Physics 23 Practice Midterm - 50 minutes
2 Pages - turn over!!

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Monday, October 29

Write your answers in a blue book. Calculators and one page of notes allowed. No textbooks allowed. Please make your work neat, clear, and easy to follow. It is hard to grade sloppy work accurately. Generally, make a clear diagram, and label quantities. Make it clear what you think is known, and what is unknown and to be solved for. Except for extremely simple problems, derive symbolic answers, and then plug in numbers (if necessary) after a symbolic answer is available. **Put a box around your final answer... otherwise we may be confused about which answer you really mean, and you could lose credit.**

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1. A dam has the shape of a rectangle, with height $H = 10\,\mathrm{m}$ and width $W = 30\,\mathrm{m}$. Take the acceleration of gravity to be $g = 10\,\mathrm{m/s^2}$, atmospheric pressure to be $p_0 = 10^5\,\mathrm{Pa}$, and the density of water to be $\rho = 10^3\,\mathrm{kg/m^3}$.

   (a) Evaluate the gauge pressure at the water at the bottom of the dam, both symbolically and numerically.

   (b) Evaluate the net torque exerted on the dam about an axis along the *top* of the dam, both symbolically and numerically.

   (c) The height of the dam is doubled to $H' = 20\,\mathrm{m}$.

      i. By what factor does the gauge pressure of the bottom of the dam change?

      ii. By what factor does the torque exerted by the water about an axis along the top of the dam change?

2. One meter away from the electric guitar player's speaker, the sound intensity from her $f = 10^3\,\mathrm{Hz}$ note is at the threshold of pain for a human. How many meters away from the speaker must a person move so that the sound from the speaker is at the threshold of hearing? Neglect reflections.

3. A string of length L is displaced at time $t = 0$ and released, with no initial velocity anywhere along its length. The axis along the string is labeled x with $x = 0$ at the left end of the string, and the displacement perpendicular to this axis is y. At $t = 0$, the displacement is:

$$y(x,0) = \begin{cases} -a & \text{if} \quad 0 < x < L/2 \\ a & \text{if} \quad L/2 < x < L, \end{cases}$$

   while at $x = 0, L/2$, and L the approximation $y(x,0) = 0$ is adequate. Express $y(x,0)$ as a Fourier series,

$$y(x,0) = \sum_{n=1}^{\infty} B_n \sin\left(\frac{n\pi}{L}x\right)$$

   (a) Make a plot of $y(x,0)$.

(b) For which values of n are the $B_n = 0$?

(c) Evaluate B_n symbolically.

4. You have a steel stick that is precisely one meter long. You clamp a brass stick of length L to one end of the steel stick, and keep those ends of the sticks flush with one another. Evaluate L both symbolically and numerically so that the distance between the other ends of the sticks is constant as a function of temperature. The linear coefficients of expansion are $1.2 \times 10^{-5}/^{\circ}\mathrm{C}$ for steel and $2.0 \times 10^{-5}/^{\circ}\mathrm{C}$ for brass.
