



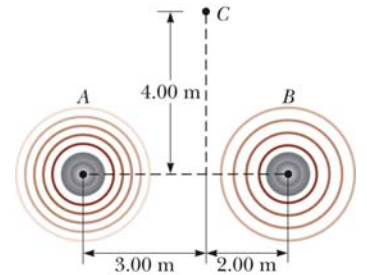
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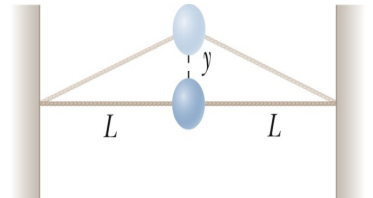
This is an open-book examine. You can use any material you brought; but you can only use the material you brought. **ABSOLUTELY NO CHEATING!**

Problems (Total 5 problems, 100%)

1. **Sound Waves:** Two small speakers emit sound waves of different frequencies equally in all directions. Speaker A has an output of 1.00 mW, and speaker B has an output of 1.50 mW. Determine the sound level (in decibels) at point C in the figure to the right, assuming (a) only speaker A emits sound, (b) only speaker B emits sound, and (c) both speakers emit sound.

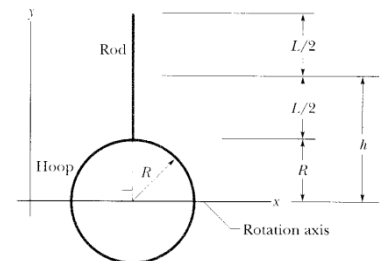


2. **String:** A ball of mass m is connected to two rubber bands of length L , each under tension T as shown in the figure to the right. The ball is displaced by a small distance y perpendicular to the length of the rubber bands. Assuming the tension does not change, show that (a) the restoring force is $-(2T/L)y$ and (b) the system exhibits simple harmonic motion with an angular frequency $\omega = \sqrt{2T/mL}$.



3. **Harmonic oscillator:** (a) If a tunnel were drilled through the earth along one of its diameters and if a stone were dropped into it from one end, how long would it before the stone return? (b) Compare the answer with the period of an earth satellite in an orbit of minimum radius and comment on the two values. (c) If the height of the satellite above the earth surface is negligible compared to the earth radius, what is the answer in (b).

4. **Rolling:** A rigid sculpture consists of a thin hoop (of mass m and radius $R=0.15\text{m}$) and a thin radial rod (of mass m and length $L=2R$), arranged as shown in the figure. The sculpture can pivot around a horizontal axis in the plane of the hoop, passing through its center. (a) In terms of m and R , what is the sculpture's rotational inertia I about the rotational axis? (b) Starting from rest, the sculpture rotates around the rotational axis from the initial upright orientation as shown. What is the angular speed ω about the axis when it is inverted?



5. A uniform, hollow, cylindrical spool has inside radius $R/2$, outside radius R , and mass M (figure below). It is mounted so that it rotates on a fixed horizontal axle. A counterweight of mass m is connected to the end of a string wound around the spool. The counterweight falls from rest at $t = 0$ to a position y at time t . Show that the torque due to the friction forces between spool and axle is the following. (20%)

$$\tau_f = R \left[m \left(g - \frac{2y}{t^2} \right) - M \frac{5y}{4t^2} \right]$$

