General Physics I **Exam 4 - Chs. 10,11,12 - Fluids, Waves, Sound** **Nov. 17, 2010**

Name Rec. Instr. Rec. Time

For full credit, make your work clear to the grader. Show formulas used, essential steps, and results with correct units and significant figures. Partial credit is available if your work is clear. Points shown in parenthesis. For TF and MC, choose the *best* answer.

1. (12) One day, the air near Earth's surface at the Manhattan airport has a uniform density of 1.20 kg/m^3, and the absolute pressure at ground level is 99.8 kPa.

a) (4) What force magnitude does the air pressure produce perpendicular to a horizontally oriented surface of area 1.00 cm^2?

b) (2) At increasing elevation above ground level, the pressure

a. increases. b. decreases. c. does not change.

c) (6) Calculate the absolute pressure at an elevation of 1.00 km above the Manhattan airport that day.

2. (10) Solid 100.0-kg samples of gold (SG=19), iron (SG=7.8), and aluminum (SG=2.70) are thrown into a container of water and sink to the bottom.

a) (2) Which sample has the greatest volume?

a. gold b. iron c. aluminum d. all tie.

b) (2) Which sample experiences the greatest bouyant force?

a. gold b. iron c. aluminum d. all tie.

e) (6) Calculate the bouyant force acting on the aluminum sample, when completely submerged in the water.

3. (2) A ship of weight mg floating in the ocean has a bouyant force acting it that is

a. less than its weight. b. equal to its weight. c. greater than its weight.

4. (2) **T F** There is no bouyant force on a sunken ship.

5. (2) **T F** Pascal's Principle: "External pressure applied to a confined fluid is transmitted throughout the fluid."

6. (2) **T F** Bernouli's equation predicts that pressure in a fluid is lower where the fluid is moving faster.

7. (2) **T F** In a transverse wave, the vibrational motions occur in the same direction as the wave propagates.

8. (2) **T F** Sound traveling in a fluid like air is longitudinal waves.

9. (2) **T F** Sound waves of high frequency travel faster than those of low frequency.

10. (2) **T F** When waves spread out in three dimensions from a source, their intensity at distance r from the source diminishes according to an inverse square law in r.

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11. (8) A boat can safely displace 2.50 m^3 of water without sinking, and the boat itself has a mass of 850 kg. What maximum mass of passengers and cargo can the boat carry safely in a fresh-water lake?

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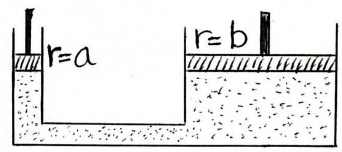
12. (12) The diagram shows a hydraulic system using oil as the fluid. The pistons' radii are 2.0 cm and 32.0 cm. An external force of $F_1 = 10.0$ N is applied to the smaller piston. Ignore the weight of the pistons themselves.



a) (6) What **pressure** (in kPa) does the smaller piston provide to the fluid?

b) (6) With 10.0 N applied to the smaller piston, what pressure **force** F_2 (in newtons) is produced on the larger piston?

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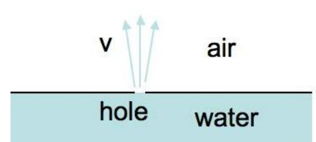
13. (10) A pipe in the basement of an apartment complex is accidentally punctured, causing a leak through the small hole formed. An astute physics student estimates that the water is leaking out a speed of 25 m/s. Apply the Bernouli equation to estimate the **gauge pressure** inside the pipe.



14. (16) A 2.00-kg mass is suspended on a spring and oscillating vertically in simple harmonic motion. It requires 0.400 seconds to move once from its lowest position to its highest position, a distance of 0.480 m.

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

b) (6) How large is the top speed of the mass?

c) (6) When the mass is at its highest point, how large is its acceleration?

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15. (12) It would be fun to set up an amusement ride that is a simple pendulum with a very long period, that people can ride in. Suppose the pendulum with the people in it has a total mass of 2.00×10^3 kg, and it reaches a maximum height of 50.0 m above its lowest point.

a) (6) On Earth, how long should the cable of such a pendulum be, to have a period of 1.00 minute?

b) (6) How much mechanical energy is in the pendulum oscillations?

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16. (10) The wave speed on a string is 575 m/s. Periodic waves are being generated on that string by an oscillator with a period of 1.52×10^{-4}s.

a) (5) What is the wavelength of these periodic waves on the string?

b) (5) At what frequency should the oscillator vibrate, so that the wavelength is 25.0 cm?

17. (2) **T F** A change in **sound level** by +3.0 decibels corresponds to a tripling of the **sound intensity**.

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18. (12) A mosquito 2.0 meters from your right ear is buzzing at a frequency of 220 Hz. Your ear detects a sound level of 25 dB from the mosquito.

a) (6) What sound intensity (in W/m^2) does the mosquito produce, measured at your right ear?

b) (6) If the mosquito keeps buzzing the same, but moves to 1.0 meter from your right ear, what is the new sound level that you hear in your right ear?

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19. (12) A 39.0 cm long violin string has a mass per unit length of 0.140 g/cm and a tension of 524 N.

a) (4) What is the wave speed on this string?

b) (4) What is the wavelength if the string is vibrating in a three-loop standing wave pattern?

c) (4) For the three-loop standing wave pattern, what is the frequency?

Score = ___________/132.

Prefixes

a=10^{-18}, f=10^{-15}, p=10^{-12}, n=10^{-9}, $\mu = 10^{-6}$, m=10^{-3}, c=10^{-2}, k=10^{3}, M=10^{6}, G=10^{9}, T=10^{12}, P=10^{15}

Physical Constants

$g = 9.80$ m/s^2 (gravitational acceleration)
$M_E = 5.98 \times 10^{24}$ kg (mass of Earth)
$m_e = 9.11 \times 10^{-31}$ kg (electron mass)
$c = 299792458$ m/s (speed of light)
$G = 6.67 \times 10^{-11}$ N·m^2/kg^2 (Gravitational constant)
$R_E = 6380$ km (mean radius of Earth)
$m_p = 1.67 \times 10^{-27}$ kg (proton mass)

Units and Conversions

1 inch = 1 in = 2.54 cm (exactly)
1 mile = 5280 ft
1 m/s = 3.6 km/hour
1 acre = 43560 ft^2 = (1 mile)^2/640
1 foot = 1 ft = 12 in = 30.48 cm (exactly)
1 mile = 1609.344 m = 1.609344 km
1 ft/s = 0.6818 mile/hour
1 hectare = 10^4 m^2

Trig summary

$\sin\theta = \frac{(\text{opp})}{(\text{hyp})}$, $\quad \cos\theta = \frac{(\text{adj})}{(\text{hyp})}$, $\quad \tan\theta = \frac{(\text{opp})}{(\text{adj})}$, $\quad (\text{opp})^2 + (\text{adj})^2 = (\text{hyp})^2$.
$\sin\theta = \sin(180° - \theta)$, $\quad \cos\theta = \cos(-\theta)$, $\quad \tan\theta = \tan(180° + \theta)$, $\quad \sin^2\theta + \cos^2\theta = 1$.

Acceleration Equations

$\bar{v} = \frac{\Delta x}{\Delta t}$, $\quad \Delta x = x - x_0$, $\quad$ slope of $x(t)$ curve $= v(t)$.
$\bar{a} = \frac{\Delta v}{\Delta t}$, $\quad \Delta v = v - v_0$, $\quad$ slope of $v(t)$ curve $= a(t)$.

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=θ or by components (V_x, V_y).
$V_x = V\cos\theta$, $\quad V_y = V\sin\theta$,
$V = \sqrt{V_x^2 + V_y^2}$, $\quad \tan\theta = \frac{V_y}{V_x}$. $\quad \theta$ 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.

Newton's Second Law:
$\vec{F}_{\text{net}} = m\vec{a}$, means $\Sigma F_x = ma_x$ and $\Sigma F_y = ma_y$. $\quad \vec{F}_{\text{net}} = \sum \vec{F}_i$, sum over all forces on a mass.

Acceleration Equations

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

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

Gravitation:
$F = G\frac{m_1 m_2}{r^2}$; $\quad g = \frac{GM}{r^2}$, $\quad$ where $G = 6.67 \times 10^{-11}$ Nm^2/kg^2;

Energy, Force, Power

Work & Kinetic & Potential Energies:
$W = Fd\cos\theta$, $\quad \text{KE} = \frac{1}{2}mv^2$, $\quad \text{PE}_{\text{gravity}} = mgy$, $\quad \text{PE}_{\text{spring}} = \frac{1}{2}kx^2$. $\quad \theta$ = angle btwn $\vec{F}$ and $\vec{d}$.

Conservation or Transformation of Energy:

Work-KE theorem:
$\Delta\text{KE} = W_{\text{net}}$ = work of all forces.

General energy-conservation law:
$\Delta\text{KE} + \Delta\text{PE} = W_{\text{NC}}$ = work of non-conservative forces.

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

Linear Momentum

Momentum & Impulse:

momentum $\vec{p} = m\vec{v}$, impulse $\Delta\vec{p} = \vec{F}_{\text{ave}}\ \Delta t$.

Conservation of Momentum:

(2-body collision): $m_A\vec{v}_A + m_B\vec{v}_B = m_A\vec{v'}_A + m_B\vec{v'}_B$.

Center of Mass:

$x_{\text{cm}} = \frac{m_1x_1+m_2x_2+\ldots}{m_1+m_2+\ldots}$, $v_{\text{cm}} = \frac{m_1v_1+m_2v_2+\ldots}{m_1+m_2+\ldots}$.

Rotational Motion

Rotational coordinates:

1 rev $= 2\pi$ radians $= 360°$, $\omega = 2\pi f$, $f = \frac{1}{T}$, $\bar{\omega} = \frac{\Delta\theta}{\Delta t}$, $\bar{\alpha} = \frac{\Delta\omega}{\Delta t}$, $\Delta\theta = \bar{\omega}\Delta t$.

Linear coordinates vs. rotation coordinates and radius:

$l = \theta r$, $v = \omega r$, $a_{\tan} = \alpha r$, $a_R = \omega^2 r$, (must use radians in these).

Constant angular acceleration:

$\omega = \omega_0 + \alpha t$, $\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$, $\bar{\omega} + \frac{1}{2}(\omega_0 + \omega)$, $\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$.

Torque & Dynamics:

$\tau = rF\sin\theta$, $I = \Sigma mr^2$, $\tau_{\text{net}} = I\alpha$, $L = I\omega$, $\Delta L = \tau_{\text{net}}\Delta t$, $\text{KE}_{\text{rotation}} = \frac{1}{2}I\omega^2$.

Static Equilibrium:

$\Sigma F_x = \Sigma F_y = \Sigma F_z = 0$, $\Sigma\tau = 0$, $\tau = rFsin\theta$.

Chapter 10 Equations: Fluids

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:

$A_1v_1 = A_2v_2 =$ a constant, $P + \frac{1}{2}\rho v^2 + \rho gy =$ a constant.

Chapter 11 Equations: Oscillations and Waves

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 12 Equations: Sound

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.