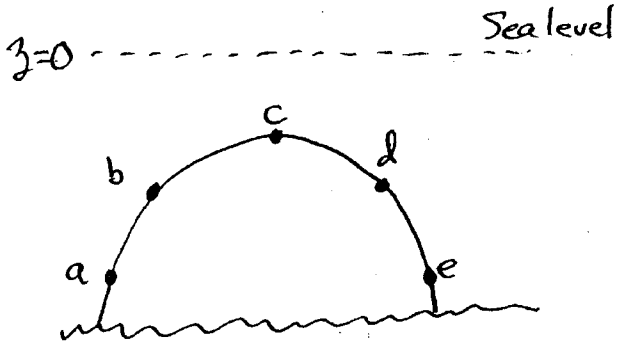
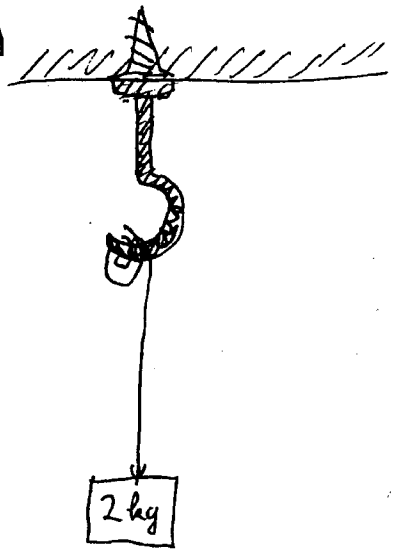
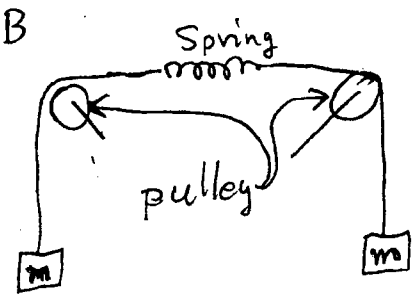
(5)



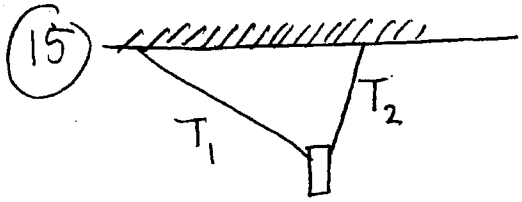
(12) A



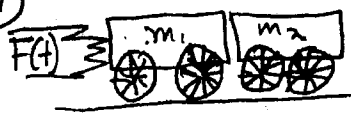
(12) B



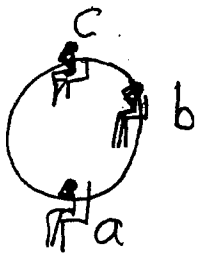
(15)



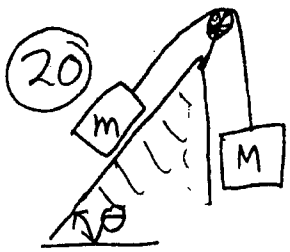
(17)



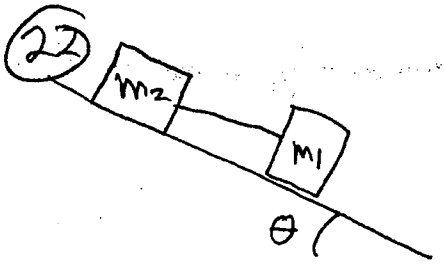
(18)



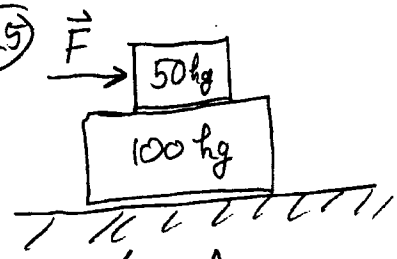
(20)



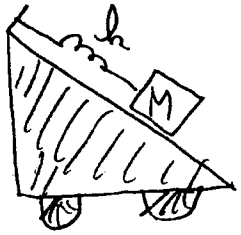
(22)



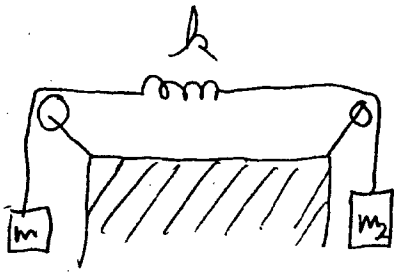
(25)



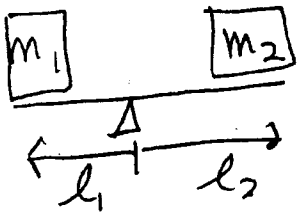
(26)



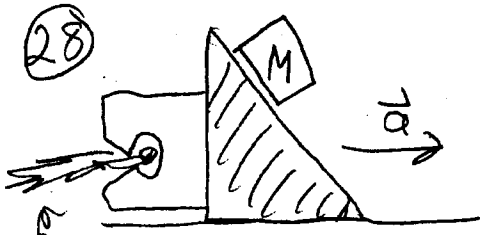
(27)



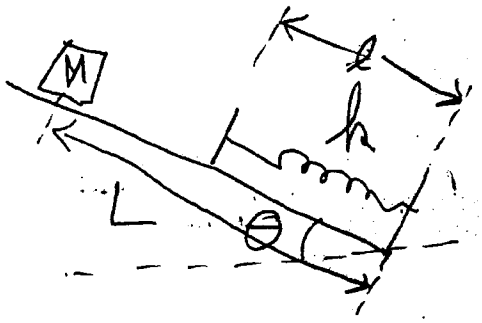
(42)



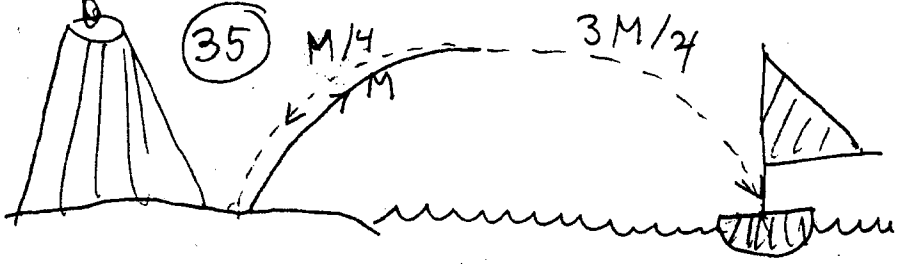
(28)



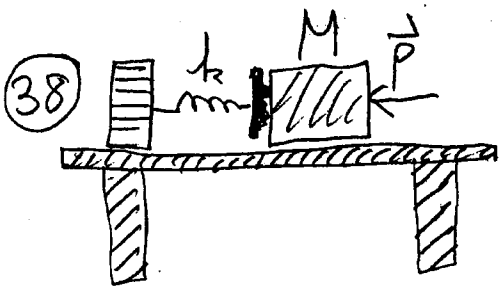
(44)



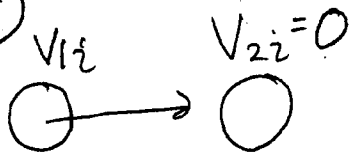
(35)



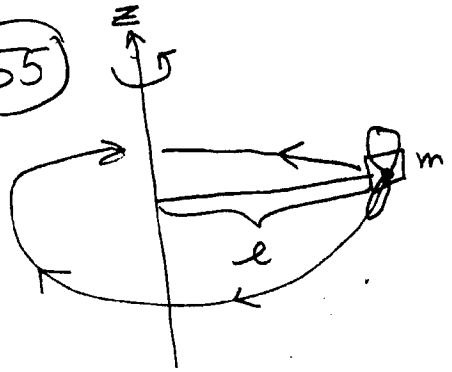
(38)



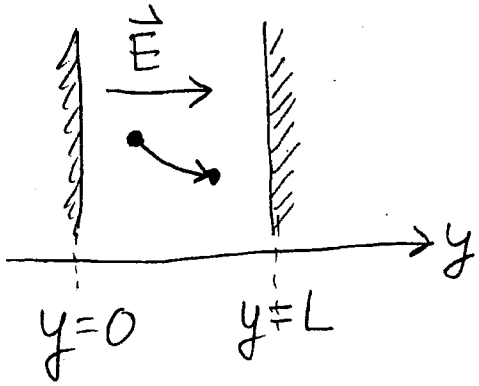
(49)



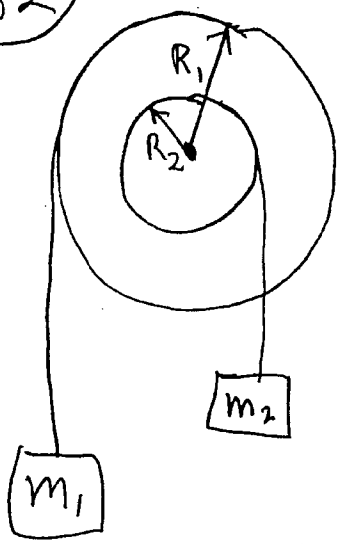
(55)



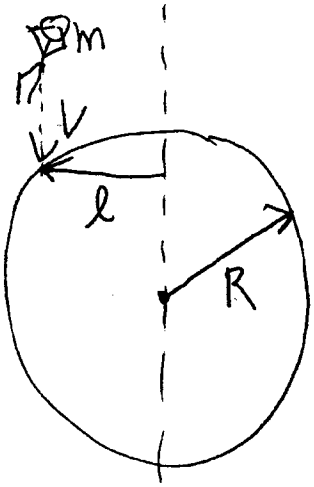
(41)



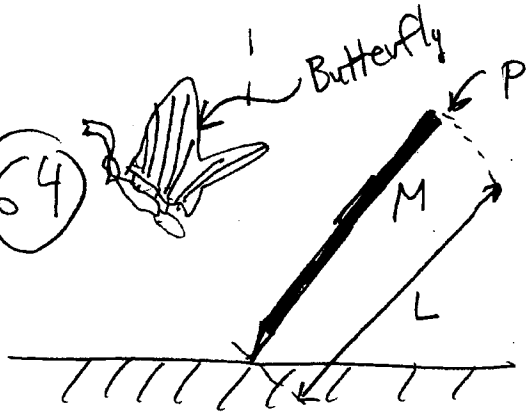
62



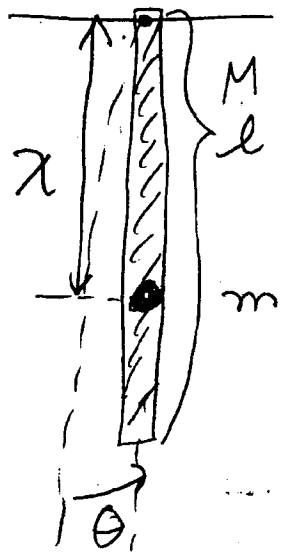
63



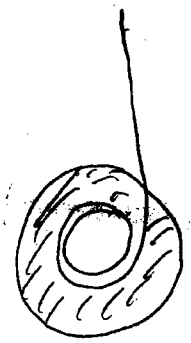
64



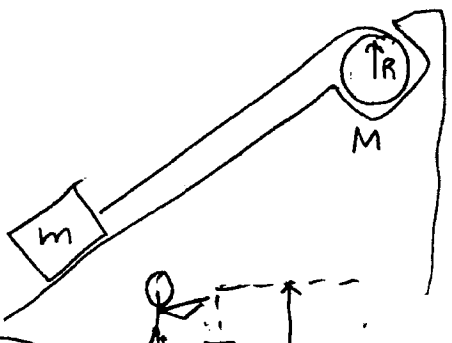
65



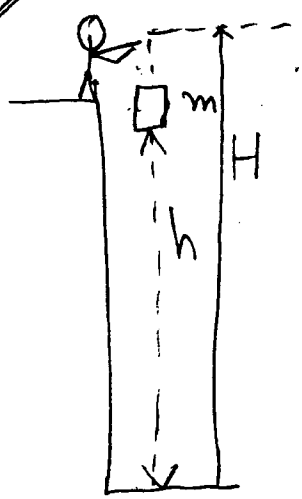
67



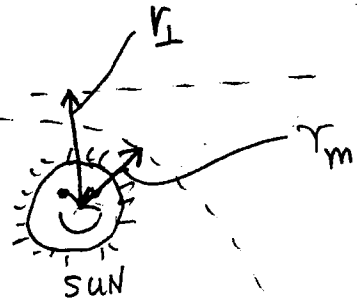
68



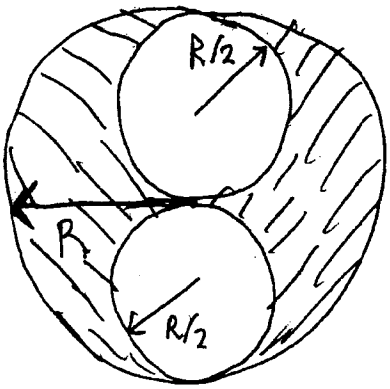
69, 70



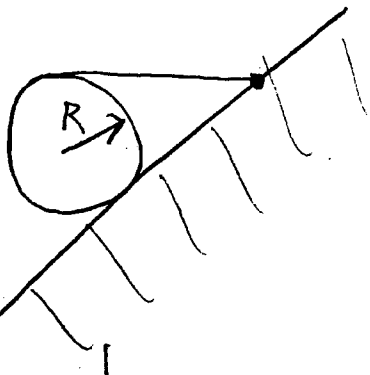
72


r_1
r_m
SUN

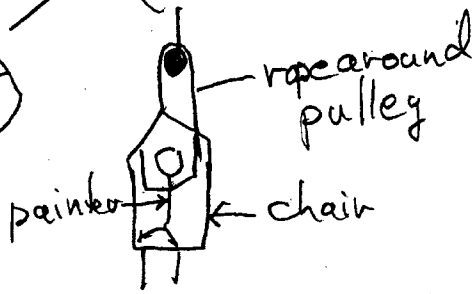
73


R/2
R
R/2

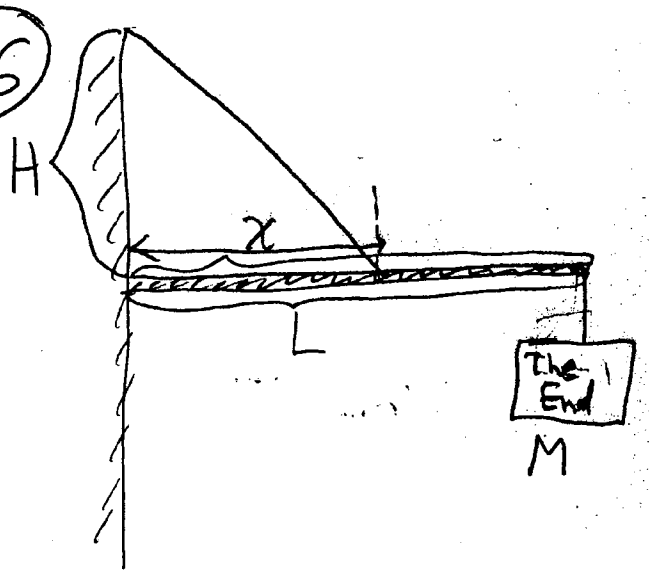
74


R

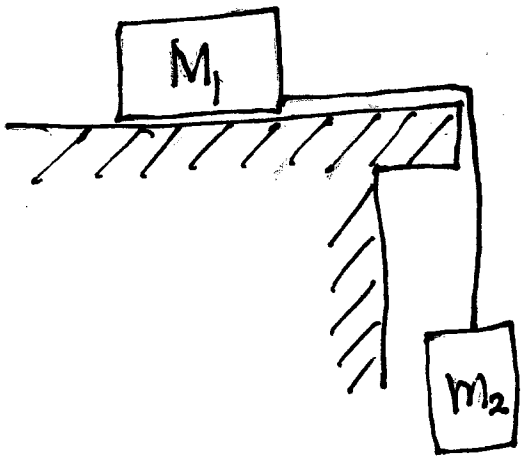
75


rope around pulley
painter
chair

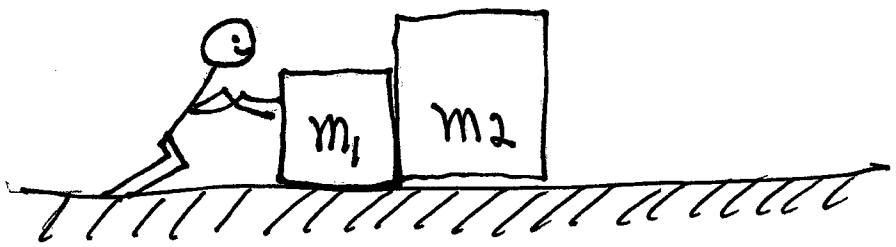
76


H
x
L
The End
M

A-13



A-14



Physics 1111

Term C 201

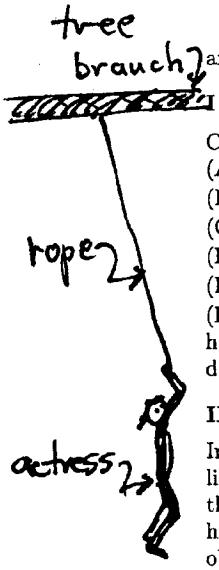
First Hour Examination

This is the first hour examination. The examination lasts for 50 minutes. There are three questions, for a total of 100 points, and two bonus problems.

This is a closed book examination. You may not use books, notes, or reference materials during this examination. You may use a pocket calculator to perform numerical calculations.

Record your answers in the blue books (provided). Begin from first principles, e.g.,

$$\vec{F} = m\frac{d^2\vec{r}}{dt^2} \tag{1}$$



Show all work. If you do not show your work, you will in general receive little or no credit for your answer. (In a few cases, there is rather little work to show.)

I [Total of 20 points]

Consider the three vectors $\vec{A} = -2\hat{i} + 3\hat{j} - 4\hat{k}$, $\vec{B} = 4\hat{i} - 6\hat{k}$, and $\vec{C} = \hat{i} + 6\hat{j}$.

(A) (3 points) Compute $\vec{A} + \vec{B}$.

(B) (2 points) What is the y-component of $\vec{A} + \vec{B}$?

(C) (3 points) Compute $\vec{A} - \vec{C}$.

(D) (4 points) Compute $\vec{A} \cdot \vec{B}$.

(E) (4 points) Compute $\vec{A} \times \vec{B}$.

(F) (4 points) If the vectors represent displacements, and an object is moved through $2\vec{A} + \vec{B} - \vec{C}$, how far has the object been moved in the z-direction? (We are using SI units here.) For 4 extra points, after the displacement, where (using only information in this problem) is the object with respect to the origin?

II [30 points]

In yet another scene from our interminable motion picture, the heroine is escaping from a pride of hungry lions by using a conveniently placed rope to swing across a bottomless gorge. At the bottom of her swing, the rope is stretched vertically downward. Note sketch. For this moment, give the force diagram for the heroine. For each force in your diagram, identify **in one or more complete sentences** the force, the object on which the force is acting, the physical nature of the force, and the object exerting the force. For each force in your diagram, identify the reaction force. For each reaction force identify **in one or more complete sentences** the force, the object on which the force is acting, the physical nature of the force, and the object exerting the force.

III [30 points]

The rocket ship from the homework is being brought for a landing. It has a constant acceleration until it is brought to a stop, some distance above the ground. At times 1, 2, and 4, respectively, the rocket ship was at altitudes 91, 84, and 76 m, respectively. Write the altitude of the ship in the exact form

$$z(t) = z_0 + v_0 t + 0.5at^2$$

including giving numerical values for z_0, v_0, and a.

IV [20 points]

The new and improved rocket car has been given a new engine. The force that the engine applies on the car, over the time of interest, increases with time as $\vec{F}(t) = F_0 t^2 \hat{i}$. Here F_0 is a constant. The rocket car with engine has mass m. The rocket car is parked on flat horizontal ground. Find the force diagram. Find the acceleration of the rocket car, the velocity of the rocket car, and the position of the rocket car as functions of time.

Bonus [6 points] Assuming that the length of rope between the pivot point and the heroine's hands is 20 m, at the bottom of the swing the heroine is travelling at 15 m/s, and the heroine with body armor and other equipment masses 70 kg, find the tension in the rope.

Bonus [4 points]

What was my advice in the course syllabus about memorization?

Physics 1111
Term C 2014
Second Hour Examination

This is the second hour examination. The examination lasts for 50 minutes. There are three questions, for a total of 100 points, and a bonus problem. This is a closed book examination. You may not use books, notes, exam partners, or reference materials during this examination. You may use a pocket calculator to perform numerical calculations. Record your answers in the blue books (provided). Begin from first principles, e.g.,

$$\vec{F} = m\frac{d^2\vec{r}}{dt^2} \tag{1}$$

Show all work. If you do not show your work, you will in general receive little or no credit for your answer. (In a few cases, there is rather little work to show.) There is no requirement that you solve the parts of a problem in the order that I ask them.

I [Total of 45 points]

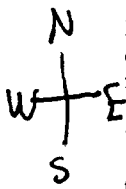
Two mountain climbers are connected by a long rope. The climber having mass m_2 is hanging over the edge of a fortunately short cliff. The climber on mass m_1 is lying on a horizontal, ice-coated, frictionless ledge. The climber on the ledge is also hanging on to another rope, attached to an immoveable tree. Unfortunately, the second rope is made of a new material that in cold weather becomes elastic; it turns into a spring having spring constant k. The unstretched length of the spring is L. The two ends of the spring are at $x = -L$ and $x = X_1$, where X_1 is the location of the climber on the ledge. If the climber were at $x = 0$ the spring would be unstretched.

A) (5 points) Find the force diagrams for the two climbers.

B) (20 points) Solve for the acceleration of the two climbers and the tension in the rope connecting them.

C) (5 points) Is the acceleration of the climbers a constant (that is, is it independent of time)? Why or why not(one sentence is plenty as an answer here)?

D) (15 points) The two climbers start out stationary, with climber m_1 at X_A. Somewhat later, climber m_1 has been dragged to point X_B, where she is about to go over the edge. How fast is she moving when she reaches X_B? Hint: Note Part C of this question.



II [30 points] It is a typical winter day in Worcester, and the interesting drivers are out in full force. A 2000 kg car proceeding due east on Salisbury street at 5 m/s enters the intersection at the same time as a 3000 kg SUV. The SUV was traveling due north at 10 m/s.

(A) (15 points) After the collision, the two vehicles have stuck to each other. Assuming no significant mass loss, calculate the velocity (speed and direction) of the stuck-together vehicles immediately after the collision.

(B) (15 points) A second pair of vehicles, identical with the first pair, enter the intersection. This pair of vehicles is being filmed for our interminable motion picture, and various spring bumpers, explosive charges, etc. as needed have been mounted on the two automobiles, as may or may not have been needed, so as to ensure that the two vehicles bounce off each other as required by the script. After the collision, the first car is proceeding due north, and the second car is proceeding due east. How fast are they each moving? Was this collision elastic or inelastic?

III [30 points]

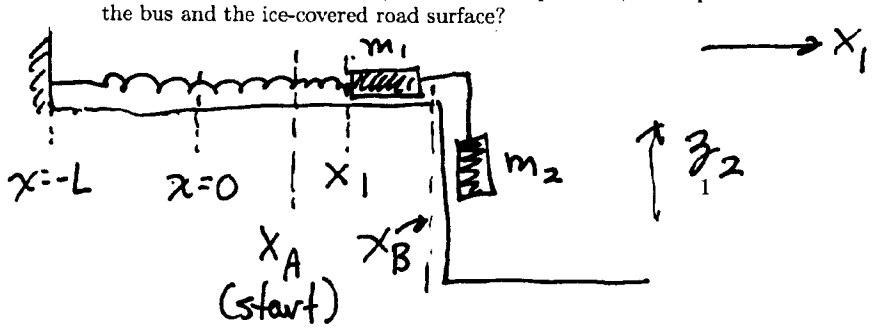
(30 points) A large, flat 1000 kg rock moves virtually without friction over the ice surface of a skating rink. The rock is attached to a nonlinear spring that over the range of interest delivers on the rock a force

$$F_y(y) = -2y - 3y^2 - 4y^3 \tag{2}$$

The rock is initially at $y = 5$. The rock is moving in the $+y$ direction. At $y = +8$ the rock is brought to a stop by the spring. (A) How fast was the rock moving when it reached y= +6? (B)How fast was the rock moving initially, when it was at $y = +5$?

Bonus [10 points]

A small bus is proceeding downhill on my street. To the great alarm of the driver, the brakes are floored, the wheels are locked and not turning, and the bus is sliding at constant speed down the hill. The bus has a mass of 6,000 kg. Across the 115 foot width of my property, the street drops 7 feet; the slope is constant. What is the constant of kinetic friction between the bus and the ice-covered road surface?



Physics 1111

Term A 2013

Third Hour Examination

This is the third hour examination. There are three questions and a bonus. This is a closed book examination. You may not use calculators, notes, reference books, crib sheets, or other material memory aids in your work. You may not consult with other persons during the examination, except to ask a proctor questions.

Record your answers in the blue books (provided). Begin from first principles, e.g., $F = m\frac{d^2\mathbf{r}}{dt^2}$. Show all work. Physics is a matter of praxis, not faith. You will be graded primarily on how you reached your answers.

I. (Total of 35 points)

We have an Atwood machine apparatus, which you should find familiar. (Figure A) The two masses are M and m; the pulley wheel has mass P, radius R, and moment of inertia I. The rope connecting the masses is sufficiently light that its mass can be neglected. You have been provided with a gadget that measures the tension in a string. You use it to measure the tension in the string at the points labeled "A" and "B". If you measure the tension correctly: What tension do you measure at point "A"? What tension do you measure at point "B"?

II. [Total of 35 points]

In yet another scene from the ongoing adventure movie, the heroine is hanging from the end of the world's longest flagstaff, which is attached near the top of the world's tallest building. The flagstaff is a steel girder having length L and mass M; the end attached to the building is hinged so that it is free to rotate. The flagstaff is initially horizontal. The other end of the flagstaff is held in place by a long wire. The good news in the film is that the heroine, mass m, has just disassembled the villain's world-ending doomsday device, saving the world. The less good news is that the villain has cut the wire and the world's longest flagstaff is about to swing downward.

Figure B shows the flagstaff, heroine, and angle θ marking the position of the flagstaff. Recalling that the moment of inertia of a uniform rod pivoted around one end is $\frac{1}{3}ML^2$, find

A) (5 points) The kinetic energy of the flagstaff and heroine as they swing downward, in terms of their angular velocity $d\theta/dt$.

B) (5 points) The potential energy of the flagstaff and heroine as they swing downward.

C) (5 points) The torque on the flagstaff and heroine, using the location of the hinge as the origin.

D) (10 points) The angular acceleration of the flagstaff and heroine as they swing downward. Does the angular acceleration depend on the time since the wire was cut?

E)(10 points) The angular velocity $d\theta/dt$ of the flagpole at the bottom of its swing.

III. (Total of 30 points)

Two objects of masses m_1 and m_2 are located so that the vector from m_1 to m_2 is $\vec{r} = a\hat{i} + b\hat{j} + c\hat{k}$.

A) (10 points) Find the gravitational force that m_1 exerts on m_2.

B) (10 points) Find mutual gravitational potential energy of m_1 and m_2.

C) (10 points) Show that the potential energy and the gravitational force are related as predicted by the work-energy theorem.

Bonus (10 points) The owners of The Flying Rhino, a local coffeehouse, hang a sign above their front door. (Figure C) The display consists of two very heavy masses M and m that hang by wires from the ends of a rigid, extremely light rod. The rod has length L. The rod is supported by two wires that hang vertically. The wires are connected to the rod at distances $L/4$ from the two ends of the rod. Find the force and torque diagrams for the rod. Find the tension T in the two wires.