Physics 101	Hour Exam 2	November 4, 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 **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 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 23 problems for a maximum possible raw score of 91 points.

Instructions for Two-Answer Multiple Choice Problems:

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.

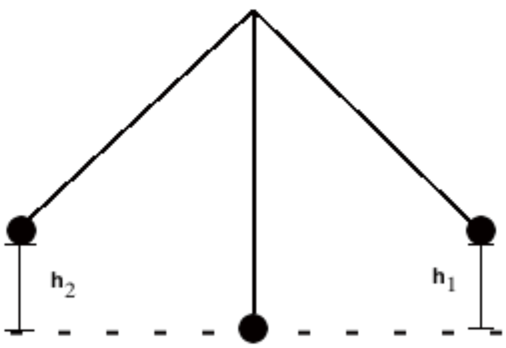
Instructions for Three-Answer Multiple Choice Problems:

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 three questions pertain to the situation described below.



An ideal pendulum (no friction, no air resistance) is shown in the figure. It is released from rest at h_1. It comes to rest at h_2 .

1) Total energy is conserved. How are h_1 and h_2 related?

a. $h_1 < h_2$
b. $h_1 > h_2$
c. $h_1 = h_2$

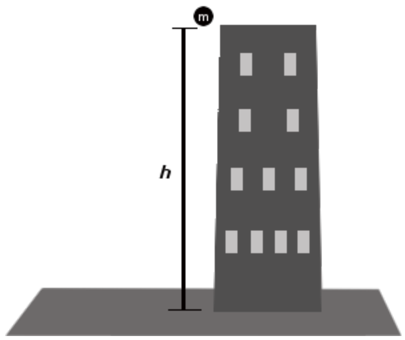
2) At the bottom of the pendulum's swing which of the following are true:

a. *Energy will be lost from each system.*
b. *The potential energy has been converted into kinetic energy.*
c. *The momentum of the bob will be smallest.*

3) If $h_1 = 5\ m$, what is the speed v of the pendulum bob at the lowest point?

a. $v = 98\ m/s$
b. $v = 20\ m/s$
c. $v = 40\ m/s$
d. $v = 9.9\ m/s$
e. $v = 5\ m/s$

The next four questions pertain to the situation described below.



A ball of mass $m = 17\ kg$ falls from a building of height $h = 280\ m$ and lands on the ground. The initial velocity of the ball is $v_i = 0\ m/s$. Ignore air resistance.

4) What is the work done by the force of gravity?

a. $W = 46700\ J$
b. $W = 23400\ J$
c. $W = 11700\ J$
d. $W = 93400\ J$
e. $W = 1.87 \times 10^5\ J$

5) How are the *work* and *kinetic energy* related?

a. *The work done on the ball is equal to the change in momentum of the ball.*
b. *The work done on the ball is equal to the change in kinetic energy of the ball.*
c. *The work is unrelated to the kinetic energy.*

6) Find the speed of the ball just before it hits the ground.

a. $v_f = 74\ m/s$
b. $v_f = 300\ m/s$
c. $v_f = 5500\ m/s$
d. $v_f = 37\ m/s$
e. $v_f = 150\ m/s$

7) If the mass of the ball is increased, will the speed of the ball just before it hits the ground change?

a. *Yes*
b. *No*

The next three questions pertain to the situation described below.

Your having fun skating at the U of I Ice Arena. You are skating along when you suddenly bounce straight off the wall surrounding the arena.

8) Which of the following accurately describe the physics of the collision between you and the wall:

a. *You will experience an an impulse from the wall.*
b. *You will not experience a change in momentum.*
c. *Total momentum in the collision will not be conserved because the wall does not move.*

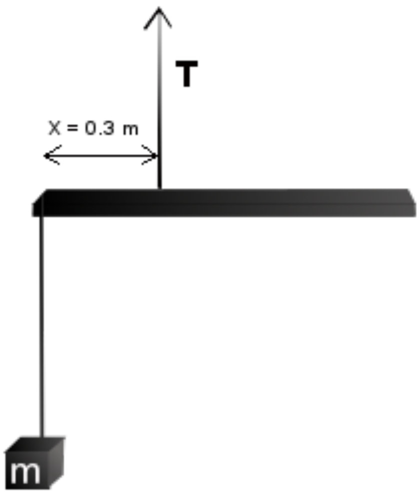
9) If you skate into the wall with a velocity of $v_i = 5\ m/s$ and bounce straight back off the wall with the same speed, what was impulse you experienced? Use $m = 60\ kg$ for your mass.

a. $\Delta p = -2400\ kg\ m/s$
b. $\Delta p = -300\ kg\ m/s$
c. $\Delta p = -1200\ kg\ m/s$
d. $\Delta p = 0\ kg\ m/s$
e. $\Delta p = -600\ kg\ m/s$

10) If you interacted with the wall for $t = 0.21\ s$, what was the average force you experienced?

a. $F = -2900\ N$
b. $F = -970\ N$
c. $F = -1400\ N$
d. $F = -8700\ N$
e. $F = -5800\ N$

The next two questions pertain to the situation described below.



A uniform, one meter board with a mass of *13 kg* hangs by a rope *X = 0.3 m* from the left end of the board with tension *T*. A box of mass *m* hangs from the left end of the board.

11) If the board is to be balanced level to the ground, what must be the mass of the box?

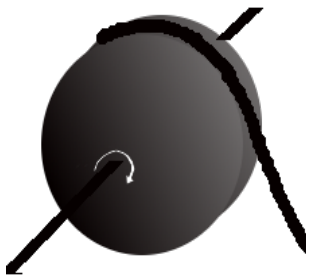
a. *m = 6.5 kg*
b. *m = 8.7 kg*
c. *m = 13 kg*
d. *m = 11 kg*
e. *m = 4.4 kg*

12) The box is removed and replaced with a new box of mass *3m*. How far to the left of the string, *X*, should this box be hung?

a. *X = 0.3 m*
b. *X = 0.2 m*
c. *X = 0.1 m*

The next four questions pertain to the situation described below.

A *uniform* disk of small thickness is shown in the figure. It can rotate *without friction* around an axis through its center. A string is wrapped around the disk. At $t = 0\ s$ the string begins to exert a constant torque of $\tau = 3.7\ N\ m$. The disk begins to rotate. The disk has mass $m = 6\ kg$ and radius $r = 1.2\ m$. For a disk $I_{disk} = 1/2\ MR^2$.



13) What is the tension in the string?

a. $T = 4.4\ N$
b. $T = 0.62\ N$
c. $T = 3.1\ N$

14) Determine the magnitude of the angular acceleration of the disk.

a. $\alpha = 13\ rad/s^2$
b. $\alpha = 0.86\ rad/s^2$
c. $\alpha = 0.72\ rad/s^2$

15) Determine the angular speed ω of the disk at $t = 4\ s$.

a. $\omega = 1.7\ rad/s$
b. $\omega = 3.4\ rad/s$
c. $\omega = 6.8\ rad/s$
d. $\omega = 0.85\ rad/s$
e. $\omega = 10\ rad/s$

16) What is the total work done by the string during the first $4\ s$.

a. $Work = 75\ J$
b. $Work = 6.2\ J$
c. $Work = 25\ J$
d. $Work = 50\ J$
e. $Work = 12\ J$

The next three questions pertain to the situation described below.

A box of mass $M = 45\ kg$ sits on a frictionless surface. It is at rest. It suddenly explodes into two pieces A and B. Piece A moves to the left with a speed $v_A = 1\ m/s$. Piece A has mass $m_A = M/3$.

17) Is total momentum conserved in this system?

a. *Yes*
b. *No*

18) What is the speed of Piece B?

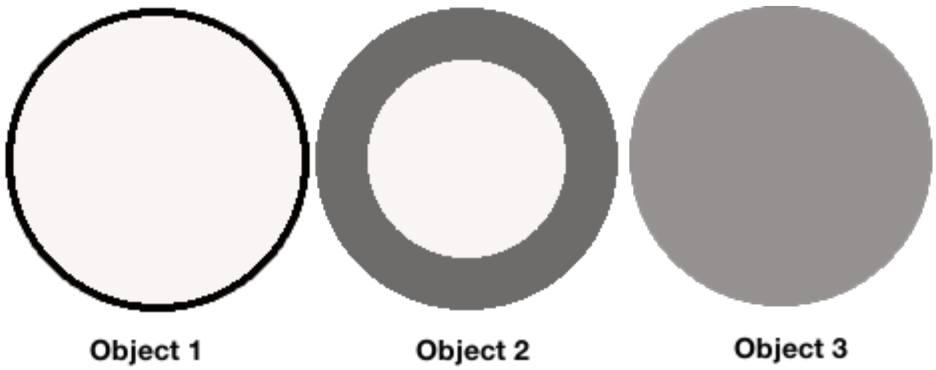
a. $v_B = 0.5\ m/s$
b. $v_B = 1\ m/s$
c. $v_B = 0.12\ m/s$

19) What is the kinetic energy of Piece B?

a. $K_B = 0.17\ J$
b. $K_B = 3.8\ J$
c. $K_B = 15\ J$

The next four questions pertain to the situation described below.

We have a collection of three cylindrical objects, all with equal mass *M* and equal outer radius *R*:



The mass of each object is uniformly distributed. Hint: For a hollow cylinder $I_{h.\ cyl} = 1/2\ M\ (R^2{}_1 + R^2{}_2)$.

20) Which of the following statements is true?

a. $I_1 > I_2 > I_3$
b. $I_1 > I_3 > I_2$
c. $I_2 > I_3 > I_1$

21) Each object is initiallyat rest and fixed to rotate about its center *without friction*. A force *F* of magnitude *7 N* is appied tangentially to the edge of each object. After 5 seconds which object spins fastest?

a. *Object 2*
b. *Object 1*
c. *Object 3*

22) Consider Object 3. It is changed so the mass *M* is doubled (i.e. $M' = 2M$) but the radius remains constant. How does the new moment of inertia, I', compare to the original moment of inertia, I?

a. $I' = I$
b. $I' = 4I$
c. $I' = 2I$

23) Now Object 3 is changed so its mass is its original value *M*, but the radius is doubled (i.e. $R'' = 2R$). How does the new moment of inertia, I'', compare to the original moment of inertia, I?

a. $I'' = 4I$
b. $I'' = I$
c. $I'' = 2I$

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

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

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

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

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)

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

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

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

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

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

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

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

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

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

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

$KE_{ave} = {}^3/_2 k_BT = {}^1/_2 m v_{rms}^2$ $U = {}^3/_2 Nk_BT$ (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)