McGill University

PHYS 131
(Mechanics & Waves)

FINAL EXAM

December 18, 2008
2:00 PM – 5:00 PM

Examiner: K.J. Ragan x6518
Associate Examiner: J. Crawford x7029

Student name: ID:

The exam comprises two parts on five pages (including this page): 10 short answer questions, and 6 problems. A formula sheet is attached to the back of the exam. A one-page formula sheet is allowed. No books are allowed. Calculators are allowed.

Answer **all the short answer questions** with a few words or a few short phrases.
For the problems, your grade will be calculated with the **best five problems**. Show your work.

The short answer problems are worth three points each, and the problems are worth 10 points each. Put all answers in the **answer booklets** provided, and return this exam paper with the booklet(s).

Good luck !

Short answer questions (answer all): you should not need to do any calculations for these questions, and should answer in **a few words, a few short phrases, or a simple sketch.** In some cases you might find it useful to quote an appropriate formula.

1) [3 pts] Where on the Earth's surface does a bathroom scale measure your true weight "mg"? Where does your apparent weight (due to the Earth's rotation) most differ from your true weight?

2) [3 pts] Several copies of "Physics for Scientists and Engineers" by Serway and Jewett are piled on top of one another on a tabletop. You push on the bottom book (only!) and the pile moves across the table – the upper books do not move relative to the lower one. Is work being done on the top book? By what force?

3) [3 pts] As astronaut on the moon hits a golf ball (yes, this happened!). Is the momentum of the ball constant during its flight? Is there a component of momentum that is constant during its flight?

4) [3 pts] One effect of significant global warming would be the melting of polar ice caps. This would effect the length of the day (the period of the Earth's rotation). By thinking about the moment of inertia, explain why, and say whether the day would increase in length, or decrease.

5) [3 pts] Consider a body, with exactly two forces F_1 and F_2 acting on it, which is in static equilibrium: its center of mass is not accelerating, nor is it rotating. What can you say about the two forces?

6) [3 pts] A mass connected to an ideal spring is oscillating horizontally on a frictionless surface. Sketch graphs of the displacement, velocity, potential energy, and kinetic energy as a function of time t. Clearly label the times t=0, t=T/2, and t=T, where T is the period of the oscillator.

7) [3 pts] The wavelength of the fundamental standing wave on a violin string depends on which of the following quantites: a) length of the string, b) mass per unit length of the string, c) tension of the string? The wavelength of the sound wave resulting from the string's vibrations depends on which of those parameters?

8) [3 pts] a) If the force on a particle at some point in space is zero, is the potential energy also zero at that point in space? b) If the potential energy of a particle at some point in space is zero, must the force on it also be zero at that point? Explain briefly.

9) [3 pts] Two objects with different masses m_1 and m_2 rest on a horizontal frictionless surface and compress a light spring between them. The objects are not attached to the spring, and after they are released and accelerated by the spring force they move freely. Do they have equal energies? Equal speeds? Equal momenta? Explain briefly.

10) [3 pts] The vertical displacement of a wave on a string is described by $y=A \sin(Bx - Ct)$ where A, B, and C are all positive. a) Does the wave propagate in the positive x or the negative x direction? b) What is the wavelength? c) What is the frequency?

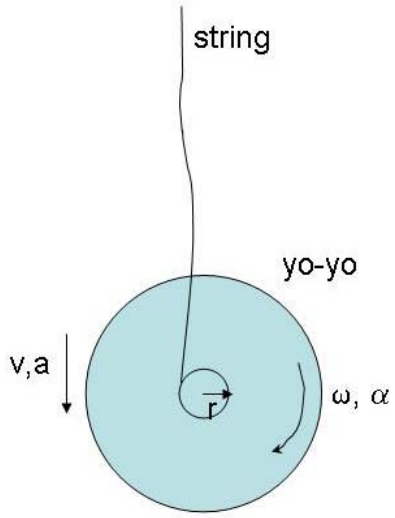
Long problems (you will be marked on the best five out of six):

1) [10 pts] A yo-yo (a wheel with a string wrapped around its axis; as the yo-yo falls, the string unwraps) has a rotational moment of inertia (about its central axis) of 950 gm cm^2. Its mass is 120 g, its axle radius is r=3.2 mm, and its string is 120 cm long. The yo-yo rolls from rest vertically downwards to the end of its string

a. What is the linear acceleration of the yo-yo?
b. How long does it take to reach the end of the string?

An instant before it reaches the end of the string:

c. What is its speed?
d. What is its translational kinetic energy?
e. What is its angular speed?

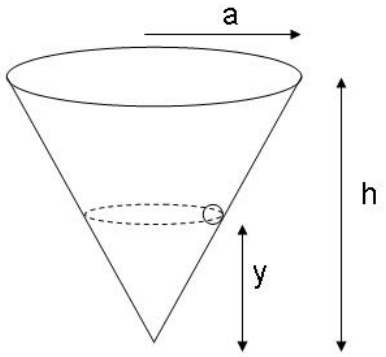


2) [10 pts] A 1.00 kg block is attached to a horizontal spring with k=2500 N/m. The block is at rest on a frictionless surface, and a 10 g bullet is fired into the block on the face opposite the spring. The bullet embeds itself into the block and the block/bullet combination now starts to oscillate on the spring because of the bullet's impact.

a. If the oscillations have an amplitude of 10.0 cm, what was the bullet's speed before impact?
b. Could you determine the bullet's speed if you were told only the oscillation frequency? If so, explain how. If not, explain why not.
c. What is the oscillation frequency of the block/bullet combination?

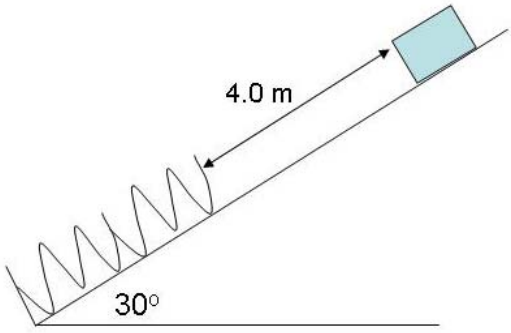
3) [10 pts] A small ball of mass m and radius r rolls (frictionlessly) around a horizontal circle at height y inside a cone, as shown below.

a. Find an expression for the ball's speed v in terms of g, the cone's upper radius a, its height h, and y.
b. What is the ball's total kinetic energy?



4) [10 pts] A 10 kg box slides 4.0 m down a frictionless ramp as shown below, then collides with a spring whose spring constant is 250 N/m.

a. What is the maximum compression of the spring?
b. At what compression of the spring does the box have its maximum speed?
c. What is the initial acceleration of the box when it starts back up the ramp after maximum compression?

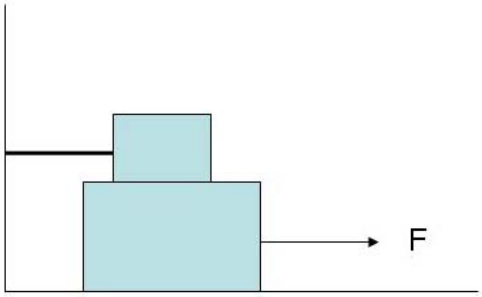


5) [10 pts] A penny rides on top of a piston as the piston undergoes simple harmonic motion (SHM) in the vertical direction with an amplitude of 4.0 cm. At low frequencies, the penny rides up and down without a problem. As the frequency is increased without changing the amplitude, there comes a point where the penny leaves the surface of the piston during the SHM.

a. At what point in the cycle does the penny first lose contact with the piston?
b. What is the maximum frequency for which the penny just barely remains in contact with the piston for the full cycle?

6) [10 pts] The upper block in the diagram below has a mass of 1.0 kg. The lower block has a mass of 2.0 kg. The lower block is pulled to the right by the rope which has a tension of 20.0 N. The coefficient of kinetic friction at both the lower and upper surfaces of the lower block is $\mu_k = 0.40$. Assume the ropes are massless.

a. What is the tension in the rope holding the upper block?
b. What is the acceleration of the lower block?



Happy holidays !