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Midterm #1, Version D
Physics 1B
Prof. David Saltzberg
April 29, 2014

Time: 50 minutes

Closed Notes. Closed Book. Allowed one 3"x5" index card.
Calculators are allowed. Show your work.

If a problem is confusing or ambiguous, notify the professor

Clarifications will be written on the blackboard. Check the board.

There are 10 pages including this cover sheet. Make sure you have them all.
Extra workspace is given and extra paper is at the front of the room.

Problem	Points	Problem	Points
1	12 /15	6	6 /25
~~2~~	~~/15~~	EC	— /10
3	15 /15		
~~4~~	~~/15~~	--------	------------------------
5	10 /15	**TOTAL**	~~45~~ /100
			43/70

61%

1. (15 pts.) Write an equation describing a [redacted] wave on a string that has a wave speed (phase [redacted], a frequency of 100 Hz, an amplitude of 20 meters and is traveling in the negative *x* direction, where at time *t=0* the wave has a displacement of zero meters and is becoming positive. (For simplicity you can put numbers down in SI units without writing the units and don't worry about significant figures.)

$A = 20\,m$ $\quad \omega = 2\pi(100\,Hz) = 628.3\ \frac{rad}{s}$

$\omega = vk \quad \frac{\omega}{v} = k$

$\frac{628.3}{314} = k = 2.00$

$y(x,t) = 20\cos(2.00x + 628.3t \pm \frac{\pi}{2})$

−3

2. (15 pts.) The speed of sound in water is 5600 kilometers/hour (km/h). The double-top-secret Navy Research Laboratory is testing a submarine that travels at 560 km/h with respect to the water. Suppose the water is not flowing and there submarine is headed towards a dolphin at rest in the water. If the submarine releases a sonar tone at 2000 Hz, what frequency does the dolphin hear?

3. (15 pts.) Suppose the velocity, v, of an under-damped harmonic oscillator is given as a function of time, *t*, by:

$$v(t) = 7e^{-0.1t}\cos(4t + \frac{\pi}{2})$$

with all numbers in SI units. How long does it take for the total energy stored in the oscillator to drop to 1% of what its value was at 5 seconds?

$V_{max} = A = 7e^{-.1t}$

$V_{max} = A_{(5)} = 7 \cdot e^{-.1(5)}$

$= 4.25$

$\frac{1}{2}m(4.25)^2$

$E_{tot} = 9.03\,m$

$.01(9.03)m = \frac{1}{2}mv^2$

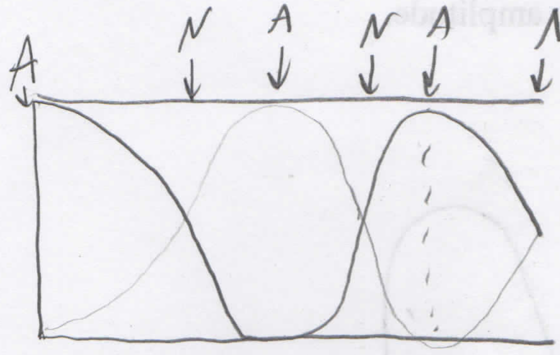
$v = .672$

$.672 = 7e^{-.1(t)}$

$t = 23.45\ s$

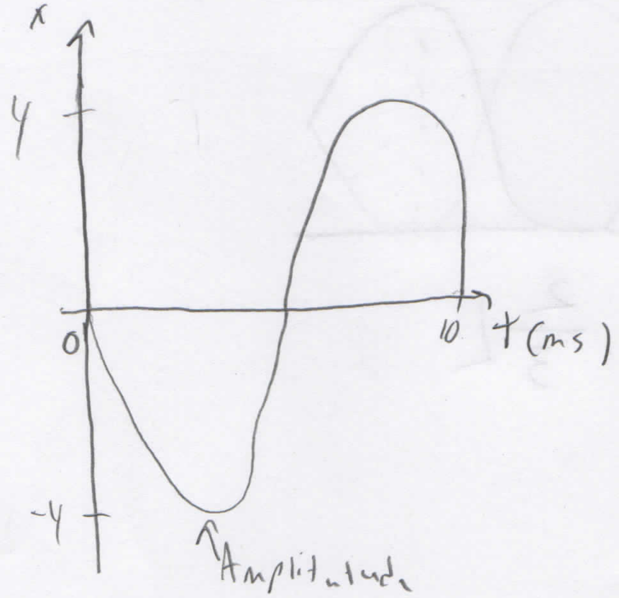
15/15

4. (15 pts.) An organ pipe of length L in air is closed on one end and open at the other. It is producing a loud tone at its 3rd harmonic (i.e., 2nd overtone). Sketch the pipe and mark the location of the pressure nodes and antinodes. What is the sound's wavelength, λ, in terms of L?



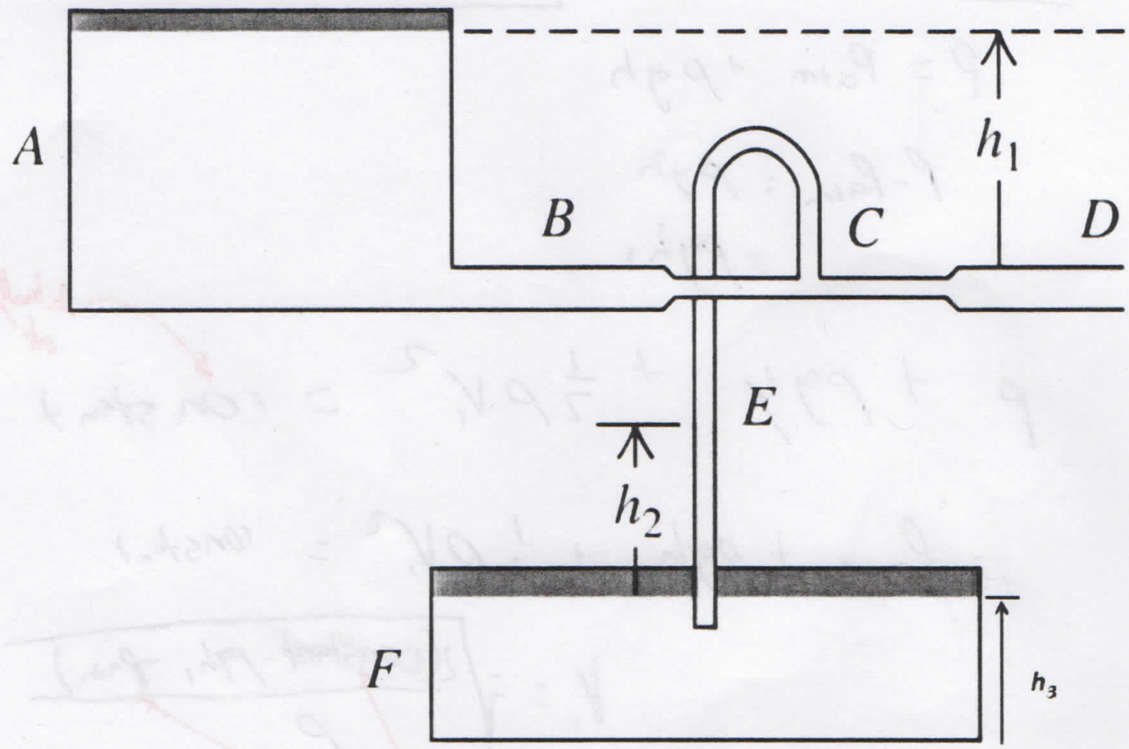
$\lambda = \frac{2}{3} L$

5. (15 pts.) Using the convention in our class, an oscillating mass on a spring is described by the complex number $z = -4i$, where $i = \sqrt{-1}$. The oscillator is known to undergo a full cycle in 10 milliseconds as simple harmonic motion. Sketch the oscillation (displacement vs. time) from 0 to 10 milliseconds and label the amplitude.



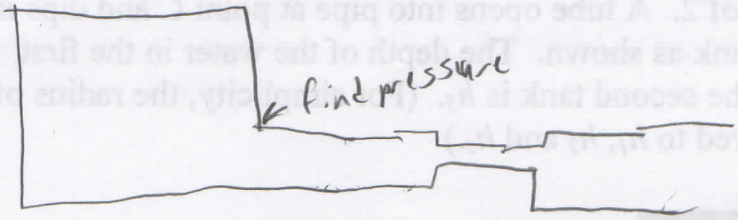
10/15

6. Two large tanks are open to atmospheric pressure, p_{atm}, and contain water as shown. A pipe passes from point *B*, past point *C*, and flows out into the air at point *D*. The pipe becomes narrower at point *C* where the cross-section (area) drops by a factor of 2. A tube opens into pipe at point *C* and dips into the liquid in the lower tank as shown. The depth of the water in the first tank is h_1. Its depth in the second tank is h_3. (For simplicity, the radius of the pipe is small compared to h_1, h_2 and h_3.)



The questions are on the next pages.

a) (10 pts) What is the speed of the water flow when it exits the tube at point D?



+4

$$P = P_{atm} + \rho g h$$

$$P - P_{atm} = \rho g h$$

$$= \rho g h_1$$

$$P + \rho g y + \frac{1}{2}\rho V_1^2 = \text{constant}$$

Actually solve at another point!

$$P_{atm} + \rho g h_1 + \frac{1}{2}\rho V_1^2 = \text{constant}$$

$$V_1 = \sqrt{\frac{2(\text{constant} - \rho g h_1 - P_{atm})}{\rho}}$$

Cancel

$\Rightarrow$ $V = \sqrt{2 g h_1}$

b) (15 pts) To what height h_2 does the water rise in the tube above the surface of the second tank? [Hints: 1) The upper and lower bodies of water are separate. 2) The pressure of the air of the tube connecting C to E is uniform.]

~~System~~

+2

$$P_1 + \rho g y_1 + \frac{1}{2}\rho V_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho V_2^2$$

$AV_1 = \frac{A}{2}V_2$

$V_1 = \frac{V_2}{2}$

$2V_1 = V_2$ ✓

$$P_1 + \frac{1}{2}\rho V_1^2 + \frac{1}{2}\rho(2V_1)^2 = P_2$$

$$\rho g h_1 + \frac{1}{2}\rho V_1^2 - 2\rho V_1^2 = P_2$$

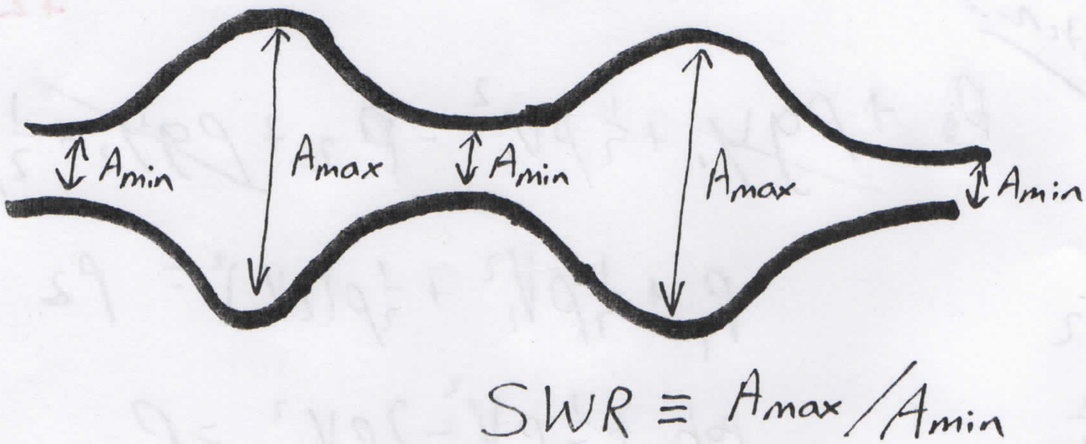
$$\rho g h_1 - \frac{3}{2}\rho V_1^2 = P_2$$

$$P_2 = P_{atm} + \rho g h_2$$

$$h_2 = \frac{\rho g h_1 - \frac{3}{2}\rho V_1^2 - P_{atm}}{\rho g}$$

note V_1 would be the answer from part A...

Extra Credit (10 pts.) If an incident wave is only partially reflected from a boundary (such as sound from a soft wall) the resulting superposition of the two waves has an envelope that does not go completely to zero, as shown:



Therefore a very important quantity in engineering and physics is the "standing wave ratio" or SWR which is defined as SWR=A_{max}/A_{min}. Suppose the reflected wave is in phase and has 50% of the incident amplitude. Find the ratio of the envelopes between the places where a node and an antinode would have been if the reflection had been 100% and in phase.