General Physics I **Exam 4 - Chs. 10,12,12 - Fluids, Waves, Sound** **Nov. 18, 2009**

Name Rec. Instr. Rec. Time

For full credit, make your work clear to the grader. Show the formulas you use, the essential steps, and results with correct units and correct number of significant figures. Partial credit is available if your work is clear. Points shown in parenthesis. For true-false and multiple choice questions, choose the *best* answer.
Use g = 9.80 m/s^2, 1 atm = 101.3 kPa, ρ_{water}=1000 kg/m^3.

1. (2) The forces caused by the pressure of a static fluid on its container act

   a. downward only. b. parallel to the container's surfaces. c. perpendicular to the container's surfaces.

2. (2) The sketch shows a flask filled with 5.0 L of solution which has a total weight of 49 N. The pressure force caused by the solution acting only on the base is

   a. less than 49 N. b. 49 N. c. greater than 49 N.

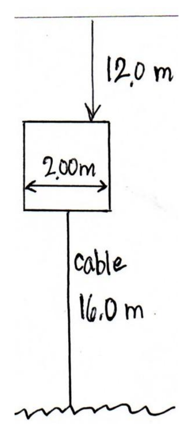
3. (6) Suppose the total weight of a 110-kg football player acts on an area of 1.00 cm^2. What pressure would that produce on that 1.00 cm^2 area? Give your answer both in pascals and in atmospheres.

4. (6) A water tower is used to produce static pressure in the city's water system. How high should the water tower be filled to produce a *gauge pressure* of 3.0 atm at ground level of the tower.

5. (4) A 750-kg boat holding 250 kg of passengers and cargo floats in a fresh-water lake. What minimum volume of water must the boat safely displace?

   a. 0.25 m^3 b. 0.75 m^3 c. 1.0 m^3 d. 250 m^3 e. 750 m^3 f. 1.0×10^3 m^3

6. (12) An 850-kg undersea research station is a cube of edge 2.00 meters. The station is tethered to the ocean floor by a 16.0 m long cable in a location 30.0 m deep. Sea water has a density of 1025 kg/m^3.

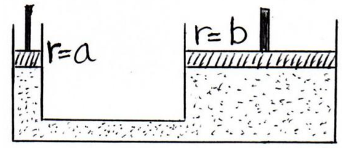


   a) (6) How large is the bouyant force acting on the research station.

   b) (6) How large is the tension in the cable?

7. (10) In a hydraulic lift system, the small piston has radius $a = 1.5$ cm and the larger piston has radius $b = 22$ cm. It is used to raise a 1400-kg car. Ignore the weights of the pistons themselves.

a) (2) While lifting the car during a small time interval Δt, what quantity has about the same magnitude for the two pistons?



a. the pressure on the pistons b. the pressure force on the pistons
c. the piston's average velocities d. the piston's displacements

b) (8) What downward force must be applied to the smaller piston to raise the car at constant speed? Ignore friction.

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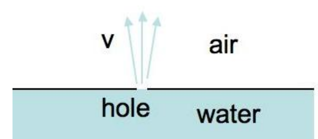
8. (14) A water main pipe contains water at a *gauge pressure* of 8.80 atm.

a) (6) What force does the water pressure produce on any square millimeter of area inside the pipe?

b) (8) A tiny leak develops in the wall of the pipe. Use the Bernouli equation and calculate the speed of the water emerging through the leak.



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9. (2) When a hollow pipe open at both ends is resonating, the type of waves present in it are

a. transverse standing waves. b. transverse traveling waves.
c. longitudinal standing waves. d. longitudinal traveling waves.

10. (2) For the resonant waves in a hollow pipe open at both ends,

a. both ends have antinodes. b. both ends have nodes. c. one end has a node and the other end has an antinode.

11. (2) In a lecture demo, a "singing rod" can be made to oscillate by

a) holding it at a node and rubbing it at a node. b) holding it at an antinode and rubbing it at an antinode.
c) holding it at a node and rubbing it at an antinode. d) holding it at an antinode and rubbing it at a node.

12. (4) The frequency of an oscillating mass connected to a spring will change by what factor if the mass is doubled?

 a. $1/\sqrt{2}$ b. $1/2$ c. $\sqrt{2}$ d. 2

13. (6) A mass connected to a spring is oscillating in simple harmonic motion along the x-axis. The equilibrium point is $x = 0$ and the amplitude is A.

a) (2) At what point(s) in its motion is the acceleration the greatest?

 a. $x = 0$ b. $x = \pm\frac{1}{\sqrt{2}}A$ c. $x = \pm\frac{1}{2}A$ d. $x = \pm\frac{\sqrt{3}}{2}A$ e. $x = \pm A$

b) (2) At what point(s) in its motion is the speed the greatest?

 a. $x = 0$ b. $x = \pm\frac{1}{\sqrt{2}}A$ c. $x = \pm\frac{1}{2}A$ d. $x = \pm\frac{\sqrt{3}}{2}A$ e. $x = \pm A$

c) (2) At which point(s) in the motion does the kinetic energy make up half of the mechanical energy?

 a. $x = 0$ b. $x = \pm\frac{1}{\sqrt{2}}A$ c. $x = \pm\frac{1}{2}A$ d. $x = \pm\frac{\sqrt{3}}{2}A$ e. $x = \pm A$

14. (8) You are given a 500. gram mass and three springs with constants $k = 120$ N/m, 240 N/m and 480 N/m.

a) (2) Which spring used with this mass will make an oscillator with the highest frequency?

 a. k =120 N/m b. k =240 N/m c. k =480 N/m d. it's a tie.

b) (6) Calculate that highest frequency in hertz.

15. (14) A mass connected to a spring with spring constant k =380 N/m oscillates in SHM with a period of 36 ms.

a) (4) What is the frequency of the oscillations, in hertz?

b) (4) How much time elapses for the mass to move from maximum positive displacement to the equilibrium point?

c) (6) How large is the mass?

16. (8) A simple pendulum made from a 480-gram mass suspended on a very light string oscillates with a period of 3.00 seconds. How long is the string?

17. (10) While singing, an artist's voice emits a sound wave at 2.50 kHz. The speed of sound in the room is 348 m/s.

a) (6) How far apart are successive wave crests in the emitted wave?

b) (4) How far does the sound wave travel during one period of the oscillations?

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18. (12) A physics student wants to make a very tiny musical instrument with a 3.00 cm long vibrating string whose fundamental resonance frequency is to be 6.50 kHz. The string has a mass of 8.00 mg (milligrams).

a) (6) What wave speed in needed on the string?

b) (6) What tension should the string have?

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19. (10) Bill is standing at the center of the field in Snyder family stadium, talking with an average acoustic power of 1.5 watts. Assume that the sound of his voice spreads out isotropically.

a) (6) What sound intensity (due to Bill's voice) reaches the end zone, about 46 meters away?

b) (4) What sound level in decibels (due to Bill's voice) reaches the end zone?

Chapter 12 Equations

Sound:

In air, $v \approx (331 + 0.60\ T)$ m/s, T in °C, $v = 343$ m/s at 20°C, $d = vt$.

Sound Intensity, Level:

$I = P/A$, $I = P/4\pi r^2$, $\beta = (10 \text{ dB}) \log \frac{I}{I_0}$, $I = I_0\ 10^{\beta/(10 \text{ dB})}$, $I_0 = 10^{-12}$ W/m^2.

Chapter 11 Equations

Oscillators, frequency, period, etc.:

$F = -kx = ma$, $f = 1/T$, $\omega = 2\pi f = 2\pi/T$, $\omega = \sqrt{k/m}$, $\omega = \sqrt{g/L}$.

Oscillator energy, speed, etc.:

$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2 = \frac{1}{2}mv_{\text{max}}^2$, $v_{\text{max}} = \omega A$.

Waves:

$\lambda = vT$, $v = f\lambda$, $v = \sqrt{\frac{F_T}{m/L}}$, $I = P/A$, $I = P/4\pi r^2$.

Standing waves:

node to node distance $= \lambda/2$.

Chapter 10 Equations

Density:

$\rho = m/V$, SG=$\rho/\rho_{\text{H}_2\text{O}}$, $\rho_{\text{H}_2\text{O}} = 1000$ kg/m^3 = 1.00 g/cm^3 (at 4°C).

Static Fluids:

$P = F/A$, $P_2 = P_1 + \rho gh$, $\Delta P = \rho gh$, $P = P_{\text{atm.}} + P_G$, $B = \rho gV$ or $F_B = \rho gV$.

Pressure Units:

1 Pa = 1 N/m^2, 1 bar = 10^5 Pa = 100 kPa, 1 mm-Hg = 133.3 Pa.

1.00 atm = 101.3 kPa = 1.013 bar = 760 torr = 760 mm-Hg =14.7 lb/in^2.

Moving Fluids:

$A_1 v_1 = A_2 v_2 =$ a constant, $P + \frac{1}{2}\rho v^2 + \rho gy =$ a constant.

(over)

Energy, Force, Power

Work & Kinetic & Potential Energies:

$W = Fd\cos\theta$, $\quad$ $\text{KE} = \frac{1}{2}mv^2$, $\quad$ $\text{PE}_{\text{gravity}} = mgy$, $\; F_{\text{gravity}} = -mg$. $\quad$ $\text{PE}_{\text{spring}} = \frac{1}{2}kx^2$, $\; F_{\text{spring}} = -kx$.

Conservation or Transformation of Energy:

"work-KE theorem" $\Delta\text{KE} = W_{\text{net}}$, **or use conservation law**: $\Delta\text{KE} + \Delta\text{PE} = W_{\text{NC}}$. $\quad E_2 = E_1 + W_{\text{NC}}$.

Power:

$P_{\text{ave}} = \frac{W}{t}$, or use $P_{\text{ave}} = \frac{\text{energy}}{\text{time}}$.

Acceleration Equations

Centripetal Acceleration:

$a_R = \frac{v^2}{r} = \omega^2 r$, towards the center of the circle.

Circular motion:

speed $v = \frac{2\pi r}{T} = 2\pi r f = \omega r$, frequency $f = \frac{1}{T}$, where T is the period of one revolution.

Newton's Second Law:

$\vec{F}_{\text{net}} = m\vec{a}$, which means $\Sigma F_x = ma_x$ and $\Sigma F_y = ma_y$.

Acceleration:

$\bar{v} = \frac{\Delta x}{\Delta t}$, $\quad \Delta x = x - x_0$, $\quad$ slope of $x(t) = v(t)$.

$\bar{a} = \frac{\Delta v}{\Delta t}$, $\quad \Delta v = v - v_0$, $\quad$ slope of $v(t) = a(t)$.

For constant acceleration in one-dimension:

$\bar{v} = \frac{1}{2}(v_0 + v)$, $\quad v = v_0 + at$, $\quad x = x_0 + v_0 t + \frac{1}{2}at^2$, $\quad v^2 = v_0^2 + 2a(x - x_0)$.

Vectors

Written $\vec{V}$ or $\mathbf{V}$, described by magnitude$=V$, direction$=\theta$ or by components (V_x, V_y).

$V_x = V\cos\theta$, $\quad V_y = V\sin\theta$,

$V = \sqrt{V_x^2 + V_y^2}$, $\quad \tan\theta = \frac{V_y}{V_x}$. $\qquad \theta$ is the angle from $\vec{V}$ to $+x$-axis.

Addition: $\mathbf{A} + \mathbf{B}$, head to tail. $\quad$ Subtraction: $\mathbf{A} - \mathbf{B}$ is $\mathbf{A} + (-\mathbf{B})$, $\quad -\mathbf{B}$ is $\mathbf{B}$ reversed.

Trig summary

$\sin\theta = \frac{(\text{opp})}{(\text{hyp})}$, $\quad \cos\theta = \frac{(\text{adj})}{(\text{hyp})}$, $\quad \tan\theta = \frac{(\text{opp})}{(\text{adj})}$, $\quad (\text{opp})^2 + (\text{adj})^2 = (\text{hyp})^2$.

$\sin\theta = \sin(180^\circ - \theta)$, $\quad \cos\theta = \cos(-\theta)$, $\quad \tan\theta = \tan(180^\circ + \theta)$, $\quad \sin^2\theta + \cos^2\theta = 1$.