

# PHYSICS 218 Final Exam

## Fall, 2009

**Name:** \_\_\_\_\_

**Signature:** \_\_\_\_\_

**E-mail:** \_\_\_\_\_

**Section Number:** \_\_\_\_\_

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- No calculators are allowed in the test.
  - Be sure to put a box around your final answers and clearly indicate your work to your grader.
  - **All work must be shown to get credit for the answer marked. If the answer marked does not obviously follow from the shown work, even if the answer is correct, you will not get credit for the answer.**
  - Clearly erase any unwanted marks. No credit will be given if we can't figure out which answer you are choosing, or which answer you want us to consider.
  - Partial credit can be given only if your work is clearly explained and labeled. **Partial credit will be given if you explain which law you use for solving the problem.**

Put your initials here after reading the above instructions:

For grader use only:

Problem 1 (15) \_\_\_\_\_

Problem 2 (20) \_\_\_\_\_

Problem 3 (20) \_\_\_\_\_

Problem 4 (15) \_\_\_\_\_

Problem 5 (20) \_\_\_\_\_

Problem 6 (15) \_\_\_\_\_

Total (105) \_\_\_\_\_

### Problem 1: (15 points)

A model airplane with mass  $m$  moves in the  $xy$ -plane such that its  $x$ - and  $y$ - coordinates vary in time according to  $x(t) = \alpha - \beta t^3$  and  $y(t) = \gamma - \delta t^2$  where  $\alpha, \beta, \gamma,$  and  $\delta$  are known constants.

a) Calculate the  $x$ - and  $y$ -components of the net force on the plane as functions of time.

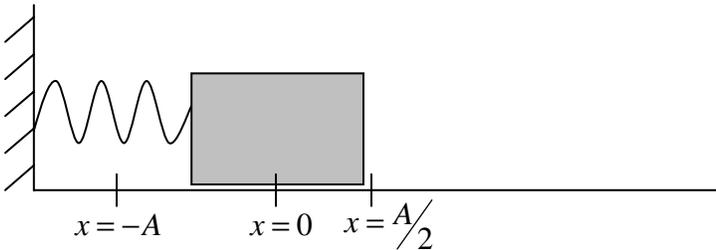
b) Find the angular momentum of the plane about the origin as a function of time.

## Problem 2: (20 points)

A certain spring is found not to obey Hooke's law; it exerts a restoring force  $F_x(x) = -\alpha x - \beta x^2$  if it is stretched or compressed, where  $\alpha$  and  $\beta$  are known constants. The mass of the spring is negligible.

a) Calculate the potential energy function  $U(x)$  for the spring.

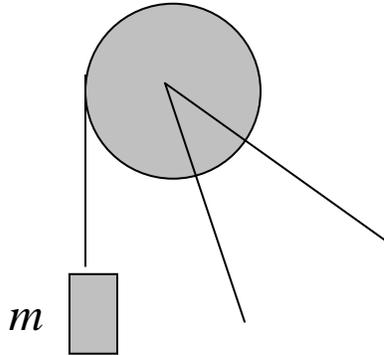
b) An object with mass  $m$  on a frictionless, horizontal surface attached to this spring is pulled a distance  $A$  to the left (in the  $-x$  direction) and then released. If the surface is frictionless, find the velocity of the object when it is  $A/2$  to the right of the equilibrium position.



c) How the answer in b) will change if there is a coefficient of friction between the block and the surface,  $\mu$ . (Assume that the block will reach this point)

### Problem 3: (20 points)

A mass  $m$  is hung from a massless, unstretchable string which is wrapped around a disk with radius  $R$  and mass  $M$ . The string pulls without slipping.



a) If the axle is frictionless, find the tension in the string.

b) Find the acceleration of the mass.

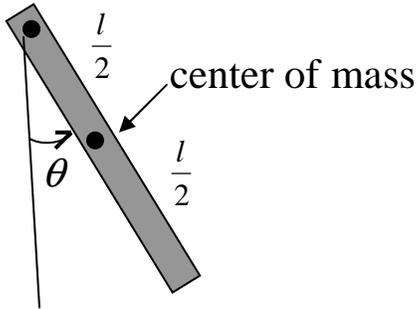
c) What will be the angular velocity of the disk as a function of time, assuming that at  $t=0$  the system was at rest?

d) Suppose there is a friction force at the axle which exerts a torque, opposing the rotation. This torque is proportional to the angular velocity, with magnitude  $\beta\omega$  where  $\beta$  is a known constant. The pulley will then reach a certain constant angular velocity. What is this constant value of  $\omega$ ?

#### Problem 4: (15 points)

A “physical pendulum” is any real object, free to rotate about some horizontal axis.

a) Show that a thin rod, length  $l$ , pivoted about one end with moment of inertia  $I$  about this end, will undergo simple harmonic motion if displaced a small angle from equilibrium (You can use  $\sin \theta \approx \theta$ ).

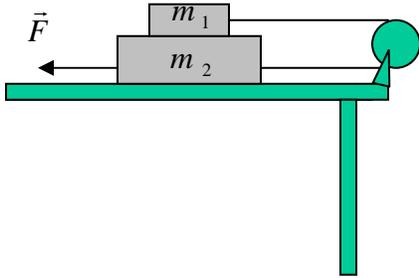


b) What is the frequency of oscillations?

c) If the rod starts at a position  $\theta_0$  from rest, how long will it take for the rod to return to its equilibrium?

### Problem 5: (20 points)

Two blocks with masses  $m_1$  and  $m_2$  are connected by a light, unstretchable cord passing around a fixed, **frictionless** pulley. The coefficient of friction between two blocks and the block of mass  $m_2$  and the surface is  $\mu$ .



a) Draw the free body diagram for both blocks assuming that block  $m_2$  is moving to the left.

b) Find the magnitude of the horizontal force  $\vec{F}$  necessary to drag block  $m_2$  to the left at a **constant velocity**.

**Problem 6: (15 points)**

Three identical pucks (each has the same mass) on a horizontal air table (frictionless) have repelling magnets. They are held together and then released simultaneously. Each has the same magnitude of velocity at any instant. One puck moves due east. What is the direction of the velocity of each of the other two pucks?