Physics 2101, Fourth Exam, Spring 2008

Name (print legibly): ____

Signature: ____

Section (circle one)

1 (Rupnik, MWF 8:40 AM)	4 (Rupnik, MWF 2:40 PM)	Seat Number:
2 (Giammanc0, MWF 10:40 AM)	5 (Rupnik, TuTh 9:10 AM)	
3 (Gonzalez, MWF 12:40 PM)	6 (Sheehy, TuTh 12:10 PM)	

■ Please be sure to print and sign your name above, and circle your section. Also write your seat number.

■ Please turn **OFF** all cell phones, pagers, iPods, MP3s, etc.

■ The formula sheet is provided as a separate item. No other reference material is allowed during the exam.

■ For the ***questions***, no work need be shown, and there is no partial credit.

■ For the ***problems***, please write as much as you can explaining to us your reasoning. Lonely correct answers will not receive full credit, and lonely wrong answers will receive no credit at all.

■ You may use scientific or graphing calculators, but you must derive answers and explain your work.

■ Carry units throughout your calculations. Lack of units will result in loss of points.

■ **GOOD LUCK!**

Question 1 (12 points)

The figure shows a hydraulic system consisting of a tank of ideal, incompressible liquid, and three pistons: P1, P2, and P3. A downward force, F, is applied to piston P1 as shown. All pistons are at the same level, as drawn.

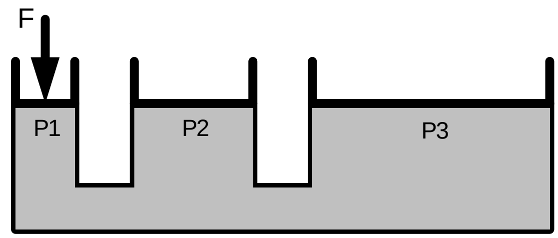
a) (4 points)
Directly beneath the pistons, where is the pressure in the fluid the greatest?

i) under P1

ii) under P2

iii) under P3

iv) all the pressures are the same



b) (4 points)
Which piston experiences the greatest upwards force?

i) P1

ii) P2

iii) P3

iv) all three pistons experience the same upwards force

v) none of the pistons experience an upwards force

c) (4 points)
If the force, F, is applied continuously, which piston moves the farthest?

i) P1

ii) P2

iii) P3

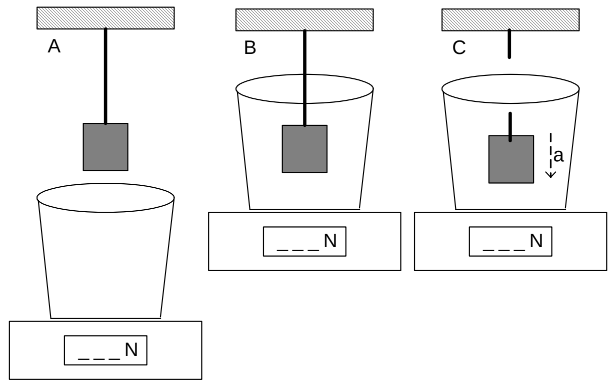
iv) all three pistons move the same distance

v) none of the pistons move at all

Problem 1 (22 points)

A lump of gold, of volume 1.0 cm^3, and whose density is 19 g/cm^3 is suspended by a thread of negligible mass. Beneath the cube is a styrofoam cup (also of negligible mass) completely filled to the brim with 5.0 cm^3 of water, whose density is 1.0 g/cm^3. The cup rests on a digital scale that will read weight in newtons.

Initially the gold is held above the water, as in Fig A.



a) (3 points) What is the tension in the thread?

b) (3 points) What is the reading on the scale?

The gold is then lowered into the water until it is completely submerged, but not touching the bottom of the cup, as in Fig. B. Some water will, of course, have to spill out onto the floor (not onto the scale).

c) (6 points) What is the tension in the thread?

d) (6 points) What is the reading on the scale?

Now the thread is cut, as in Fig. C

e) (4 points) What is the magnitude of the initial (right after the string is cut) acceleration of the gold cube?

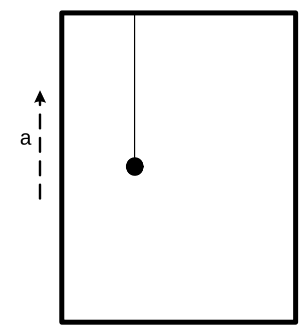
Question 2 (12 points)

A small lead sphere, of radius R and mass M, is suspended from the ceiling of an elevator by a thread of negligible mass and length L, where L >>> R. The elevator is at rest. The lead sphere is displaced slightly to one side and released.

a) (4 points)
Which expression (circle one) below properly gives the period of the oscillations while the elevator is at rest?

$2\pi\sqrt{\frac{L}{g}}$ $\qquad$ $2\pi\sqrt{\frac{2L}{3g}}$ $\qquad$ $2\pi\sqrt{\frac{3g}{2L}}$ $\qquad$ $2\pi\sqrt{\frac{g}{L}}$

The elevator now begins accelerating upwards …



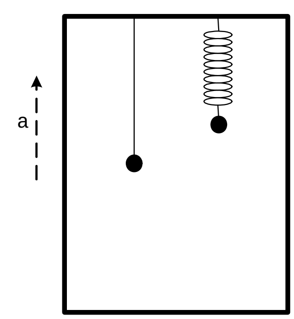
b) (4 points)
The period of the oscillations will now be (compared to when the elevator was at rest)

the same as before $\qquad$ longer than before $\qquad$ shorter than before

Now, suppose a spring-block oscillator consisting of a spring, of spring constant k, and an identical lead sphere of mass M is also hung from the ceiling of the same elevator. The force constant k is selected so that, when the elevator is at rest, the two oscillators have the same period.

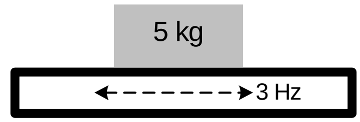
(c) (4 points)
When the elevator is accelerating upwards at a constant rate, the period of the spring-block oscillator will now be (compared to when the elevator was at rest)

the same as before $\qquad$ longer than before $\qquad$ shorter than before



Problem 2 (22 points)

A 5.0 kg mass rests on the horizontal surface of a "shake table." The coefficient of static friction between the surface and the block is 0.45, and the table is driven by a 3.0 Hz mechanical oscillator.



a) (4 points) What is the magnitude of the greatest force on the block that static friction can provide?

b) (5 points) What is the magnitude of the greatest acceleration that the block can experience without slipping on the table?

c) (9 points) What is the greatest amplitude of oscillation than can occur before the block slips?

d) (4 points) Assume slippage will occur. If time t = 0 s is the moment when the block is in equilibrium, what is the time, t, at which the block first would begin to slip?
Note: partial credit may be awarded here if you show some supporting work.

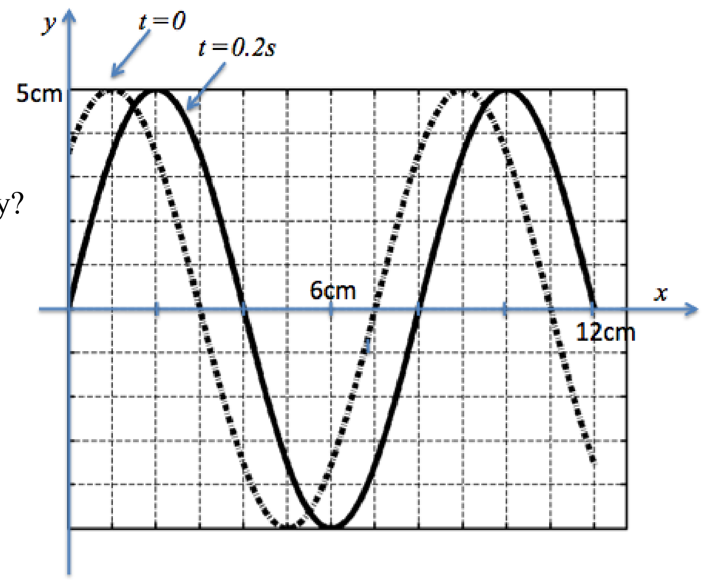
immediately, that is, at t=0 s $\quad \frac{1}{4}$ period later $\quad \frac{1}{2}$ period later $\quad \frac{3}{4}$ period later $\quad$ 1 full period later

Question 3 (12 points)

The figure shows two snapshots of a traveling wave on a string. The snapshots are taken at t = 0 s (dashed line), and at t = 0.2 s (solid line). The wave is described by an expression of the form

$$y(x,t) = y_m \sin(kx - \omega t + \varphi)$$

as is shown on your formula sheet.



a) (4 points) What is the magnitude of the wave's velocity?

1 cm/s 5 cm/s 25 cm/s 30 cm/sec 40 cm/s

b) (3 points) What is the wavelength of the wave?

1 cm 5 cm 6 cm 8 cm 12 cm 16 cm

c) (2 points) What is the phase constant, φ ?

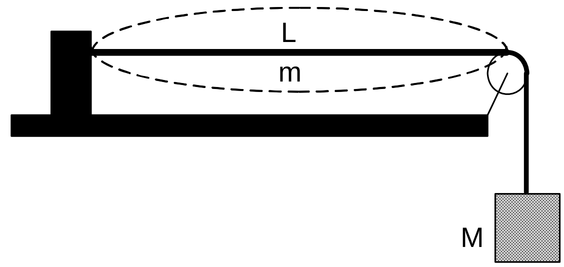
0 $\frac{\pi}{4}$ $\frac{\pi}{2}$ $\frac{3\pi}{4}$ π

d) (3 points) At t = 0.2 s, the point on the string at x = 4 cm is ...

moving up moving down momentarily at rest moving to the right moving to the left

Problem 3 (22 points)

A cast iron block of mass M is suspended by a string that passes over a pulley of negligible mass and negligible friction. The string between the pulley and the fixed support has length L and mass m. ($m << M$). Neglect the mass of that part of the string hanging over the pulley. The string is set into vibration in the pattern pictured.



a) (4 points)
What is the wavelength of the transverse wave on the string?
Explain your reasoning in one or two sentences.

b) (9 points)
Derive (that means show your work) an expression for the speed of a transverse wave that would move along the wire.
Your final answer should involve all or some of the following: numerical constants, L, M, m, and g.

c) (9 points)
Now, using the above results, derive (that means show your work) an expression for the frequency of vibration of the wire.
Your final answer should involve all or some of the following: numerical constants, L, M, m, and g.