General Physics I **Exam 4 - Chs. 10,11,12 - Fluids, Waves, Sound** **Nov. 14, 2012**

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. (8) What force magnitude in newtons does air pressure of 1.00 atm produce on the upper surface of a rectangular 2.00 m $\times$ 3.00 m table?

2. (14) One day at a fresh water lake, the pressure in the air is 104 kPa just above the surface of the water. The density of the air above is 1.20 kg/m^3.

a) (3) At increasing depth under the water, the pressure

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

b) (3) At increasing altitude above the lake, the pressure

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

c) (8) Calculate the pressure (in kPa) at a depth of 25.0 m under the water.

3. (10) Iron has a specific gravity of 7.8 . Suppose you have a solid cube-shaped piece of iron and know that its mass is 56 kg. The volume of a cube with edge a is $V = a^3$.

a) (4) How large is the density of the iron, in kg/m^3?

b) (6) What is the volume of the iron cube, in m^3?

4. (3) The magnitude of the buoyant force equals the weight of the object for

a. an object that sinks.
b. any object submerged partially or completely in a fluid.
c. an object that floats.
d. no object submerged to any extent in a fluid.

5. (3) The magnitude of the buoyant force equals the weight of the fluid with the same volume as the object for

a. an object completely submerged in a fluid.
b. any object submerged partially or completely in a fluid.
c. an object that floats.
d. no object submerged to any extent in a fluid.

6. (3) An object is floating on the surface of a liquid. Some compound is dissolved into the liquid, increasing its density. What happens?

a. The object would float submerged less deeply.
b. The object would float submerged more deeply.
c. The object might sink to the bottom of the container.
d. More than one of these outcomes is possible.

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7. (10) A 150000-kg undersea research chamber is spherical with an external diameter of 6.8 m. It is anchored to the sea bottom by a cable. The density of the sea water is 1030 kg/m^3.

a) (7) How large is the buoyant force F_B on the chamber?

b) (3) The magnitude of tension in the cable is equal to

a. the weight mg of the chamber.
b. the buoyant force F_B on the chamber.
c. the sum of the weight mg and the buoyant force F_B.
d. the difference of weight minus buoyant force, $mg - F_B$.
e. the difference of buoyant force minus weight, $F_B - mg$.

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8. (8) Atmospheric pressure of 101.3 kPa can be considered the force per unit area ($p = F/A$) due to the weight of air above us (per unit area!). What is the total mass in a column of air with a 1.00 cm^2 cross-sectional area, extending up through the atmosphere?

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9. (2) **T F** If the length of a pendulum is doubled, its period will also be doubled.

10. (2) **T F** If the mass of a pendulum is doubled, its period will not change.

11. (2) **T F** The speed of an oscillating mass on a spring is greatest when passing the equilibrium point.

12. (2) **T F** The acceleration of an oscillating mass on a spring is greatest when passing the equilibrium point.

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13. (6) In some old grandfather clocks, the pendulum has a length of 1.00 m. Suppose the mass is 250 grams. What is the period of the pendulum?

14. (24) A spring is attached to the ceiling. It stretches by 3.20 cm when a force of 4.50 N pulls on the free end.

a) (4) How large is the spring constant k?

b) (6) With what frequency in hertz will a 1.20 kg mass connected to this spring oscillate?

c) (4) While oscillating, the mass moves up and down between points at 1.00 m and 1.48 m below the ceiling. How large is the amplitude of the oscillations?

d) (6) When the mass is at its lowest point, how large is its acceleration?

e) (4) How much total mechanical energy is in the oscillations?

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15. (12) The wave speed on a string is 425 m/s. Periodic waves are being generated on that string by an oscillator with a frequency of 20.4 kHz.

a) (6) What is the wavelength of these periodic waves on the string?

b) (6) The string has a mass per unit length of 8.80×10^{-4} kg/m. What tension is the string under?

16. (12) A 78-dB sound wave strikes an eardrum whose area is 4.8×10^{-5} m^2.

a) (6) What sound intensity (in W/m^2) does this sound level correspond to?

b) (6) How much sound energy is incident on the eardrum per second?

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17. (12) A 0.88 m long string on a musical instrument is vibrating in a two-loop pattern at a frequency of 440 Hz.

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

b) (4) What is the frequency of the fundamental mode of vibration for this string?

c) (4) If the same string were made to vibrate in a five-loop pattern, what would be its frequency?

Score = ___________/133.

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

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

Acceleration Equations

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

For constant acceleration in one-dimension:
$\bar{v} = \frac{1}{2}(v_0 + v)$, $v = v_0 + at$, $x = x_0 + v_0 t + \frac{1}{2}at^2$, $v^2 = v_0^2 + 2a(x - x_0)$.

Vectors

Written $\vec{V}$ or **V**, described by magnitude=V, direction=θ or by components (V_x, V_y).
$V_x = V\cos\theta$, $V_y = V\sin\theta$,
$V = \sqrt{V_x^2 + V_y^2}$, $\tan\theta = \frac{V_y}{V_x}$. θ is the angle from $\vec{V}$ to x-axis.
Addition: $\mathbf{A} + \mathbf{B}$, head to tail. Subtraction: $\mathbf{A} - \mathbf{B}$ is $\mathbf{A} + (-\mathbf{B})$, $-\mathbf{B}$ is $\mathbf{B}$ reversed.

Newton's Second Law:
$\vec{F}_{\text{net}} = m\vec{a}$, means $\Sigma F_x = ma_x$ and $\Sigma F_y = ma_y$. $\vec{F}_{\text{net}} = \sum \vec{F}_i$, 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:
$F = G\frac{m_1 m_2}{r^2}$; $g = \frac{GM}{r^2}$, where $G = 6.67 \times 10^{-11}$ Nm^2/kg^2;

Energy, Force, Power

Work & Kinetic & Potential Energies:
$W = Fd\cos\theta$, $\text{KE} = \frac{1}{2}mv^2$, $\text{PE}_{\text{gravity}} = mgy$, $\text{PE}_{\text{spring}} = \frac{1}{2}kx^2$. θ = 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:
$P_{\text{ave}} = \frac{W}{t}$, 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 = 2π 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=$\rho/\rho_{\text{H}_2\text{O}}$, $\rho_{\text{H}_2\text{O}} = 1000\ \text{kg/m}^3 = 1.00\ \text{g/cm}^3$ (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: $I = P/A$, $I = P/4\pi r^2$, $\beta = (10\ \text{dB})\log\frac{I}{I_0}$, $I = I_0\ 10^{\beta/(10\ \text{dB})}$, $I_0 = 10^{-12}\ \text{W/m}^2$.