

Physics 2101, Final Exam, Spring 2007

May 10, 2007

Name : _____

Section: (Circle one)

1 (Rupnik, MWF 7:40am)

2 (Giammanco, MWF 9:40am)

3 (Rupnik, MWF 11:40am)

4 (Rupnik, MWF 2:40pm)

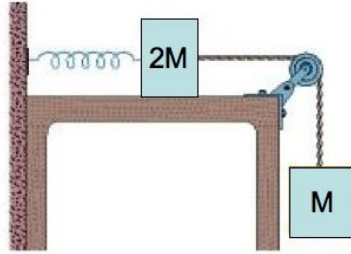
5 (Giammanco, TTh 10:40am)

6 (González, TTh 1:40pm)

- Please be sure to write your name and circle your section above.
- For the problems, you *must* show all your work. Let us know what you were thinking when you solved the problem! Lonely right answers will not receive full credit, lonely wrong answers will receive no credit.
- For the questions, no work needs to be shown (there is no partial credit).
- Please carry units through your calculations when needed, lack of units will result in a loss of points.
- You may use scientific or graphing calculators, but you must derive your answer and explain your work.
- Feel free to detach, use and keep the formula sheet. No other reference material is allowed during the exam.
- **GOOD LUCK!**

Problem 1 - 13 points

Two blocks of masses M and $2M$ are connected to a spring of constant k that has one end fixed, as shown in the figure. The horizontal surface and the pulley are frictionless, and the pulley has negligible mass. The blocks are released with the spring relaxed.



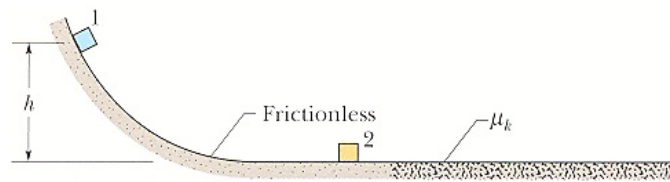
- (a) (3 pts) Write an expression for the work done by gravity on the M hanging block when it reaches the lowest position, a distance H below its initial position, where it momentarily stops. Your expression should be in terms of M , g , H and numerical constants.

- (b) (4 pts) Write an expression for the work done by the spring when the M block reaches the lowest position, using k , H and numerical constants.

- (c) (6 pts) Derive an expression for the maximum distance H the spring stretches after the blocks are released, in terms of M , g and k .

Question 1 - 6 Points

In the figure below, block 1 slides from rest along a frictionless ramp from height h and then collides with stationary block 2, sticking to it. After the collision, the blocks now stuck together, slide into a region with a coefficient of kinetic friction μ_k , and come to a stop in distance d within that region.



- (a) (2 pts) Circle the quantity (or quantities) that are conserved in the fall of block 1 *before the collision*:

Mechanical energy

Linear momentum

Neither

- (b) (2 pts) Circle the quantity (or quantities) that are conserved for the system of blocks 1 and 2 *during the collision*:

Mechanical energy

Linear momentum

Neither

- (c) (2 pts) Circle the quantity (or quantities) that are conserved in the motion of the blocks *after the collision*, until the blocks stop:

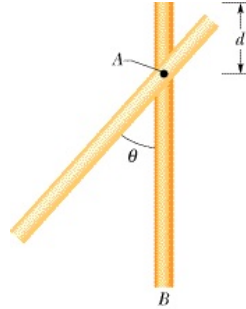
Mechanical energy

Linear momentum

Neither

Problem 2 - 13 points

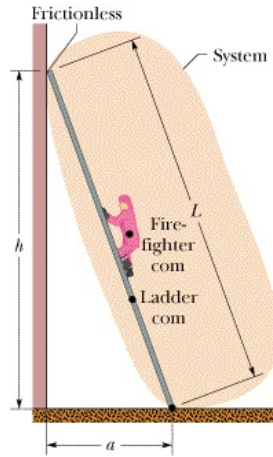
In the figure, a thin uniform rod of mass $m = 2\text{kg}$ and length $L = 5\text{m}$ rotates freely about a horizontal axis A that is perpendicular to the rod and passes through a point at distance $d = 1.5\text{m}$ from the end of the rod. At $t = 0$, the rod is released from rest from a maximum angle $\theta_{max} = 10^\circ$, and it oscillates about the equilibrium position AB indicated in the figure.



- (a) (5 pts) During the oscillations, at what angular position does gravity exert the largest torque about the axis of rotation? Draw a free body diagram of the rod at that position, and calculate gravity's torque at that instant.
- (b) (5 pts) Calculate the rod's rotational inertia with respect to the axis of rotation through point A. (The rotational inertia of a thin rod about its center of mass is $mL^2/12$).
- (c) (3 pts) Calculate the angular frequency of the simple harmonic motion of the rod.

Question 2 - 6 Points

The figure shows a firefighter climbing a ladder of length L leaning against a frictionless wall. There is friction between the ladder and the horizontal floor, but there is no friction between the ladder and the vertical wall. As the firefighter moves up the ladder, do the following forces become larger, smaller, or stay the same? The ladder does not slip, and you can neglect the ladder's weight.



(a) (2 pts) Normal force on ladder from the ground:

larger

smaller

stays the same

(b) (2 pts) Force on the ladder from the vertical, frictionless, wall:

larger

smaller

stays the same

(c) (2 pts) Static frictional force on the ladder from the ground:

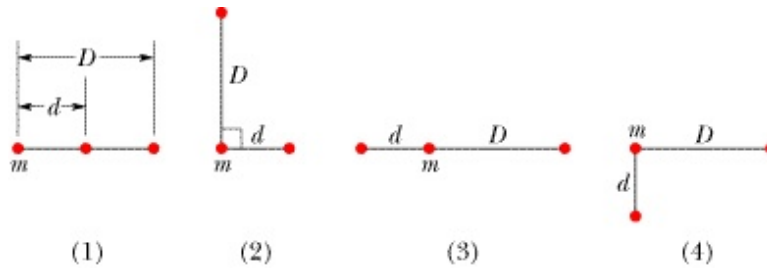
larger

smaller

stays the same

Question 3 - 5 Points

The figure shows four arrangements of three particles of equal masses. Consider gravitational forces only between the particles shown.



- (a) (2 pts) Which arrangement produces the largest magnitude of the net gravitational force on the particle labeled m ?

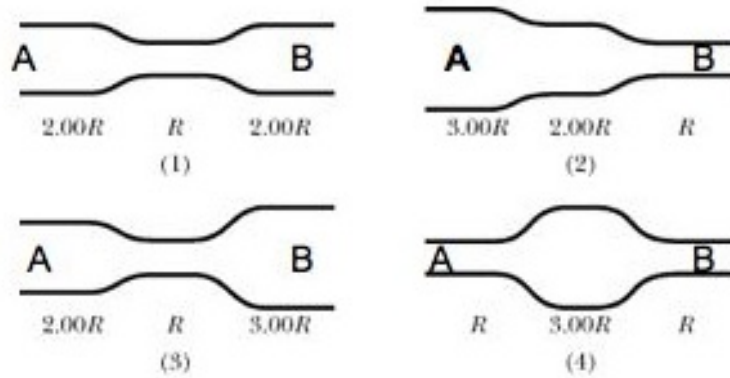
(1) (2) (3) (4) (1)=(3) (2)=(4) All tie

- (b) (3 pts) Which arrangement has the smallest absolute value of the gravitational potential energy of the 3-mass system?

(1) (2) (3) (4) (1)=(3) (2)=(4) All tie

Question 4 - 6 Points

The figure shows four arrangements of pipes through which water flows smoothly to the right, from point A to point B. The radii of the pipe sections are indicated. Consider water as an ideal, incompressible fluid. Circle all the right answer(s) to the following questions:



- (a) (3 pts) In which arrangement(s) is the kinetic energy of a unit volume of water moving at point B greater than the kinetic energy of a unit volume of water at point A?

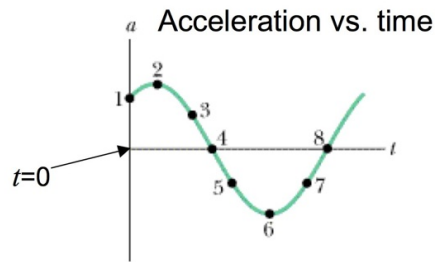
(1) (2) (3) (4) (1) and (4) (2) and (3) (1), (2), (3) and (4)

- (b) (3 pts) In which arrangement(s) is the absolute pressure at point B greater than the absolute pressure at point A?

(1) (2) (3) (4) (1) and (4) (2) and (3) (1), (2), (3) and (4)

Question 5 - 6 Points

The acceleration $a(t)$ of a particle undergoing Simple Harmonic Motion (SHM) is shown in the figure.



- (a) (2 pts) Circle the point(s) where the particle is at the maximum positive displacement, $x = +x_m$.

1 2 3 4 5 6 7 8

- (b) (2 pts) Circle the point(s) where the particle's velocity is negative.

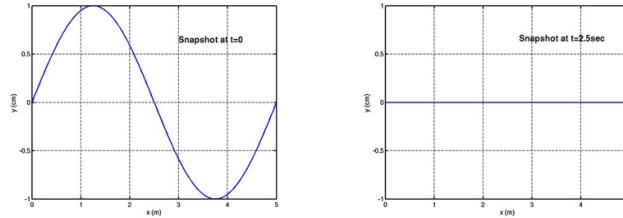
1 2 3 4 5 6 7 8

- (c) (2 pts) Which of the following describes the phase constant ϕ of the particle's motion if the position function $x(t)$ has the form $x(t) = x_m \cos(\omega t + \phi)$?

$0 \leq \phi < \pi/2$ $\pi/2 \leq \phi < \pi$ $\pi \leq \phi < 3\pi/4$ $3\pi/4 \leq \phi < 2\pi$

Problem 3 - 13 points

The figure shows two snapshots taken of a wave on 5m long rope, with a 0.2kg mass, with fixed ends. The first snapshot is taken at $t = 0$, when all the points in the rope have their maximum amplitude position. The second snapshot is taken at $t = 2.5$ sec, the first time after $t = 0$ when all the points of the rope are at $y = 0$.



(a) (4 pts) What are the period T and the wavelength λ of the wave?

(b) (2 pts) The pictures describe a ...

a wave traveling to positive x a wave traveling to negative x a standing wave

(c) (4 pts) What is the tension on the rope?

(d) (3 pts) What is the frequency of the fundamental mode?

Problem 4 - 13 points

In the past, McDonald's used to sell its coffee at a temperature of 85°C , which produced third degree burns on a customer who spilled her coffee on her lap. She sued and a jury awarded her \$2.9 million. Trying to avoid such burns, a customer put 100 g of McDonald's hot coffee in an insulated Thermos, but also added in a 10.0g ice cube at -10°C , to cool the coffee. The ice melted and cooled the coffee. (Assume you can treat coffee as water.)

(a) (3 pts) How much energy is absorbed by the ice warming up to the melting temperature, 0°C ?

(b) (3 pts) How much energy is absorbed by the ice melting to water?

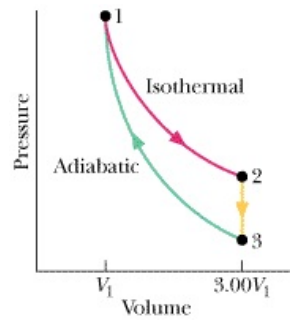
(c) (4 pts) What is the final temperature of the coffee?

(d) (3 pts) What is the sign of the change in entropy for each of the processes listed below? (Answer positive, negative or zero):

- ice warming up to the melting temperature and melting into water:
- water cooling down to final temperature:
- ice + water system, from the time the ice is put into the coffee until the system achieves final temperature:

Question 6 - 6 points

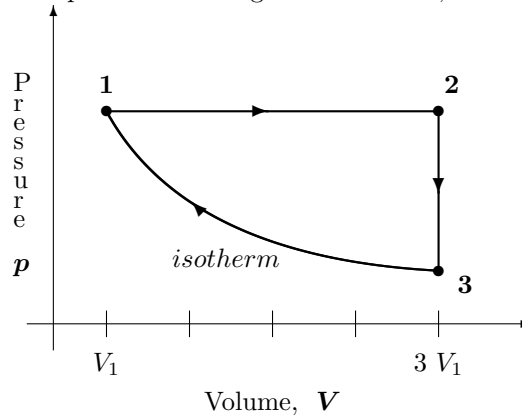
A sample with one mole of an ideal diatomic gas is taken through the cyclic process shown in the figure. Fill in the table with the signs of the different quantities in each process (+, − or 0).



	$1 \rightarrow 2$	$2 \rightarrow 3$	$3 \rightarrow 1$
Change in Internal Energy of the gas		−	+
Energy transferred as heat	+		
Work done <u>by</u> the gas	+	0	
Change in entropy of the gas	+		

Problem 5 - 13 points

A sample with one mole of an ideal diatomic gas is taken through the cyclic process shown in the figure. At point 1, the temperature of the gas is $T = 200\text{K}$, and the volume is $V_1 = 1.00$ liter.



- (a) (3 pts) What is the temperature at points 2 and 3?
- (b) (4 pts) What is the work done by the gas in each of the three processes, and the net work done by the gas during the whole cycle?
- (c) (4 pts) What is the energy transferred as heat in each of the the three processes?
- (d) (2 pts) What is the efficiency of the cycle?