Gen Phys I   Quiz 4 - OS Chs. 12,16,17,13 - Fluid Dynamics, Waves, Sound, Ideal Gas   4/20/23

Rec. Time: Name:

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

1. (3) Which volume flow rate through a pipe is the largest?

   a. 4000 cm^3/s.   b. 4 L/s.   c. 4×10^{-3} m^3/s.   d. 4000 mL/s.   e. all tie.

2. (3) If a nozzle at the end of a pipe has half the inside radius as the pipe itself, by what factor does the speed of the water flowing through it change when exiting through the nozzle?

   a. 1/4 as fast.   b. half as fast.   c. it doesn't change.   d. twice as fast.   e. 4 times as fast.

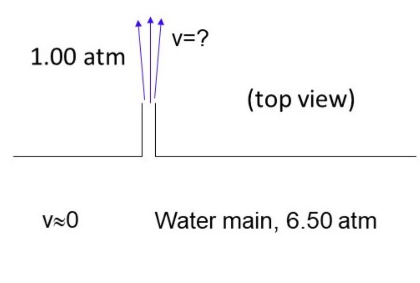
3. (2) **T F** Bernouli's equation relating P, v and y in a fluid is based on conservation of energy.

4. (2) **T F** The Poiseuille equation for flow rate through a pipe accounts for friction in a fluid.

5. (2) **T F** Along a streamline, fluid pressure decreases where the fluid speed increases.

6. (6) Blood at human body temperature has a viscosity around $\eta = 2.1 \times 10^{-3}$ Pa$\cdot$ s. An artery 16.0 cm long has a radius of 1.00 mm and carries blood at a speed of 12.4 cm/s. Calculate the volume flow rate through the artery, in cm^3/s.

7. (8) A very wide water main pipe has absolute pressure of 6.50 atm inside it. If a small tap connected directly to it is opened, at what speed does the water emerge from the tap?



1. _______ / 26

8. (3) The **mass** only of a simple pendulum is increased by a factor of 16. By what factor does the period change?

a. by 1/16. b. by 1/4. c. it doesn't change. d. by 4. e. by 16.

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9. (3) The **length** only of a simple pendulum is increased by a factor of 16. By what factor does the period change?

a. by 1/16. b. by 1/4. c. it doesn't change. d. by 4. e. by 16.

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

11. (2) **T F** In one period, a periodic wave travels one wavelength.

12. (2) **T F** For traveling waves on a string, longer wavelength waves travel faster.

13. (2) **T F** For standing waves on a string, the none-to-node distance is half the wavelength.

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14. (4) In a 1.5-m long organ pipe open at one end oscillating in its fundamental resonance, which two quantities increase if the temperature goes up?

a. The wavelength. b. The period. c. The wave speed. d. The frequency.

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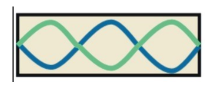
15. (3) The sketch shows the standing wave pattern for displacement of an oscillating string. Which resonance is it?



a. The fundamental. b. The 1st overtone. c. The 2nd overtone. d. The 3rd overtone.

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16. (3) The sketch shows the standing wave pattern for displacement of air molecules in an oscillating pipe closed at one end. Which resonance is it?

a. The fundamental. b. The 1st overtone. c. The 2nd overtone. d. The 3rd overtone.

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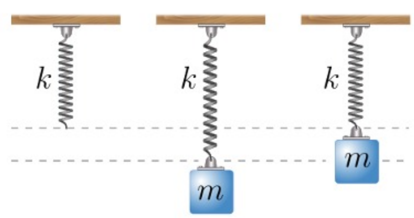
17. (12) A 2.50-kg mass is attached to a hanging spring (left image), stretching it by 0.64 m to its equilibrium position (center image). Then it is raised back to the original spring length, and released (right image).



a) (6) How large is the spring constant?

b) (6) After being released, how long does it take for the mass to first return to the release point?

18. (10) An organ pipe open at both ends emits a pure 324 Hz tone on a day when the speed of sound in air is 349 m/s.

a) (5) How far apart are two neighboring crests of the emitted traveling waves, in meters?

b) (5) If the organ pipe is oscillating in its fundamental resonance, how long is it, in meters?

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19. (6) If one dog barking 8.0 m away from you produces a sound level of 86 dB at your ear, what sound level is caused by 10 dogs barking the same way at the same distance from your ear?

20. (2) At which of these temperatures does 1.0 kg of liquid water have the smallest volume?
a. 0 °C. b. 4 °C. c. 8 °C. d. 25 °C.

21. (2) Of these elements, which has the least number of atoms in a kilogram?
a. hydrogen (H) b. carbon (C) c. nickel (Ni) d. gold (Au) e. all tie.

22. (2) Of these elements, which has the greatest number of atoms in a mole?
a. hydrogen (H) b. oxygen (O) c. copper (Cu) d. uranium (U) e. all tie.

23. (2) Which of the following gases, as a pure sample at 1 atm, 22 °C, has the highest density?
a. oxygen (O_2) b. nitrogen (N_2) c. helium (He) d. propane (C_3H_8) e. all have the same density.

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24. (8) A gas is inside a container at 55.0 °F. Show how to convert that temperature to kelvin.

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25. (12) A 20.0-liter bottle of fixed volume contains pressurized oxygen (O_2) gas, initially at a temperature of 3.00×10^2 K and a pressure of 135 atm.

a) (2) If the absolute temperature were doubled, by what factor would the pressure change?
a. 1/2 b. $1/\sqrt{2}$ c. 1.00 d. $\sqrt{2}$ e. 2 f. 4

b) (2) If the absolute temperature were doubled, by what factor would the rms molecular speed change?
a. 1/2 b. $1/\sqrt{2}$ c. 1.00 d. $\sqrt{2}$ e. 2 f. 4

c) (2) If the O_2 molecules were replaced by an equal number of helium atoms at the same temperature, by what factor would the pressure change?
a. 1/8 b. $1/\sqrt{8}$ c. 1.00 d. $\sqrt{8}$ e. 8

d) (6) How many kilograms of oxygen are inside the container?

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}.
atto, femto, pico, nano, micro, milli, centi, kilo, mega, giga, tera, peta.

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 (exact speed of light)
$u = 1.6605 \times 10^{-27}$ kg (atomic mass unit)
$R = 8.314$ J/mol·K (gas constant)

$G = 6.67 \times 10^{-11}$ 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)
$\sigma = 5.67 \times 10^{-8}$ W/m^2·K^4 (Stefan-Boltzmann constant)
$N_A = 6.022 \times 10^{23}$/mol (Avogadro's number)
$k = 1.38 \times 10^{-23}$ J/K (Boltzmann's constant)

Units and Conversions

1 inch = 1 in = 2.54 cm (exact)
1 mile = 5280 ft (exact)
1 m/s = 3.6 km/hour (exact)
1 acre = 43560 ft^2 = (1 mile)^2/640 (exact)

1 foot = 1 ft = 12 in = 30.48 cm (exact)
1 mile = 1609.344 m = 1.609344 km (exact)
1 ft/s = 0.6818 mile/hour
1 hectare = 10^4 m^2 (exact)

symbol	element	atomic number	mass number
H	hydrogen	1	1.00794
He	helium	2	4.00260
C	carbon	6	12.0107
N	nitrogen	7	14.0067
O	oxygen	8	15.9994
Ne	neon	10	20.180
Ar	argon	18	39.948
Fe	iron	26	55.845
Ni	nickel	28	58.693
Cu	copper	29	63.546
Au	gold	79	196.97
U	uranium	92	238.03

← Some Elemental Properties

Mass numbers are atomic masses in units of "u" where 1 u = 1.6605×10^{-27} kg, or, molar masses for the element (1 mole = 6.02×10^{23} atoms), measured in grams/mole. ($N_A \times 1$ u = 1 gram)

Trig summary

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

Vectors:

written $\vec{V}$ or **V**, described by magnitude=V, direction=θ or by components (V_x, V_y).
$V_x = V\cos\theta$, $V_y = V\sin\theta$,
$V = \sqrt{V_x^2 + V_y^2}$, $\tan\theta = V_y/V_x$. 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.

Forces, Work, Energy

$F_{\text{gravity},y} = -mg$, $F_{\text{spring}} = -kx$, $W = Fd\cos\theta$, θ = angle btwn $\vec{F}$ and $\vec{d}$.
$\text{PE}_{\text{gravity}} = mgy$, $\text{PE}_{\text{spring}} = \frac{1}{2}kx^2$, $\text{KE} = \frac{1}{2}mv^2$.

Conservation or Transformation of Energy:

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

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

Power:

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

OpenStax Ch. 11: Static Fluids

Density:

$\rho = m/V$, SG=ρ/ρ_{H_2O}, $\rho_{H_2O} = 1000$ kg/m^3 = 1.00 g/cm^3 (at 4°C).

Static Pressure, Buoyancy:

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

OpenStax Ch 12: Fluid Dynamics

Moving fluid:

$Q = A_1 v_1 = A_2 v_2 =$ a constant, Bernouli Eqn: $P + \frac{1}{2}\rho v^2 + \rho g y =$ a constant.

Viscosity:

Definition: $F = \eta A v/\ell$, Poiseuille Eqn: $Q = \pi r^4 (P_2 - P_1)/(8\eta L)$.

OpenStax Ch 13: Ideal Gases & Kinetic Theory

Atomic Theory & Moles:

$n = \frac{N}{N_A}$, $n = \frac{M}{M_A}$, M=sample, $N_A = 6.022 \times 10^{23}$/mol, 1 u = $\frac{1 \text{ gram}}{N_A} = 1.6605 \times 10^{-27}$ kg.

Temperature scales:

T(°C) = $\frac{5}{9}$[T(°F)-32], T(°F)=$\frac{9}{5}$ T(°C)+32, T(K)=T(°C)+273.15

Thermal Expansion:

$\Delta L = \alpha L_0 \Delta T$, $\Delta V = \beta V_0 \Delta T$.

Ideal Gas Law:

$PV = nRT$, or $PV = Nk_B T$, $R = 8.314$ J/mol·K, $k_B = R/N_A = 1.38 \times 10^{-23}$ J/K.

Kinetic Theory:

$\overline{\text{KE}} = \frac{1}{2}mv_{rms}^2 = \frac{3}{2}k_B T$, $v_{rms} = \sqrt{3k_B T/m} = \sqrt{3RT/M_A}$, $m = M_A/N_A$ = atom or molecule.

OpenStax Ch 16: 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.:

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

Waves:

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

Standing waves:

node to node distance = $\lambda/2$, sketch displacement of string or molecules.

nodes at both ends of strings. nodes (antinodes) at closed (open) ends of pipes.

OpenStax Ch 17: Sound

Sound in air:

$v \approx (331 \text{ m/s})\sqrt{T(\text{K})/273 \text{ K}}$, T in kelvin, $v = 343$ m/s at 20°C, $d = vt$.

Sound intensity, Sound level:

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