Physics 101	Hour Exam 3	December 2, 2013

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 **9** **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 hand in BOTH the exam booklet AND the answer sheet. Your exam will not be graded unless both are present.

Academic Integrity—**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 A. Mark the **A** 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 mixture of

∗ Two-Answer Multiple Choice	(2 points each)
∗ Three-Answer Multiple Choice	(3 points each)
∗ Five-Answer Multiple Choice	(6 points each)

There are 26 problems for a maximum possible raw score of 106 points.

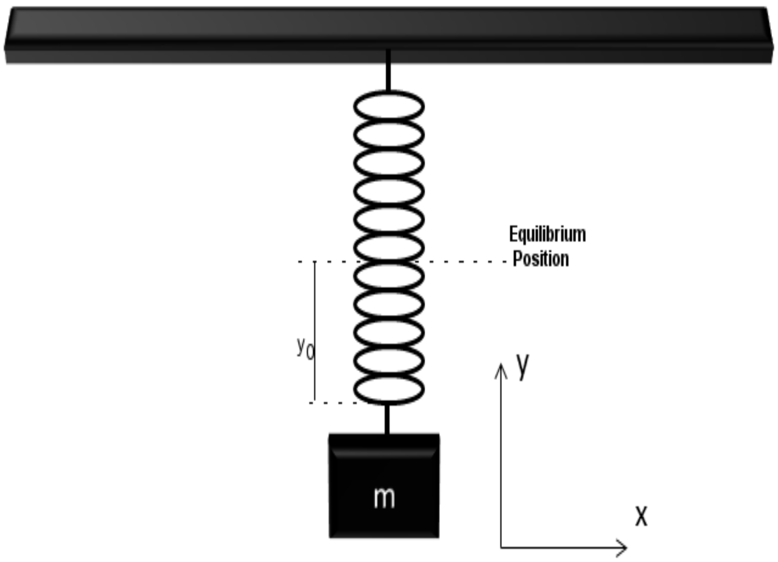
<u>Instructions for Two-Answer Multiple Choice Problems:</u>
Indicate on the answer sheet the correct answer to the question (*a* or *b*).
Each question is worth 2 points. If you mark the wrong answer, or mark more than one answer, you receive 0 points.

<u>Instructions for Three-Answer Multiple Choice Problems:</u>
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.

<u>Instructions for Five-Answer Multiple Choice Problems:</u>
Indicate on the answer sheet the correct answer to each question (*a*, *b*, *c*, *d* or *e*).
<u>Credit is awarded in the following way:</u>

- 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 three questions pertain to the situation described below.



A block of mass *m* = 5 *kg* is connected to a vertical spring as shown in the diagram. When the mass is at rest, the spring stretches $y_0 = 4\ cm$ beyond its natural length $l_{spring} = 15.8\ cm$.

1) For this system, in the *vertical configuration*, $y_0 = 4\ cm$ gives the equilibrium position.

a. True
b. False

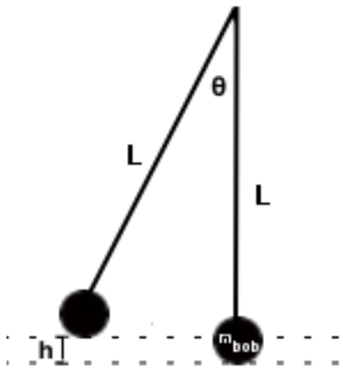
2) You pull straight down on the block with a force $F = 147.15\ N$. How far does the spring stretch if the spring constant is $k = 1200\ N/m$?

a. $y = 12\ cm$
b. $y = 37\ cm$
c. $y = 4.1\ cm$

3) With what frequency will the block oscillate?

a. $f = 6.6 \times 10^{-4}\ s^{-1}$
b. $f = 15\ s^{-1}$
c. $f = 0.065\ s^{-1}$
d. $f = 2.5\ s^{-1}$
e. $f = 0.01\ s^{-1}$

The next four questions pertain to the situation described below.



A simple pendulum hangs from the ceiling. The bob has mass $m_{bob} = 0.25\ kg$. The string has length $L = 4\ m$. The pendulum is gently released from rest at an angle $\theta = 6.2^o$.

4) Find the potential energy of the pendulum bob just before it is released?

a. $U = 1.06\ J$
b. $U = 9.81\ J$
c. $U = 0.0574\ J$

5) What is the maximum speed of the pendulum bob?

a. $v = 0.479\ m/s$
b. $v = 0.678\ m/s$
c. $v = 0.339\ m/s$

6) Find the period of this pendulum.

a. $T = 0.64\ s$
b. $T = 1.6\ s$
c. $T = 4\ s$
d. $T = 9.8\ s$
e. $T = 0.25\ s$

7) You would like to use this pendulum as a clock. What is the length of the string needed to obtain a period of $T = 1.0\ s$?

a. $L = 0.102\ m$
b. $L = 1.56\ m$
c. $L = 0.248\ m$

The next four questions pertain to the situation described below.

Figure 1

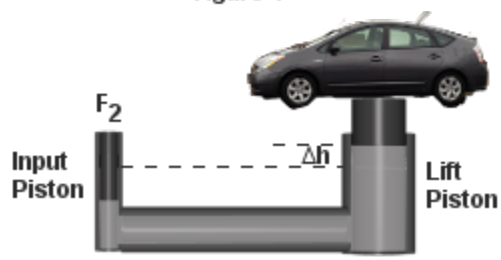


Figure 2

To work on your car you use a hydraulic lift as shown in the diagram. It confines a fluid with $\rho = 2.16\ kg/m^3$. Your car has mass $M_{car} = 888\ kg$. The lift piston has mass $M_{piston} = 216\ kg$. The input piston (on the left) is massless and has an area of $0.785\ m^2$. The lift piston (on the right) has an area of $3.14\ m^2$.

8) In Figure 1 the piston bases are at the same height. How are the pressures on lift side and the input side related?

a. $P_{lift} = P_{input}$
b. $P_{lift} < P_{input}$
c. $P_{lift} > P_{input}$

9) The lift piston base and the input piston base are at the same height. What force is required to maintain this system?

a. $F_{input} = 2180\ N$
b. $F_{input} = 34800\ N$
c. $F_{input} = 2710\ N$
d. $F_{input} = 43300\ N$
e. $F_{input} = 530\ N$

10) Now you would like to lift the car $\Delta\ h = 1.7\ m$ from its current position. How does the work done by the input piston relate to the work done by the lift piston?

a. $W_{input} < W_{output}$
b. $W_{input} > W_{output}$
c. $W_{input} = W_{output}$

11) How far must you push the input piston down to lift the car $\Delta h = 1.7\ m$?

a. $h_{input} = 3.4\ m$
b. $h_{input} = 34\ m$
c. $h_{input} = 6.8\ m$

The next two questions pertain to the situation described below.

Archimedes has been tasked with finding out if the King's crown is really gold. Let's use Archimedes' Principle to see if we can help him figure it out.

12) How can Archimedes' Principle help solve this problem?

a. *Archimedes Principle only works for objects that float.*
b. *The atmospheric pressure will cause the crown to sink.*
c. *The crown's mass and displaced volume will tell us the density of the crown.*

13) You weigh the King's crown. Its mass is $m_{crown} = 1.74\ kg$. How much water should it displace if it is solid gold ($\rho_{gold} = 19.3\ g/cm^3$)?

a. $V_{crown} = 34\ cm^3$
b. $V_{crown} = 0.09\ cm^3$
c. $V_{crown} = 3.4 \times 10^4\ cm^3$
d. $V_{crown} = 270\ cm^3$
e. $V_{crown} = 90\ cm^3$

The next four questions pertain to the situation described below.

The diagram shows two attached garden hoses. Hose 1 has a cross-sectional area $A_1 = 1.06\ cm^2$. Hose 2 has a cross-sectional area $A_2 = 3.06\ cm^2$. Water $(\rho = 1.0\ g/cm^3)$ flows through the hoses.

14) Bernoulli's Equation is a statement about conservation of energy:

a. *False*
b. *True*

15) The water in hose 1 has a velocity $v_1 = 4.6\ cm/s$. What is the velocity v_2 of the water in hose 2?

a. $v_2 = 0.32\ cm/s$
b. $v_2 = 3.2\ cm/s$
c. $v_2 = 13\ cm/s$
d. $v_2 = 1.6\ cm/s$
e. $v_2 = 8\ cm/s$

16) What is the change in pressure between hose 1 and hose 2?

a. $\Delta P = 0.31\ Pa$
b. $\Delta P = 0.93\ Pa$
c. $\Delta P = 1.5\ Pa$

17) The pressure in hose 1 is $P_1 = 7.08\ Pa$. If you put a plate of the same area as hose 2, $A_{plate} = 3.06\ cm^2$, at the end of of hose 2, what force would the plate experience from the water?

a. $F_2 = 19\ N$
b. $F_2 = 6.5\ N$
c. $F_2 = 46\ N$

The next four questions pertain to the situation described below.

An E guitar string of length 70 cm is fixed at both ends. Its fundamental frequency (frequency of the fundamental harmonic) is $f = 330\ Hz$.

18) What is the wavelength of the fundamental oscillation of this string?

a. $\lambda = 175\ cm$
b. $\lambda = 35\ cm$
c. $\lambda = 70\ cm$
d. $\lambda = 105\ cm$
e. $\lambda = 140\ cm$

19) What is the velocity of a wave travelling in the string?

a. $v = 684\ m/s$
b. $v = 462\ m/s$
c. $v = 200\ m/s$

20) The string is retuned. The new tension is $T' = 4T$. What is the new fundamental frequency of the string, f'?

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

21) The string is replaced with a new string. The new string has the same length (70 cm) and tension T. It has four times the mass, $M'' = 4M$. What is the new fundamental frequency of the string, f''?

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

The next two questions pertain to the situation described below.

You are standing *12.9 m* away from a speaker and measure a loudness of *75 dB*.

22) If you measure the sound *25.8 m* from the speaker, what intensity, I', would you measure compared to the original intensity, I?

a. *I' = I/4*
b. *I' = I/2*
c. *I' = I/16*

23) Your friend stacks a second, identical speaker on top of the first. It plays at the same intensity. You measure the loudness at the original position, *12.9 m* from the speakers. What is the new level of loudness you measure?

a. *89 dB*
b. *76 dB*
c. *82 dB*

24) At what speed, v_s, must a car drive towards a stationary observer so that the frequency heard by the observer, f_o, is twice that emitted by the source, f_s, i.e. $f_o = 2f_s$? The speed of sound is $v = 330\ m/s$.

a. $v_s = 187\ m/s$
b. $v_s = 165\ m/s$
c. $v_s = 212\ m/s$
d. $v_s = 375\ m/s$
e. $v_s = 100\ m/s$

25) You heat a metallic strip from *275 K* to *1248 K*. If at *275 K* its length is *1.58 m* and the coefficient of linear expansion is $\alpha = 19 \times 10^{-6}\ K^{-1}$, what is the length of the strip at *1248 K*?

a. $l = 2.37\ m$
b. $l = 1.61\ m$
c. $l = 0.79\ m$

26) We use a piston to compress *94 ml* of a gas at a pressure of *53 Pa* to a new volume of *19 ml* at constant temperature. What is the new pressure of the gas?

a. $P = 167\ Pa$
b. $P = 148\ Pa$
c. $P = 19\ Pa$
d. $P = 33.7\ Pa$
e. $P = 262\ Pa$

Physics 101 Formulas

Kinematics

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

$v = v_0 + at$ $x = x_0 + v_0 t + {}^1/_2 at^2$ $v^2 = v_0^2 + 2a\Delta x$

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

Dynamics

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

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

$f_k = \mu_k F_N$ $a_c = v^2 / R = \omega^2 R$

Work & Energy

$W_F = FD\cos(\theta)$ $K = {}^1/_2 mv^2 = p^2/2m$ $W_{NET} = \Delta K = K_f - K_i$ $E = K + U$

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

$U_{grav} = mgy$

Impulse & Momentum

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

$\Sigma\mathbf{F}_{ext}\Delta t = \Delta\mathbf{P}_{total} = \mathbf{P}_{total,final} - \mathbf{P}_{total,initial}$ (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

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

$\Delta x_T = R\Delta\theta$ $v_T = R\omega$ $a_T = R\alpha$ (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)

$I = {}^1/_2 MR^2$ (solid disk or cylinder) $I = {}^2/_5 MR^2$ (solid ball) $I = {}^2/_3 MR^2$ (hollow sphere)

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

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

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

$K_{rot} = {}^1/_2 I\omega^2 = L^2/2I$ $K_{total} = K_{trans} + K_{rot} = {}^1/_2 mv^2 + {}^1/_2 I\omega^2$

Simple Harmonic Motion

Hooke's Law: $F_s = -kx$

$U_{spring} = {}^1/_2 kx^2$

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

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

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

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

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

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

Fluids

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

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

Flow rate $Q = v_1A_1 = v_2A_2$ continuity equation (area of circle $A = \pi r^2$)

$P_1 + {}^1/_2\rho v_1^2 + \rho gy_1 = P_2 + {}^1/_2\rho v_2^2 + \rho gy_2$ Bernoulli equation

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

$Q = \kappa A\Delta Tt/L$ conduction

$Q = e\sigma T^4At$ radiation ($\sigma = 5.67\text{x}10^{-8}\ J/(s{\cdot}m^2{\cdot}K^4)$)

$P_{net} = e\sigma A(T^4 - T_0^4)$ (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

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

$KE_{ave} = {}^3/_2k_BT = {}^1/_2mv_{rms}^2$ $U = {}^3/_2Nk_BT$ (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)

$C_V = ({}^3/_2)R = 12.5\ J/(mol{\cdot}K)$ (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)