Physics 213H Test 3

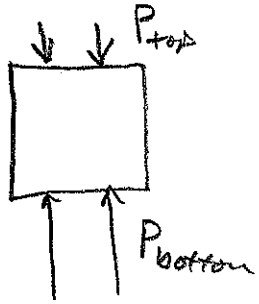
Dr. Gladden, Dec. 1, 2009

NAME: KEY UM ID#:_____

Conceptual Questions (*5 points each*) Answer each of the following questions drawing on and referencing the physical concepts we have covered. Sketches may aid your discussion and no more than 2 - 4 sentences should be required.

1. Briefly explain why objects immersed in a fluid will experience an upward buoyant force.

Because pressure increases with depth, there is more pressure below an object than above. Since $F = PA$, there is a net upward force. This is the buoyant force.

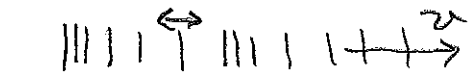


2. A mass on a spring is oscillating in SHM with a certain amplitude (A), and frequency (ω). Some *positive* work is done on the mass. How do A and ω each change (increase, decrease, or remain the same) and why?

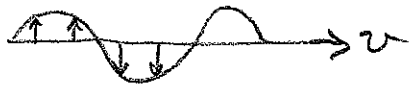
If positive work is being done, the energy of the oscillator is increasing and $E \propto A^2$. So A will increase. In simple harmonic motion, ω is independent of A, so ω will not change.

3. Explain the difference between longitudinal and transverse waves and give an example of each.

Longitudinal: displacement of medium is parallel to wave velocity.
example: Sound wave



Transverse: displacement is perpendicular to wave velocity
example: light, wave on a string



Conceptual Multiple Choice (*4 points each*): Clearly write the letter corresponding to the BEST possible answer in the space provided. You may also circle the answer to be sure.

1. A A book weighs 6 N. When held at rest above your head the net force on the book is
   A) 0 N.
   B) 6 N.
   C) 9.8 N.
   D) -6 N.

2. B A cone balanced on its small end is in
   A) stable equilibrium.
   B) unstable equilibrium.
   C) neutral equilibrium.
   D) positive equilibrium.

3. C A person weighing 800 N stands with one foot on each of two bathroom scales. Which statement is definitely true?
   A) Each scale will read 800 N.
   B) Each scale will read 400 N.
   C) If one scale reads 500 N, the other will read 300 N.
   D) None of the above is definitely true.

4. B Density is
A) proportional to both mass and volume.
B) proportional to mass and inversely proportional to volume.
C) inversely proportional to mass and proportional to volume.
D) inversely proportional to both mass and volume.

5. D You are originally 1.0 m beneath the surface of a pool. If you dive to 2.0 m beneath the surface, what happens to the **absolute** pressure on you?
A) It quadruples.
B) It more than doubles.
C) It doubles.
D) It less than doubles.

6. B As a rock sinks deeper and deeper into water of constant density, what happens to the buoyant force on it?
A) It increases.
B) It remains constant.
C) It decreases.
D) It may increase or decrease, depending on the shape of the rock.

7. A A mass on a spring undergoes SHM. When the mass is at maximum displacement from equilibrium, its instantaneous acceleration
A) is a maximum.
B) is less than maximum, but not zero.
C) is zero.
D) cannot be determined from the information given

8. C Doubling only the amplitude of a vibrating mass-and-spring system produces what effect on the system's mechanical energy?
A) increases the energy by a factor of two
B) increases the energy by a factor of three
C) increases the energy by a factor of four
D) produces no change

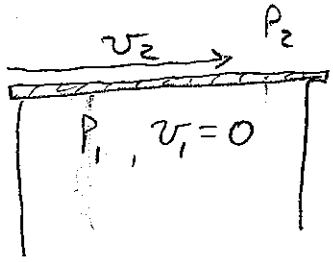
9. C Which of the following increases as a sound becomes louder?
A) frequency
B) wavelength
C) amplitude
D) period
E) velocity

10. D The lowest tone to resonate in an open pipe of length L is 200 Hz. Which one of the following frequencies will not resonate in the same pipe?
A) 400 Hz
B) 600 Hz
C) 800 Hz
D) 900 Hz

Problems: Work each of the following problems. Make sure to **show your work** and put a box around your final answer. (*15 points each*)

1. A 30 m/s wind blows horizontally over a flat roof with area of 150 m^2. Some useful information: ρ_{Al}=2700 kg/m^3, ρ_{air}=1.27 kg/m^3. $P_{atm} = 1.0 \times 10^5$ N/m^2

   (a) (5 points) What is the lift force on the roof? Horizontal Flow so



$$P_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \tfrac{1}{2}\rho v_2^2$$

($v_1 \to 0$)

$$\Delta P = P_1 - P_2 = \tfrac{1}{2}\rho v_2^2$$

$$= 572 \text{ N/m}^2$$

and $\Delta P = \frac{F_L}{A} \Rightarrow F_L = \Delta P A = 572 \frac{\text{N}}{\text{m}^2}(150 \text{ m}^2) = 85{,}725 \text{ N}$

↳ lift force

   (b) (5 points) If the roof is made of a 1 cm thick aluminum slab, will it lift off (there are no bolts to hold it down)?

Is the lift force greater than the weight?

$$F_g = mg = \rho V g = 2700 \frac{\text{kg}}{\text{m}^3}(150 \text{ m}^2)(0.01 \text{ m})(9.8 \text{ m/s}^2)$$

$$= 3969 \text{ N}$$

So $F_L >> F_g$ and it will lift off!

   (c) (5 points) Regardless of the wind, what is the buoyant force on the metal slab from being immersed in atmosphere?

$$F_b = \rho_F V g$$

$$= 1.27 \frac{\text{kg}}{\text{m}^3}(150 \text{ m}^2)(0.01 \text{ m})(9.8 \text{ m/s}^2)$$

$$= 18.7 \text{ N} \rightarrow \text{not much compared to the weight}$$

2. A 3kg mass hangs from a 1.2 m long string to form a pendulum. The mass is displaced by 15 degrees from vertical and released.

(a) (5 points) How long will it take to make 1 complete oscillation?

$$T = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{1.2\ m}{9.8\ m/s^2}} = 2.2\ \text{Seconds}$$

(b)(5 points) How fast will it be moving at it's lowest point?

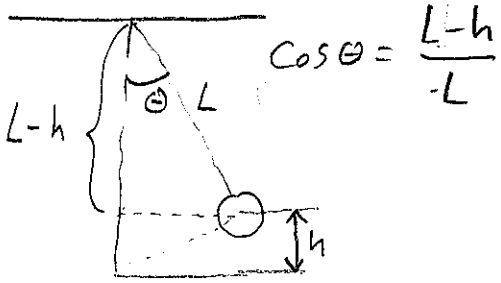
Use Conservation of energy ($E_{top} = E_{bottom}$)

$$mgh = \frac{1}{2}mv^2$$

$$v = \sqrt{2gh}$$

$$= \sqrt{2(9.8)(0.041)}$$

$$= 0.90\ m/s$$



$$\cos\theta = \frac{L-h}{L}$$

so $h = L(1-\cos\theta)$

$= 0.041\ m$

(c) (5 points) If the pendulum were placed in an elevator which is upwardly accelerating at 2.0 m/s^2, how would the period change? (increase, decrease, remain unchanged) Explain your answer!

Then $T = 2\pi\sqrt{\frac{L}{g+a}}$ so the period would decrease. The upward acceleration effectively increases the gravitational acceleration.

3. A cylindrical organ pipe is open at both ends and has a length of 2.5 m. The speed of sound in air is 343 m/s.

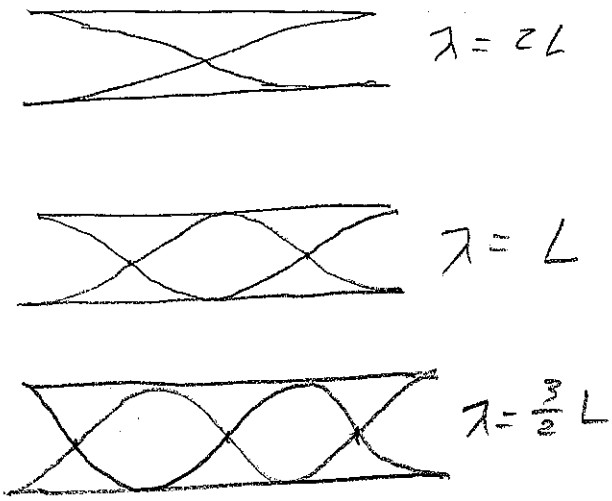
(a) (10 points) What are the first three lowest resonant frequencies of the pipe?

open at both ends

$$f_1 = \frac{v}{2L} = \frac{343}{2(2.5)} = 68.6\ Hz$$

$$f_2 = \frac{v}{L} = 137.2\ Hz$$

$$f_3 = \frac{3v}{2L} = 205.8\ Hz$$



(b) (5 points) If the tube were filled with helium (and the speed of sound in helium is 1005 m/s), what would the new lowest (fundamental) frequency be? (like inhaling helium and speaking in a high pitched voice ;)

Then

$$f_1 = \frac{v}{2L} = \frac{1005}{2(2.5)} = 201\ Hz$$

about the same as the third harmonic in air

Extra Credit(+5 points)

A guitar string is being tuned. If the tension is increased by 20%, how much does the pitch increase?

$f = \frac{v}{2L}$, $v = \sqrt{\frac{T}{\mu}}$ let T_1 be the lower tension,

$T_2 = 1.2\,T_1$

so $\frac{f_1}{f_2} = \frac{\frac{\sqrt{\frac{T_1}{\mu}}}{2L}}{\frac{\sqrt{\frac{T_2}{\mu}}}{2L}} \Rightarrow \frac{f_1}{f_2} = \sqrt{\frac{T_1}{T_2}}$

Then $f_2 = f_1\sqrt{\frac{T_2}{T_2}} = f_1\sqrt{1.2}$

$= 1.095\,f_1$

or about 9.5% higher in pitch