° F), how many kwh of electricity would have been consumed?

Problem #3

Consider a system consisting of two particles connected by a spring of negligible mass:
$m_1 = 5$ kg, vector $\vec{v}_1 = \langle 5,\ -10,\ 15 \rangle$ m/s
$m_2 = 10$ kg, vector $\vec{v}_2 = \langle -10,\ 0,\ -5 \rangle$ m/s

(a) What is the total momentum $\vec{p}_{total}$ of this system?

(b) What is $\vec{V}_{CM}$, the velocity of the center of mass of this system?

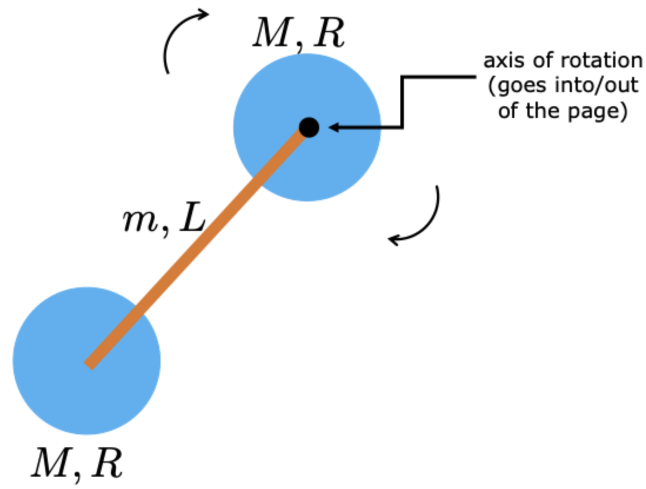
(c) What is K_{trans}, the translational kinetic energy of this system?

(d) What is K_{total}, the total kinetic energy of this system?

(e) What is K_{rel}, the kinetic energy of this system relative to the center of mass?

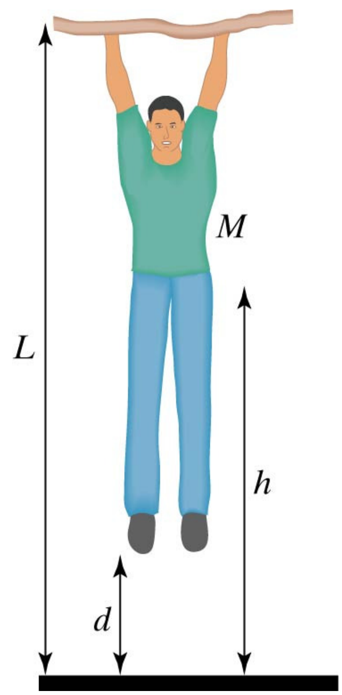
Problem #4

A barbell is made up of two solid spheres of mass M and radius R whose centers are attached to the ends of a thin rod that has mass m and length L. The entire thing rotates about an axis that goes through the center of sphere 1. Determine the total moment of inertia of the barbell about this axis of rotation. Hint: remember the parallel axis theorem.



Problem #5

You hang by your hands from a tree limb that is a height $L = 6$ m above the ground, with your center of mass a height $h = 5$ m above the ground and your feet a height $d = 4$ m above the ground, as shown in the figure (not to scale). You then let yourself fall. You absorb the shock by bending your knees, ending up momentarily at rest in a crouched position with your center of mass a height $b = 0.25$ m above the ground. Your mass is $M = 110$ kg. Hint: this problem is like the lemur problem from the homework, but backwards.



(a) Starting from the energy principle, find your speed just before your feet touch the ground.

(b) Starting from the energy principle (point particle model) and assuming that the contact force of the ground on your feet is constant, find the magnitude of the contact force during your landing.

(c) What is the (real) work done by the contact force?

(d) Starting from the energy principle (real model), find the change in your internal energy during landing.