Your name: _____

Total 9 problems, 8 pages. No separate solution sheets necessary.
Good LUCK!

For the following five problems, you can indicate your answer by drawing a circle around one of the choices. The best choice is unique for each problem. No explanation is necessary. Each of the following five problems is worth 4 points.

Problem 1 The maximum speed of a 3.00 kg object in simple harmonic motion is 4.00 m/s. The maximum acceleration of the object is 5.00 m/s^2. What is the period of simple harmonic motion?

(a) 1.25 s (b) 0.417 s (c) 3.75 s (d) 5.03 s

Problem 2 Consider a mass on spring ($F = -kx$). The mass is undergoing simple harmonic motion with amplitude A. At $x = x_H$, it is noted that the kinetic energy and the potential energy ($\frac{1}{2}kx^2$) are equal. Which of the following statements is correct?

(a) $|x_H| > \frac{A}{2}$. (b) $|x_H| < \frac{A}{2}$. (c) $|x_H| = \frac{A}{2}$.

Problem 3 A tsunami, an ocean wave generated by an earthquake, propagates along the open ocean at 700 km/hr and has a wavelength of 750 km. What is the frequency of the waves in such a tsunami?

(a) 0.00026 Hz (b) 1.1 Hz (c) 1100 Hz (d) 930 Hz (e) 0.93 Hz

Problem 4 Sound wave is _____.

(a) a pressure wave.

(b) a displacement wave.

(c) both a pressure wave and a displacement wave.

(d) either a pressure wave or a displacement wave, depending on medium (gas/liquid or solid).

Problem 5 In a solid, sound can propagate as a transverse wave or a longitudinal wave, like S wave or P wave, respectively, in an earthquake. Which of the two waves has a greater speed, in most solids?

(a) transverse wave (b) longitudinal wave (c) neither (same speed)

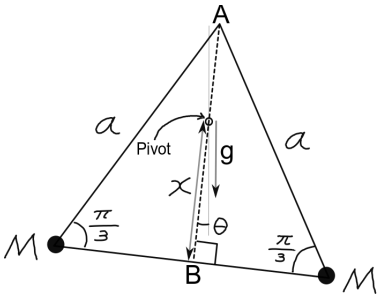
Use this page and the next page for scratch space or for overflow space, should you need more space for your solutions for problems 6 through 9. In the latter case, it is your responsibility to indicate clearly how to find your overflow solutions. *Otherwise, anything written on this page or the next page will be completely ignored.*

For the following four problems, you must show short but sufficient derivations. Answer alone will not get you much credit, even if it is correct. Each of the following four problems is worth 20 points.

Proceed to the next page to start short writing problems.

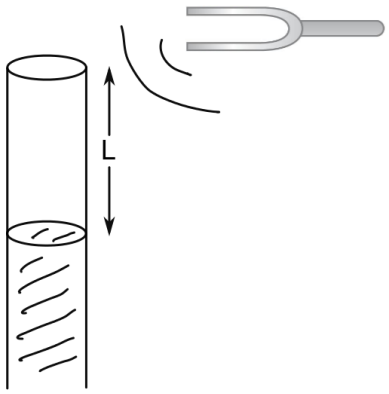
Problem 6 A thin equilateral triangle (with side length a) plate is made of light plastic. Two heavy steel balls of negligible size are attached at two vertices of this triangle. The mass of each steel ball is M, while the mass of the triangle plate is negligible. This object is hanging on a wall as shown in the diagram below, free to rotate (no friction) around the pivot point, which is on the center line AB (see diagram). The position of the pivot point is given by x, $0 < x < \frac{\sqrt{3}}{2}a$ (cf., $\sin\frac{\pi}{3} = \frac{\sqrt{3}}{2}$). (a) Find the period of small oscillation ($|\theta| \ll 1$). (b) An extremum period, T_m, occurs at $x = x_m$, $0 < x_m < \frac{\sqrt{3}}{2}a$. Find x_m, T_m, and the nature (minimum or maximum) of the extremum.

Your solution:



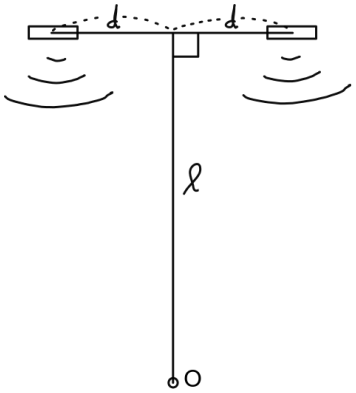
Problem 7 A tuning fork is set into vibration near a vertical open tube filled with water. The water level is allowed to drop slowly from the top ($L = 0$). You find the first seven positions $L = L_1, L_2, L_3, L_4, L_5, L_6, L_7$ (where $L_2 = 3L_1$, $L_3 = 5L_1$ and $L_m = (2m-1)L_1$ for $m = 1, 2, 3, ..., 7$), at which the tube resonates with the vibrating tuning fork. Suppose now that your entire experimental setup is then enclosed in a big glove box filled with helium gas. For the sake of this problem, let us make some simplifying approximations: the bulk modulus of helium gas is equal to that of air and the density of helium gas is one ninth of that of air. As the water level is made to rise back from L_7 to 0, at what value(s) of L, if any, will the tube resonate with the vibrating tuning fork? [Hint: the frequency of the tuning fork does not change.]

Your solution:



Problem 8 Two speakers, connected to the *same* sound source, are blasting off loud sound. The loudness is measured at point O. If the sound from one of the speakers is suppressed completely, with speaker surrounded by thick sound-absorbing material, the loudness that you measure at point O is 70 dB. The frequency of the sound f = 3.00 kHz, the speed of sound v = 340 m/s, d = 3.00 m, and l = 10.00 m. (a) What is the loudness measured at point O, with sounds from both speakers unsuppressed, as shown in the diagram below? (b) What is the loudness measured at point O, if the cable from the sound source to one of the speakers is then fitted with a "phase shifter" that shifts the phase of the sound from that speaker by π? [Hint: do the values of f, v, d, l really matter?]

Your solution:



Problem 9 A police car (car A) is chasing another car (car X). Both cars are moving in the same exact direction, car X is going faster than car A, and the air is still. Siren is sounding off from car A at frequency f = 200 Hz, as heard by the driver of car A, a policeman. As this sound hits car X and returns to car A, the policeman hears 30 beats in 10 seconds as the two sounds—this returning sound and the sound directly from the siren—mix. Car A is going at v_A = 90 miles per hour (mph). How fast is car X going in unit of mph? The speed of sound in air is 760 mph. [Hint: you do *not* need to convert mph to m/s, although one can know that 1 m/s = 2.2 mph.]

Your solution:

You can use this page for scratch space or for overflow space, also. In the latter case, it is your responsibility to indicate clearly how to find your overflow solutions. *Otherwise, anything written on this page will be completely ignored.*