McGill University

PHYS 101
(Introduction to Mechanics for the Life Sciences)

FINAL EXAM

December 12, 2005
14:00 – 17:00

Examiner: K.J. Ragan
Associate Examiner: D.S. Hanna

The exam comprises two parts on five pages: 8 short answer questions, and 6 problems. A formula sheet is attached to the back of the exam. Simple non-graphing calculators are allowed. No books or notes of any kind are allowed.

Answer **all the short answer questions** with a few words or a phrase (**no** more, please!). For the problems, your grade will be calculated with the **best five problems**. Show your work.

The short answer problems are worth two points each, and the problems are worth 10 points each. Put all answers in the **answer booklets** provided; you may keep this exam.

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 short phrase, or a simple sketch.**

1) [2 pts] Two objects move down an inclined plane: a block slides down without friction, and a sphere rolls down without slipping. Which arrives first? (No calculations are necessary).

2) [2 pts] A transverse wave on a string is described by the equation $x=0.27\cdot\sin(2\pi\cdot100\cdot t)$, where x is in meters and t is in seconds. What is:
   a) the amplitude of the wave;
   b) the frequency of the wave in Hz.

3) [2 pts] A child moves from the centre of a spinning merry-go-round towards the outer edge. For the following two quantities answer "Yes" if the quantity changes and "No" if the quantity does not change as the child moves:
   i) angular momentum
   ii) angular velocity

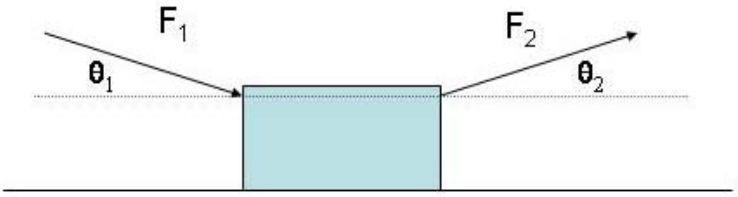
4) [2 pts] A grandfather clock is running too fast (that is, the period of its pendulum is too small). What adjustment should you make to the pendulum to correct it?

5) [2 pts] Lost on a camping trip, you find that your friend's eyeglasses can be used to start a signal fire by focusing the Sun's light on your (obviously useless) map. Is the friend nearsighted or farsighted?

6) [2 pts] Your kid brother is swinging a ball on the end of a rope in a vertical plane. The ball is moving at a constant speed around its circular trajectory. Where in the trajectory is the tension in the rope the greatest?

7) [2 pts] At what distance from a converging lens of focal length f will light from a source at infinity be focused? Will the image be virtual or real?

8) [2 pts] A heavy box is resting on the floor as shown in the figure. If the two forces F_1 and F_2 are equal in magnitude and the two angles θ_1 and θ_2 are equal, which of the two forces will result in the larger acceleration when applied to the box? Assume that there **is** friction at the box-floor surface.



Long problems (do five out of six):

1) [10 pts] You are racing along a road at 140 km/h and overtaking a train (the track is close to and parallel to the road) moving at 90 km/h in the same direction as you. The train whistle has a frequency of 500 Hz (as measured by a passenger in the train).

a) What frequency do you hear as you are behind the train but catching up to it?

b) What frequency do you hear when you are past the train and pulling away from it?

Take the speed of sound to be 340 m/s.

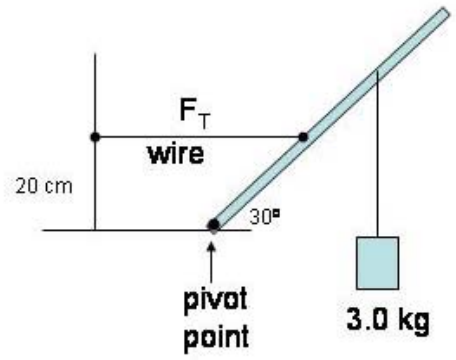
In both cases, note that **both** observer and source are moving! It may be advantageous to consider an imaginary **stationary** object that hears the sound and re-emits it: calculate the frequency that the object would hear due to the moving source, then how the moving observer would perceive this re-emitted sound.

2) [10 pts] In the figure, the uniform rod is free to pivot about its base in the plane of the paper. If it is motionless at an angle of 30 degrees from the horizontal, find the tension F_T in the wire.

The rod has a mass of 4.0 kg and a length of 60.0 cm. The 3.0 kg mass is suspended 40.0 cm from the pivot end of the rod. The wire is anchored 20 cm (vertically) above the pivot point, and is horizontal.

Hint: consider the different **torques** about the pivot point. Don't forget the mass of the rod itself, considered to be concentrated at its center of mass (half-way down the rod).

The moment of inertia I of a rod of mass M and length L, about its end, is given by 1/3 ML^2.

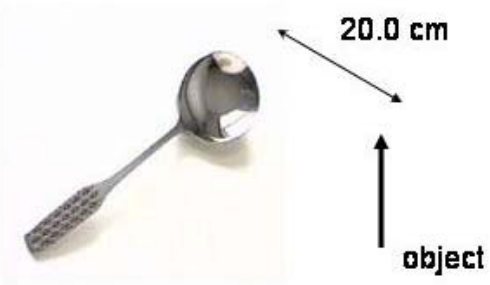


3) [10 pts] An object 20.0 cm away from the bowl of a soup spoon creates an image with a magnification of -0.060.

a) What is the radius of curvature of the spoon?

b) Where is the image? Is it real or virtual?

Darrell suspected someone had once again slipped him a spoon with the concave side reversed.



4) [10 pts] A noisy computer printer produces sound of intensity 6.3×10^{-6} W/m^2 at a distance of 5.0 m from the printer.

a) What is the sound level in decibels (dB) at that point?

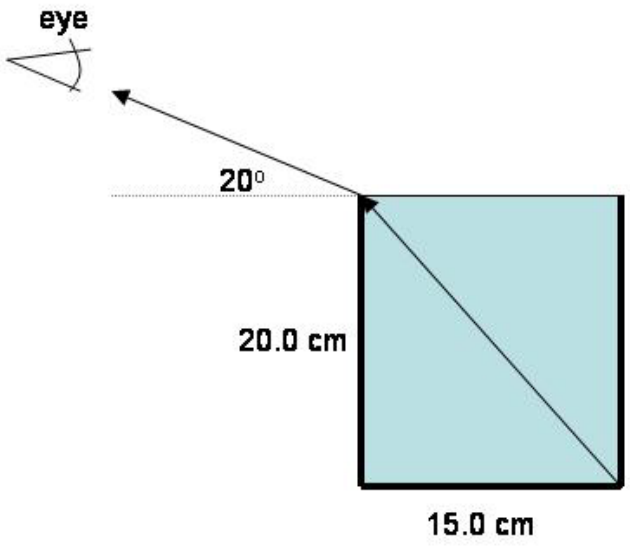
b) What is the sound level in decibels (dB) at a point 20.0 m from the printer?

c) Using the results from a) and b), find the sound level in decibels of a motorbike at 20.0 m, if it is 95 dB at 5.0 m. You do **not** need to calculate the intensities at either location.

5) [10 pts] You are trying to determine the index of refraction of an unknown liquid filling a small tank as shown in the figure. You can just see the lower back corner of the container at an angle of 20^o, as illustrated.

a) What is the index of refraction?

b) How deep does the container appear to you as you peer into the liquid?



6) [10 pts] A wire is fixed at one end and the other end is attached to a mass and hung over a frictionless pulley, as in the diagram. The mass is 5.0 kg, the distance from the wall to the pulley is 1.0 m, and the wire has a total length of 1.5 m and a mass of 4.0 grams.

a) What is the fundamental frequency if the wire is plucked?

b) What is the first overtone (harmonic)?