Physics 1425
Midterm 3

Your Name____________________________ Your Computer ID:____________ Your Section:_____

Instructions
- In this test neither your book nor any notes are allowed; only your calculator.
- You have one hour to do the problems.
- Formulas and constants that might be helpful are given on the last page. Feel free to tear it off.
- On this exam booklet, please print your name, computer ID, the date, and sign the pledge.
- On your bubble sheet, please fill in your name and the date in the spaces provided.
- Under 'Test' please write 'Test 3, and under 'Class name/abbreviation' please write 'PHYS1425.
- In the column on the right–hand side PLEASE BE CERTAIN to bubble in your UVa computing ID, left justified.
- You will return this signed sheet along with your signed bubble sheet.
- Each multiple choice question has one and only one correct answer.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Your section is:
A) 1 (9 AM) B) 2 (10 AM) C) 3 (11 AM)

2) This version of the test is (see page number below):
A) A B) B C) C D) D

3) A figure skater rotating at 5.00 rad/s with arms extended has a moment of inertia of 2.25 kg m^2. If the arms are pulled in so the moment of interia decreases to 1.80 kg m^2, what is the final angular speed?

A) 2.25 rad/s B) 4.00 rad/s C) 6.25 rad/s D) 1.76 rad/s E) 0.81 rad/s

4) You are holding on to the axle of a spinning bicycle wheel with one hand on either side of the wheel. The top part of the wheel is rotating away from you and the bottom is rotating toward you and the axle is horizontal. As you start to turn left, pulling the left (right) part of the axle toward (away) from you, you feel the right side of the axle

A) push on your right hand toward the left.
B) push on your right hand toward you.
C) pull on your right hand away from you.
D) push on your right hand vertically up.
E) push on your right hand vertically down.

5) Several forces act on an object at rest. It is known that the sum of the forces acting on the object is zero. Which statement is necessarily true?

A) The object will neither move nor rotate.

B) The object's center of mass may move in such a way that the object will roll without slipping.

C) The object's center of mass will not move, but the object may begin to rotate.

D) The object's center of mass may accelerate and the object may begin to rotate.

E) The object's center of mass may accelerate, but the object will remain in the same orientation.

6) A 3.00 m long plank of negligible mass has a 30.0 kg mass at one end and a 40.0 kg mass at the other end. How far from the 30.0 kg mass should a fulcrum be placed so the plank is balanced?

A) 1.71 m B) 1.29 m C) 0.75 m D) 1.50 m E) 2.25 m

7) Consider three drinking glasses. All three have the same area base, and all three are filled to the same depth with water. Glass A is cylindrical. Glass B is wider at the top than at the bottom, and so holds more water than A. Glass C is narrower at the top than at the bottom, and so holds less water than A. Which glass has the greatest liquid pressure at the bottom?

A) Glass B
B) Glass A
C) Glass C
D) All three have zero pressure at the bottom
E) All three have equal, nonzero pressure

8) A cup of water is filled to the brim when an ice cube is placed in it. The top of the ice cube sticks out of the surface. As the ice melts, you observe that

A) The cup overflows.
B) The cup might overflow but it depends on the actual mass of the ice cube.
C) The water level remains the same.
D) The water level goes down.
E) There is not enough information to answer the question.

9) A large cylindrical tank of water of radius 12.0 m is filled to a depth of 3.00 m. A spigot on the tank is a 3.00 cm inner diameter pipe that is located 20.0 cm above the bottom of the tank. If the spigot is opened, what is the speed of the water leaving the spigot?

A) 3.68 ms B) 27.5 m/s C) 54.9 ms D) 7.41 m/s E) 5.24 m/s

10) A mass at the surface of the earth is attached to a vertical spring and bobs up and down between points A and B. Where is the mass located when its potential energy is a maximum?

A) one–third of the way between A and B
B) none of the above
C) midway between A and B
D) at either A or B
E) one–fourth of the way between A and B

11) Doubling only the mass of an oscillating mass–and–spring system while leaving the amplitude the same produces what effect on the systems mechanical energy?

A) increases the energy by a factor $\sqrt{2}$

B) increases the energy by a factor of 2

C) increases the energy by a factor of 3

D) increases the energy by a factor of 4

E) produces no change in the energy

12) A pendulum is made by suspending a solid circular disk from a pivot point that is at the edge of the disk with the plane of the disk lying in the vertical plane. The period of oscillation of the disk is T. If a disk with the same radius but a mass 4 times as great is suspended the same way, what will be its period of oscillation?

A) 4T B) T/2 C) 2T D) T E) T/4

13) Suppose that a steel bridge, 1000 m long, were built without expansion joints. Suppose that only one end of the bridge was held fixed. What would the difference in the length of the bridge by between winter and summer, taking a typical winter temperature to be 0^oC, and a typical summer temperature as 40^o C ? The coefficient of thermal expansion of steel is $10.5x10^{-6}$ K^{-1}.

A) 0.42 m B) 0.11 m C) 0.11 mm D) 0.42 mm E) 0.37 cm

14) A weather balloon contains 12.0 m^3 of hydrogen gas when it is released from a location at which the temperature is 22^o C and the pressure is 101 kPa. It rises to a location where the temperature is -30^o C and the pressure is 20 kPa. If the balloon is free to expand so that the pressure of the gas inside is equal to the ambient pressure, what is the new volume of the balloon?

A) 14.0 m^3 B) 2.38 m^3 C) 49.9 m^3 D) 82.6 m^3 E) 4.16 m^3

15) According to the kinetic theory of gases, the pressure of a gas in a container is due to:

A) change in kinetic energy of molecules as they strike the walls

B) change in momentum of molecules as they strike the walls

C) average kinetic energy of the molecules

D) force of repulsion between the molecules

E) rms speed of the molecules

16) A vacuum chamber with a volume of 100 cm^3 is pumped down to a very low pressure, so that there are only 100 molecules of gas in the chamber. The average kinetic energy of a single molecule is 1.0×10^{-23} J. What is the pressure inside the chamber?

A) 2.00×10^{-17} Pa

B) 6.67×10^{-24} Pa

C) 2.00×10^{-23} Pa

D) 6.67×10^{-18} Pa

E) 1.00×10^{-17} Pa

17) A sample of ideal gas is slowly compressed to one–half its original volume with no change in temperature. What happens to the average speed of the molecules in the sample ?

A) It does not change
B) It quadruples
C) It doubles
D) It halves
E) none of the above

Some possibly useful formulas:

$\bar{v} = \frac{\Delta x}{\Delta t}$ | $v = \frac{dx}{dt}$ | $\bar{a} = \frac{\Delta v}{\Delta t}$ | $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$

$x = x_0 + v_{0x}t + \frac{1}{2}a_xt^2$ | $v_x = v_{0x} + a_xt$ | $x = \frac{1}{2}(v_{0x} + v_x)t$ | $v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$

$y = y_0 + v_{y0}t + \frac{1}{2}a_yt^2$ | $v_y = v_{0y} + a_yt$ | $y = \frac{1}{2}(v_{0y} + v_y)t$ | $v_y^2 = v_{0y}^2 + 2a_y(y - y_0)$

$\vec{\mathbf{v}} = \vec{\mathbf{v}}_0 + \vec{\mathbf{a}}t$ | $\vec{\mathbf{r}} = \vec{\mathbf{r}}_0 + \vec{\mathbf{v}}_0t + \frac{1}{2}\vec{\mathbf{a}}t^2$ | $\vec{\mathbf{v}}_{13} = \vec{\mathbf{v}}_{12} + \vec{\mathbf{v}}_{23}$ | $\sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}$

$\vec{\mathbf{F}}_G = m\vec{\mathbf{g}}$ | $a_c = \frac{v^2}{R}$ | $R = \frac{v_0^2 \sin 2\theta}{g}$ | $T = \frac{1}{f}$

$F_{\mathrm{fr}} = \mu_{\mathrm{k}}F_{\mathrm{N}}$ | $F_{\mathrm{fr}} \leq \mu_{\mathrm{s}}F_{\mathrm{N}}$ | $a_R = \frac{v^2}{R}$ | $a_{\tan} = \frac{dv}{dt}$

$F_{\mathrm{D}} = -bv$ | $\vec{\mathrm{F}} = G\frac{m_1m_2}{r^2}\hat{\mathbf{r}}$ | $\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$ | $W = F_{\parallel}d = \vec{\mathrm{F}} \cdot \vec{\mathrm{d}} = \int_a^b \vec{\mathrm{F}} \cdot d\vec{\boldsymbol{\ell}}$

$F_{\mathrm{S}} = -kx$ | $W = \frac{1}{2}kx^2$ | $K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ | $W_{\mathrm{net}} = \Delta K$

$\Delta U = U_2 - U_1 = -\int_1^2 \vec{\mathrm{F}} \cdot d\vec{\boldsymbol{\ell}} = -W$ | $U_{\mathrm{el}}(x) = \frac{1}{2}kx^2$ | $F(x) = -\frac{dU(x)}{dx}$

$W_{\mathrm{NC}} = \Delta K + \Delta U$ | $U(r) = -G\frac{mM}{r}$ | $U_{\mathrm{grav}} = mgy$ | $P = \frac{dW}{dt} = \frac{dE}{dt}$

$P = \vec{\mathbf{F}} \cdot \vec{\mathbf{v}}$ | $e = \frac{P_{\mathrm{out}}}{P_{\mathrm{in}}}$ | $\vec{\mathbf{p}} = m\vec{\mathbf{v}}$ | $\sum \vec{\mathbf{F}}_{\mathrm{ext}} = \frac{d\vec{\mathbf{p}}}{dt}$

$\vec{\mathbf{J}} = \int_{t_1}^{t_2} \vec{\mathbf{F}}dt = \Delta\vec{\mathbf{p}}$ | $m_{\mathrm{A}}\vec{\mathbf{v}}_{\mathrm{A}} + m_{\mathrm{B}}\vec{\mathbf{v}}_{\mathrm{B}} = m_{\mathrm{A}}\vec{\mathbf{v}}'_{\mathrm{A}} + m_{\mathrm{B}}\vec{\mathbf{v}}'_{\mathrm{B}}$ | $\vec{\mathbf{r}}_{\mathrm{CM}} = \frac{\sum m_i\vec{\mathbf{r}}_i}{M}$ | $M\vec{\mathbf{a}}_{\mathrm{CM}} = \sum \vec{\mathbf{F}}_{\mathrm{ext}} = \frac{d\vec{\mathbf{P}}}{dt}$

$\vec{\mathbf{P}} = M\vec{\mathbf{v}}_{\mathrm{CM}}$ | $\theta = \theta_0 + \omega_0t + \frac{1}{2}\alpha t^2$ | $\omega = \omega_0 + \alpha t$ | $\theta = \theta_0 + \frac{1}{2}(\omega_0 + \omega)t$

$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$ | $\omega = 2\pi f = \frac{2\pi}{T}$ | $\theta = \frac{\ell}{r}$ | $\omega = \frac{d\theta}{dt} = \frac{v}{r}$

$\alpha = \frac{d\omega}{dt} = \frac{a_{\tan}}{r}$ | $\tau = rF_{\perp} = rF\sin\theta = \vec{\mathbf{r}} \times \vec{\mathbf{F}}$ | $\sum \tau = I\alpha$ | $W = \int_{\theta_1}^{\theta_2} \tau d\theta$

$I = \sum m_iR_i^2 = \int R^2dm$ | $I = I_{\mathrm{CM}} + Mh^2$ | $I_{\mathrm{bar\ at\ end}} = \frac{1}{3}ML^2$ | $I_{\mathrm{hoop}} = mR^2$

$I_{\mathrm{disk}} = \frac{1}{2}mR^2$ | $I_{\mathrm{sphere}} = \frac{2}{5}mR^2$ | $I_{\mathrm{point\ mass}} = mR^2$

$L = I\omega$ | $L = rp\sin\theta$ | $\vec{\mathbf{L}} = \vec{\mathbf{r}} \times \vec{\mathbf{p}}$ | $P = \tau\omega$

$\sum \vec{\tau}_{\mathrm{ext}} = \frac{d\vec{\mathbf{L}}}{dt}$ $\Delta\ell = \frac{1}{E}\frac{F}{A}\ell_0$ | $\Delta\ell = \frac{1}{G}\frac{F}{A}\ell_0$ | $\frac{\Delta V}{V_0} = -\frac{1}{B}\Delta P$ | $\rho = \frac{m}{V}$

$P = \frac{F}{A}$ | $P = \rho gh$ | $F_{\mathrm{B}} = \rho_{\mathrm{F}}Vg$ | $Av = \text{constant}$

$P_1 + \frac{1}{2}\rho v_1^2 + \rho gy_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho gy_2$ | $Q = \frac{\pi R^4(P_2 - P_1)}{8\eta\ell}$ | $x = A\cos(\omega t + \phi)$

$\omega = \sqrt{\frac{g}{L}}$ | $\omega = \sqrt{\frac{k}{m}}$ | $\omega = \sqrt{\frac{mgh}{I}}$ | $x = Ae^{-\gamma t}\cos\omega' t$

$A_0 = \frac{F_0}{m\sqrt{(\omega^2 - \omega_0^2)^2 + (b\omega/m)^2}}$ | $\Delta\ell = \alpha\ell_0\Delta T$ | $\Delta V = \beta V_0\Delta T$

$PV = nRT = NkT$ | $T_{\mathrm{K}} = T_{\mathrm{C}} + 273.15$ | $K = \left(\frac{1}{2}mv^2\right)_{\mathrm{av}} = \frac{3}{2}kT$ | $\ell_{\mathrm{M}} = \frac{1}{4\pi\sqrt{2}r^2(N/V)}$

$J = DA\frac{\Delta C}{\Delta x}$

Some possibly useful constants:

$C = 2\pi r$	$A = \pi r^2$	$A = 4\pi r^2$	$V = \frac{4}{3}\pi r^3$
$\lvert\vec{\mathbf{g}}\rvert = 9.80\ m/s^2$	$1\,\mathrm{mi} = 5{,}280\,\mathrm{ft}$	$1\,\mathrm{in} = 2.54\,\mathrm{cm}$	$G = 6.67 \times 10^{-11}\ \mathrm{N{\cdot}m^2/kg^2}$
$1\,\mathrm{atm} = 1.013 \times 10^5\ \mathrm{N/m^2}$	$\rho_{\mathrm{water}} = 1.0 \times 10^3\,\mathrm{kg/m^3}$	$R = 8.314\,\mathrm{J/mol{\cdot}K}$	$k = 1.38 \times 10^{-23}\,\mathrm{J/K}$
$4.186\ \mathrm{J} = 1\ \mathrm{cal}$	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W/m^2{\cdot}K^4}$	$N_{\mathrm{A}} = 6.022 \times 10^{23}$ [molecules/mole]	

1 H 1.008																1 H 1.008	2 He 4.003
3 Li 6.939	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.91	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (99)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (267)	105 Ha (268)	106 Sg (271)	107 Bh (272)	108 Hs (270)	109 Mt (276)	110 Ds (281)	111 Rg (280)	112 Cn (285)	113 Uut (284)	114 Fl (289)	115 Uup (288)	116 Lv (293)	117 Uus (294)	118 Uuo (294)

58 Ce 140.1	59 Pr 140.1	60 Nd 144.2	61 Pm 144.9	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa 231	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lw (262)