Physics 101	Hour Exam 3	December 1, 2014

Last Name: ________________ **First Name** ________________ **ID** ________________

Discussion Section: ____________________ **Discussion TA Name:** ____________________

Instructions—Turn off your cell phone and put it away.
Calculators cannot be shared. Please keep yours on your own desk.

This is a closed book exam. You have 90 minutes to complete it.
This is a multiple choice exam. Use the bubble sheet to record your answers.

1. Use a #2 pencil; do **not** use a mechanical pencil or a pen. Fill in completely (until there is no white space visible) the circle for each intended input – both on the identification side of your answer sheet and on the side on which you mark your answers. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner.

2. Print your last name in the **YOUR LAST NAME** boxes on your answer sheet and print the first letter of your first name in the **FIRST NAME INI** box. Mark (as described above) the corresponding circle below each of these letters.

3. Print your NetID in the **NETWORK ID** boxes, and then mark the corresponding circle below each of the letters or numerals. Note that there are different circles for the letter "I" and the numeral "1" and for the letter "O" and the numeral "0". **Do not** mark the hyphen circle at the bottom of any of these columns.

4. You may find the version of **this Exam Booklet at the top of page 2**. Mark the version circle in the **TEST FORM** box in the bottom right on the front side of your answer sheet. **DO THIS NOW!**

5. Stop **now** and double-check that you have bubbled-in all the information requested in 2 through 4 above and that your marks meet the criteria in 1 above. Check that you do not have more than one circle marked in any of the columns.

6. Print your UIN# in the **STUDENT NUMBER** designated spaces and mark the corresponding circles. You need not write in or mark the circles in the SECTION box.

7. Write in your course on the **COURSE LINE** and on the **SECTION** *line*, print your **DISCUSSION SECTION**. (You need not fill in the INSTRUCTOR line.)

8. Sign **(DO NOT PRINT)** your name on the **STUDENT SIGNATURE** *line*.

*Before starting work, check to make sure that your test booklet is complete. After these instructions, you should have **7*** ***numbered pages*** *plus 2 Formula Sheets.*

On the test booklet:
Write your **NAME**, your **Discussion TA's NAME**, your **DISCUSSION SECTION** and your **NETWORK-ID**. Also, write your **EXAM ROOM** and **SEAT NUMBER**.

When you are finished, you must <u>hand in BOTH the exam booklet AND the answer sheet</u>. Your exam will not be graded unless both are present.

***<u>Academic Integrity</u>*—Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including expulsion.**

This Exam Booklet is Version F. Mark the **F** circle in the **TEST FORM** box in the bottom right on the front side of your answer sheet. **DO THIS NOW!**

Exam Format & Instructions:

This exam is a combination of

* Three-Answer Multiple Choice (3 points each)
* Five-Answer Multiple Choice (6 points each)

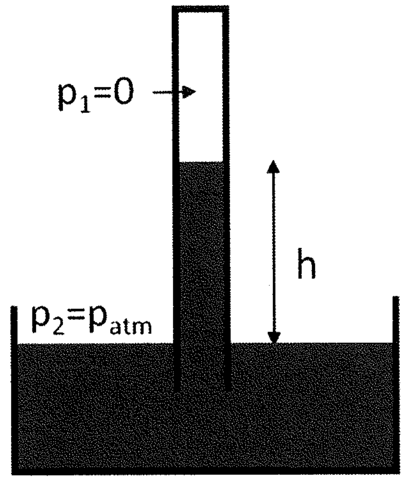
There are 23 problems for a maximum possible raw score of 108 points.

Instructions for Three-Answer Multiple Choice Problems:
Indicate on the answer sheet the correct answer to the question (*a, b* or *c*).
Each question is worth 3 points. If you mark the wrong answer, or mark more than one answer, you receive 0 points.

Instructions for Five-Answer Multiple Choice Problems:
Indicate on the answer sheet the correct answer to each question (*a, b, c, d* or *e*).
Credit is awarded in the following way:
- If you mark one answer and it is correct, you will receive 6 points;
- If you mark two answers, and one of them is correct, you will receive 3 points;
- If you mark three answers and one of them is correct, you will receive 2 points.
- If you mark no answer or more than three answers, you will receive 0 points.

The next two questions pertain to the situation described below.

Shown below is a barometer, a device to measure atomspheric pressure. An evacuated tube is inserted into a pool of liquid with density of 829.7 kg/m^3.



1) If the liquid rises up inside the tube such that the height difference between inside and outside levels h =9.6m, what is the atmospheric pressure?

a. P_{atm} =3.9 × 10^4 Pa
b. P_{atm} =38200 Pa
(c) P_{atm} =78100 Pa
d. P_{atm} =7970 Pa
e. P_{atm} =847 Pa

$P_{atm} = \rho g h$
$= 829.7\ kg/m^3 \times 9.8\ m/s^2 \times 9.6\ m$
$= 78{,}058\ Pa$

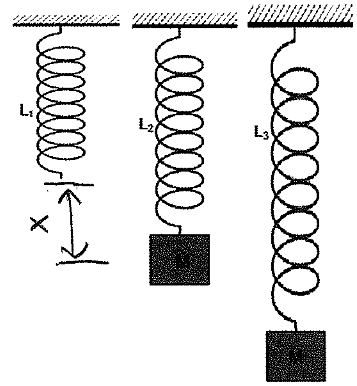
2) For the same atmospheric pressure, how would the height difference, h, change if a tube of smaller diameter is used?

a. h will increase.
(b) h will remain the same.
c. h will decrease.

The next four questions pertain to the situation described below.

Consider a vertically hanging spring with force constant $k = 17\ N/m$ and length $L_1 = 14\ cm$ as shown on the left of the figure.

A mass $M = 0.8\ kg$ is attached to the spring, which extends the spring a to a *new equilibrium* length L_2 as shown in the middle of the figure.



3) Determine the length of the spring L_2

$L_2 = L_1 + x \qquad kx = mg \Rightarrow x = \frac{mg}{k} = \frac{0.8\ kg \times 9.8\ m/s^2}{17\ N/m}$

(a) $L_2 = 60\ cm$
b. $L_2 = 46\ cm$
c. $L_2 = 110\ cm$

$= 14\ cm + 46\ cm \leftarrow = 0.46\ m$

$= 60\ cm$

4) The mass is gently pulled vertically down such that the spring extends from length L_2 to a length L_3 and then released as shown on the right of the figure. The mass begins to execute simple oscillations. Determine the period of the oscillations T.

$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0.8\ kg}{17\ N/m}} = 1.36\ s$

a. $T = 29\ s$
b. $T = 12\ s$
c. $T = 0.68\ s$
(d) $T = 1.4\ s$
e. $T = 14\ s$

5) If the total energy of the oscillating mass is $0.1\ J$, determine the maximum extension of the spring $(L_3 - L_2)$. Take the potential energy of the mass to be zero when the spring has a length L_2.

$\frac{1}{2} k (L_3 - L_2)^2 = 0.1\ J$

$(L_3 - L_2) = \sqrt{\frac{2 \times 0.1\ J}{k}} = 0.108\ m \qquad (k = 17\ N/m)$

a. $0.054\ m$
(b) $0.11\ m$
c. $0.077\ m$
d. $0.22\ m$
e. $0.15\ m$

6) What is the maximum speed of the mass v_{max} ?

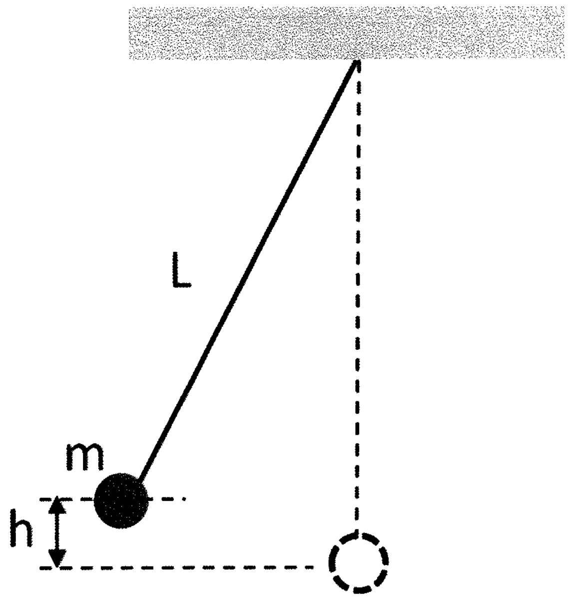
$\frac{1}{2} m v^2 = 0.1\ J$

$v = \sqrt{\frac{2 \times 0.1\ J}{m}} = 0.5\ m/s \qquad (m = 0.8\ kg)$

a. $v_{max} = 0.707\ m/s$
b. $v_{max} = 1\ m/s$
c. $v_{max} = 0.25\ m/s$
(d) $v_{max} = 0.5\ m/s$
e. $v_{max} = 0.354\ m/s$

The next two questions pertain to the situation described below.

A pendulum bob of mass m =1.3 kg hangs from a ceiling as shown below. The length of the pendulum L =4.1 m. Initially, it is held at a position h =0.01 m high from the lowest position.



7) Once released, the pendulum will start oscillating. What is the oscillation period?

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{4.1\ m}{9.8\ m/s^2}} = 4.06\ s$$

(a.) 4.06 s
b. 2.63 s
c. 0.647 s

8) Now imagine you bring the pendulum to another planet where the gravitational acceleration is smaller than that on Earth ~~(the pendulum is no longer in an elevator)~~. If you want to have it oscillate with the same period as on Earth, what modification should you make?

a. Make the bob heavier.
b. Make the initial height h larger.
(c.) Reduce the length of the pendulum.

Using $A = \pi R^2 = \frac{\pi}{4} D^2$

9) Consider water falling from a faucet. At the faucet opening, water flows with a velocity of 0.75 *m/s* and a diameter of 4 *cm*. What is the diameter of the water flow after the water has fallen 53*cm*? Assume the water is incompressible.

$A_1 v_1 = A_2 v_2 \Rightarrow A_2 = A_1 \frac{v_1}{v_2} \Rightarrow D_2^2 = D_1^2 \frac{v_1}{v_2}$

a. 2.36 *cm*
b. 6 *cm*
(c.) 1.9 *cm*
d. 2.99 *cm*
e. 1.61 *cm*

$v_2^2 = v_1^2 + 2g\Delta y = (0.75\ m/s)^2 + 2 \times 9.8\ m/s^2 \times 0.53\ m$

$\Rightarrow v_2 = 3.309\ m/s$

So $D_2^2 = D_1^2 \frac{v_1}{v_2} = (4\ cm)^2 \frac{0.75}{3.309} \Rightarrow D_2 = 1.9\ cm$

10) A 1.2 *kg* block is attached to a massless spring of unknown spring constant. The spring is stretched by 6.5 *cm* and released, when the block starts oscillating. The oscillation period is found to be 0.2 *s*. What is the total energy of the block-spring system?

a. 0.0385 *J*
b. 6.34×10^{-5} *J*
c. 7.96×10^{-5} *J*
d. 0.005 *J*
(e.) 2.5 *J*

$\omega = \sqrt{\frac{k}{m}} \Rightarrow k = m\omega^2$

$T = \frac{2\pi}{\omega} \Rightarrow \omega = \frac{2\pi}{T}$

$U = \frac{1}{2} k A^2 = \frac{1}{2} m\omega^2 A^2 = \frac{1}{2} m \left(\frac{2\pi}{T}\right)^2 A^2 = \frac{1}{2}\ 1.2\ kg \left(\frac{2\pi}{0.2\ s}\right)^2 (0.065\ m)^2 = 2.5\ J$

11) A 2 *kg* mass bounces on the end of a spring completing one period every 2π seconds. What is the spring constant of the spring?

$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}} \Rightarrow k = m\left(\frac{2\pi}{T}\right)^2 = 2\ kg \left(\frac{2\pi}{2\pi\ s}\right)^2 = 2\ N/m$

a. 1.41 *N/m*
b. 1 *N/m*
c. 2.83 *N/m*
(d.) 2 *N/m*
e. 4 *N/m*

12) Which of the following will decrease the period of a pendulum?

$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{L}{g}}$

a. Placing the pendulum on the moon
(b.) Decreasing the length of the pendulum
c. Increasing the mass of the pendulum bob

13) A sound wave is

a. An electromagnetic wave
b. A transverse wave
(c.) A longitudinal wave

14) If the frequency of a wave is 170 Hz, and the wavelength is 2 m, what is the velocity of the wave?

$v = \lambda f = 2m \times 170\ Hz$

$= 340\ m/s$

a. 85 m/s
(b.) 340 m/s
c. 4 m/s
d. 34 m/s
e. 1360 m/s

15) If a sound source moves in the direction of a stationary observer, the observer hears the sound wave at a greater

a. Velocity
b. Period
c. Wavelength
d. Amplitude
(e.) Frequency

Problems 16 - 19 not on Exam 3

16) A cylinder is capped by a piston such that it contains a volume of 20 ml of an ideal gas at a pressure of 40 psi. If the volume is decreased to 10 ml, what is the new pressure? Assume the temperature is constant.

a. 20 psi
b. 80 psi
c. 40 psi

17) The temperature of an ideal gas quadruples. How does the root-mean-square speed of the gas molecules of the hotter gas, v'_{rms}, compare to the root-mean-square molecular speed of the cooler gas, v_{rms}?

a. $v'_{rms} = 2v_{rms}$
b. $v'_{rms} = v_{rms}$
c. $v'_{rms} = 16v_{rms}$
d. $v'_{rms} = 4v_{rms}$
e. $v'_{rms} = 0.5v_{rms}$

18) A piece of metal with coefficient of expansion $\alpha = 16 \times 10^{-6} K^{-1}$ at $273K$ has length $1\ m$. By how much does the length change if it is heated to $900\ K$?

a. $1\ mm$
b. $10\ mm$
c. $100\ mm$

19) A ring of metal with a circular hole in the middle is heated. As a result of heating, the diameter of the hole

a. Decreases
b. Stays the same
c. Increases

20) An observer measures the loudness of a speaker to be $50\ dB$. What would be the loudness of 100 identical speakers together?

(a.) $70\ dB$
b. $250\ dB$
c. $55\ dB$
d. $150\ dB$
e. $500\ dB$

$$\beta_2 = \beta_1 + (10\ dB)\log_{10}\frac{I_2}{I_1}$$

$$= 50\ dB + (10\ dB)\underbrace{\log_{10} 100}_{=2}$$

$$= 70\ dB$$

21) The speed of a 370 *Hz* sound wave is v. What will be the speed, v', of an 740 *Hz* sound wave with the same wavelength?

$v = \lambda f$ $\quad v' = \lambda f'$ $\quad$ Same λ

a. $v' = 2v$
b. $v' = v$
c. $v' = 16v$
d. $v' = 4v$
e. $v' = v/2$

So $\frac{v'}{v} = \frac{f'}{f} = \frac{740}{370} = 2 \Rightarrow v' = 2v$

22) You are standing 9*m* from a speaker and measure sound intensity I. If you walk until you are 18 *m* from the speaker, what will be the new intensity you measure, I'?

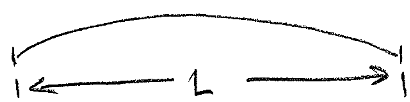
a. $I' = 4I$
b. $I' = 2I$
c. $I' = I/4$
d. $I' = I$
e. $I' = I/2$

$I = \frac{P}{(4\pi r)^2}$

23) One of the strings on a guitar is 29 *cm* long. What is the wavelength of the fundamental frequency for this string?

$\lambda = 2L$

a. 14.5 *cm*
b. 58 *cm*
c. 29 *cm*



Physics 101 Formulas

Kinematics

$\mathbf{v}_{ave} = \Delta\mathbf{x}/\Delta t$ $\quad \mathbf{a}_{ave} = \Delta\mathbf{v}/\Delta t$

$v = v_0 + at$ $\quad x = x_0 + v_0t + {}^1/_2at^2$ $\quad v^2 = v_0^2 + 2a\Delta x$

$g = 9.8\ m/s^2 = 32.2\ ft/s^2$ (near Earth's surface)

Dynamics

$\Sigma\mathbf{F} = m\mathbf{a}$ $\quad F_g = Gm_1m_2 / R^2$ $\quad F_g = mg$ (near Earth's surface)

$f_{s,max} = \mu_sF_N$ $\quad$ Gravitational constant, $G = 6.7 \times 10^{-11}\ N{\cdot}m^2/kg^2$

$f_k = \mu_kF_N$ $\quad a_c = v^2 / R = \omega^2R$

Work & Energy

$W_F = FD\cos(\theta)$ $\quad K = {}^1/_2mv^2 = p^2/2m$ $\quad W_{NET} = \Delta K = K_f - K_i$ $\quad E = K + U$

$W_{nc} = \Delta E = E_f - E_i = (K_f + U_f) - (K_i + U_i)$

$U_{grav} = mgy$

Impulse & Momentum

Impulse $\mathbf{I} = \mathbf{F}_{ave}\Delta t = \Delta\mathbf{p}$ $\quad \mathbf{F}_{ave}\Delta t = \Delta\mathbf{p} = m\mathbf{v}_f - m\mathbf{v}_i$ $\quad \mathbf{F}_{ave} = \Delta\mathbf{p}/\Delta t$

$\Sigma\mathbf{F}_{ext}\Delta t = \Delta\mathbf{P}_{total} = \mathbf{P}_{total,final} - \mathbf{P}_{total,initial}$ (momentum conserved if $\Sigma\mathbf{F}_{ext} = 0$)

$\mathbf{x}_{cm} = (m_1\mathbf{x}_1 + m_2\mathbf{x}_2)/(m_1 + m_2)$

Rotational Kinematics

$\omega = \omega_0 + \alpha t$ $\quad \theta = \theta_0 + \omega_0t + {}^1/_2\alpha t^2$ $\quad \omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

$\Delta x_T = R\Delta\theta$ $\ v_T = R\omega$ $\ a_T = R\alpha$ (rolling without slipping: $\Delta x = R\Delta\theta$ $\ v = R\omega$ $\ a = R\alpha$)

1 revolution = 2π radians

Rotational Statics & Dynamics

$\tau = Fr\sin\theta$

$\Sigma\tau = 0$ and $\Sigma F = 0$ (static equilibrium)

$\Sigma\tau = I\alpha$

$I = \Sigma mr^2$ (for a collection of point particles)

$I = {}^1/_2MR^2$ (solid disk or cylinder) $\quad I = {}^2/_5MR^2$ (solid ball) $\quad I = {}^2/_3MR^2$ (hollow sphere)

$I = MR^2$ (hoop or hollow cylinder) $\quad I = {}^1/_{12}\ ML^2$ (uniform rod about center)

$W = \tau\theta$ (work done by a torque)

$L = I\omega$ $\quad \Sigma\tau_{ext}\Delta t = \Delta\mathbf{L}$ (angular momentum conserved if $\Sigma\tau_{ext} = 0$)

$K_{rot} = {}^1/_2I\omega^2 = L^2/2I$ $\quad K_{total} = K_{trans} + K_{rot} = {}^1/_2mv^2 + {}^1/_2I\omega^2$

Simple Harmonic Motion

Hooke's Law: $F_s = -kx$

$U_{spring} = {}^1/_2kx^2$

$x(t) = A\cos(\omega t)$ $\quad$ or $\quad x(t) = A\sin(\omega t)$

$v(t) = -A\omega\sin(\omega t)$ $\quad$ or $\quad v(t) = A\omega\cos(\omega t)$

$a(t) = -A\omega^2\cos(\omega t)$ $\quad$ or $\quad a(t) = -A\omega^2\sin(\omega t)$

$\omega^2 = k/m$ $\quad T = 2\pi/\omega = 2\pi\sqrt{m/k}$ $\quad f = 1/T$

$x_{max} = A$ $\quad v_{max} = \omega A$ $\quad a_{max} = \omega^2A$ $\quad \omega = 2\pi f$

For a simple pendulum $\omega^2 = g/L$, $T = 2\pi\sqrt{L/g}$

Fluids

$P = F/A$, $P(d) = P(0) + \rho g d$ change in pressure with depth d

Buoyant force $F_B = \rho g V_{dis}$ = weight of displaced fluid

Flow rate $Q = v_1 A_1 = v_2 A_2$ continuity equation (area of circle $A = \pi r^2$)

$P_1 + {}^1/_2 \rho v_1^2 + \rho g y_1 = P_2 + {}^1/_2 \rho v_2^2 + \rho g y_2$ Bernoulli equation

$\rho_{water} = 1000\ kg/m^3$ $1 m^3 = 1000$ liters

$\rho = M/V$ 1 atmos. = 1.01×10^5 Pa 1 Pa = 1 N/m^2

Temperature and Heat

Temperature: Celsius (T_C) to Fahrenheit (T_F) conversion: $T_C = (5/9)(T_F - 32)$

Celsius (T_C) to Kelvin (T_K) conversion: $T_K = T_C + 273$

$\Delta L = \alpha L_0 \Delta T$ $\Delta V = \beta V_0 \Delta T$ thermal expansion

$Q = cM\Delta T$ specific heat capacity

$Q = L_f M$ latent heat of fusion (solid to liquid) $Q = L_v M$ latent heat of vaporization

$Q = \kappa A \Delta T t/L$ conduction

$Q = e\sigma T^4 A t$ radiation ($\sigma = 5.67 \times 10^{-8}$ J/(s·m^2·K^4))

$P_{net} = e\sigma A(T^4 - T_0^4)$ (surface area of a sphere $A = 4\pi r^2$)

Ideal Gas & Kinetic Theory

$N_A = 6.022 \times 10^{23}$ molecules/mole Mass of carbon-12 = 12.000 u

$PV = nRT = Nk_BT$ $R = 8.31$ J/(mol·K) $k_B = R/N_A = 1.38 \times 10^{-23}$ J/K

$KE_{ave} = {}^3/_2 k_B T = {}^1/_2 m v_{rms}^2$ $U = {}^3/_2 N k_B T$ (internal energy of a monatomic ideal gas)

$v_{rms}^2 = 3k_BT/m = 3RT/M$ (M = molar mass = kg/mole)

Thermodynamics

$\Delta U = Q + W$ (1'st law)

$U = ({}^3/_2)nRT$ (internal energy of a monatomic ideal gas for fixed n)

$C_V = ({}^3/_2)R = 12.5$ J/(mol·K) (specific heat at constant volume for a monatomic ideal gas)

$Q_H + Q_C + W = 0$ (heat engine or refrigerator)

$e = -W/Q_H = 1 + Q_C/Q_H$ $e_{max} = 1 - T_C/T_H$ (Carnot engine)

$-Q_C/Q_H = T_C/T_H$ at maximum efficiency (2'nd law)

$W = -P\Delta V$ (work done by expanding gas)

Harmonic Waves

$v = \lambda / T = \lambda f$

$v^2 = F/(m/L)$ for wave on a string

$v = c = 3 \times 10^8$ m/s for electromagnetic waves (light, microwaves, etc.)

$I = P/(4\pi r^2)$ (sound intensity)

Sound Waves

Loudness: $\beta = 10 \log_{10}(I/I_0)$ (in dB), where $I_0 = 10^{-12}$ W/m^2

$$f_{observer} = f_{source} \frac{v_{wave} - v_{observer}}{v_{wave} - v_{source}}$$ (Doppler effect)