| Physics 101 | Hour Exam II | April 6, 2015 |
|---|---|---|

**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 <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 95 points.

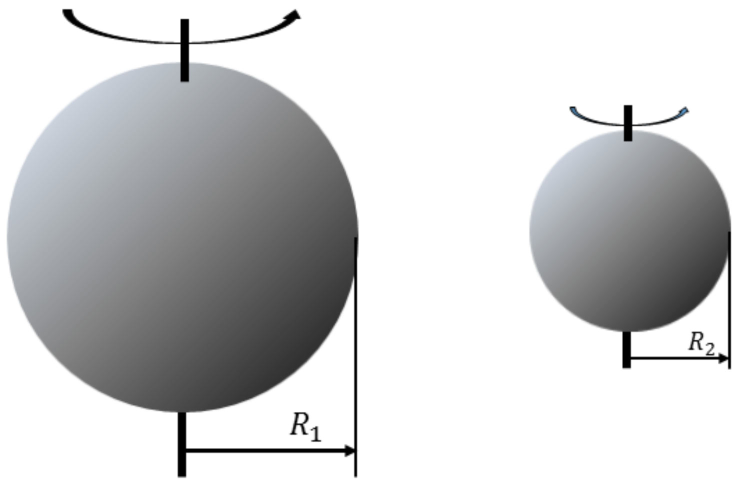
**Instructions for Two-Answer Multiple Choice Problems:**
Indicate on the answer sheet the correct answer to the question (*a* or *b*).
Each question is worth 2 points. If you mark the wrong answer, or mark more than one answer, you receive 0 points.

**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 two questions pertain to the situation described below.**

Consider on the left a star made of uniform sphere of radius $R_1 = 2\times10^7\ m$ rotating about its axis It makes one full revolution every *45 days*. The star collapses into a much smaller uniform sphere, $R_2 = 6\ km$ in radius as shown on the right. Assume no torques act on the mass during the collapse.




1) How many revolutions the collapsed star makes per day?

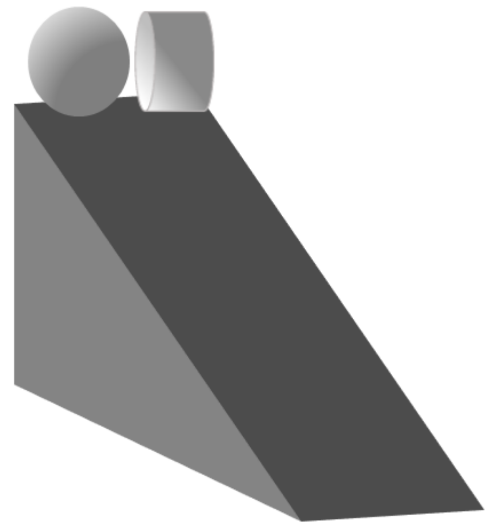
a. $5 \times 10^8$ *rev/day*
b. $2.4 \times 10^5$ *rev/day*
c. $10^4$ *rev/day*
d. *4100 rev/day*
e. $1.2 \times 10^{10}$ *rev/day*

2) What is the ratio of the moment of inertia of the star before the collapse $I_1$ to that after the collapse $I_2$: $(I_1/I_2)$

a. *3300*
b. $6 \times 10^7$
c. *1100*
d. *660*
e. $1.1 \times 10^7$

**The next four questions pertain to the situation described below.**

A solid sphere and a solid cylinder, both made from aluminum with mass *M* and radius *R*, are released from rest simultaneously at the top of a ramp.



3) Which has larger moment of inertia around its axis?

a. *Sphere*
b. *Cylinder*
c. *They have the same moment of inertia*

4) Which of them reaches the bottom of the ramp first?

a. *They arrive at the same time*
b. *Sphere*
c. *Cylinder*

5) Which has greater total kinetic energy (including rotational and translational) when arriving at the bottom of the ramp?

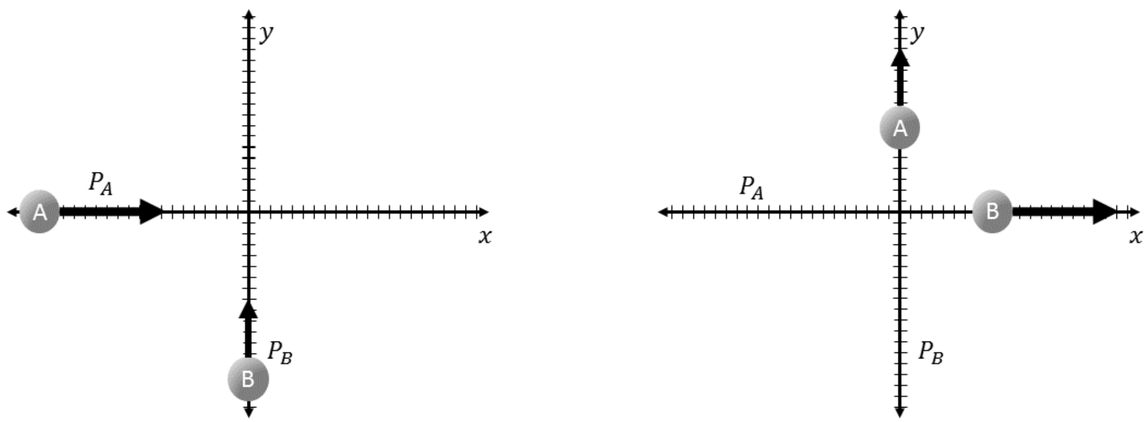
a. *They have the same kinetic energy*
b. *Cylinder*
c. *Sphere*

6) <u>Now</u> the cylinder is made of wood instead of aluminum, with a mass equal to *M/4*, which of them reaches the bottom of the ramp first?

a. *Cylinder*
b. *Sphere*
c. *They arrive at the same time*

**The next two questions pertain to the situation described below.**

Two <u>identical</u> billiard balls collide <u>elastically</u> as shown in the figure.




Before    After

7) Which quantities are conserved:

a. *momentum and kinetic energy*
b. *kinetic energy only*
c. *momentum only*

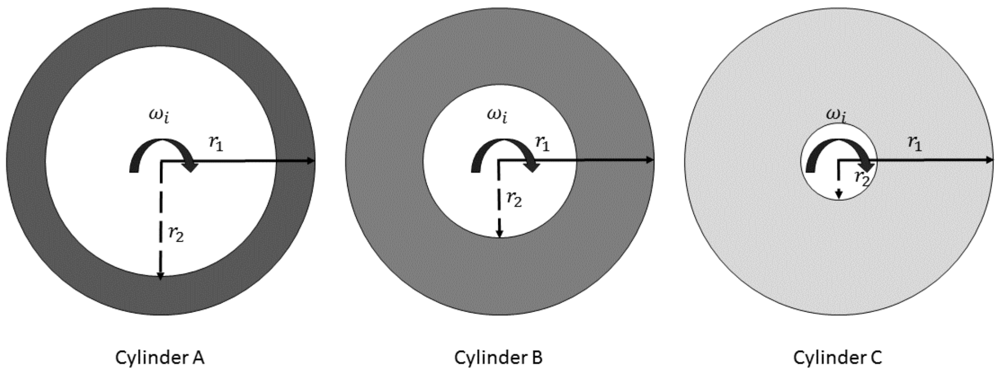
8) Which figure best describes the total momentum vector $(\vec{p_1} + \vec{p_2})$ for the system <u>after</u> the collision

Figure A    Figure B    Figure C    Figure D    Figure E

a. *Figure B*
b. *Figure D*
c. *Figure A*
d. *Figure C*
e. *Figure E*

**The next three questions pertain to the situation described below.**

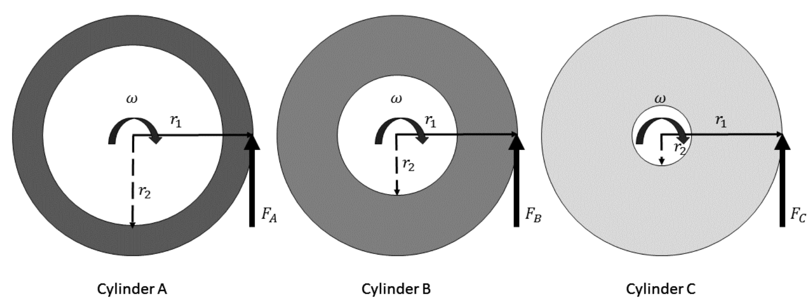
Three cylinders of mass $M = 3.5\ kg$ and outer radius $r_1 = 0.75\ m$, but different inner radii $r_2$ (not given), rotate with initial angular speed $\omega_i = 6\ rad/s$ as shown in the figure. (The moment of inertia for a thick cylindrical shell is $I = \frac{1}{2}M(r_1^2 + r_2^2)$.)




9) Which has the largest rotational kinetic energy?

a. *Cylinder B*
b. *Cylinder C*
c. *Cylinder A*

10) A force is applied to the edge of each cylinder and each comes to rest, at the same time, in $t = 0.7\ s$ The correct order for the forces experienced by each cylinder is:



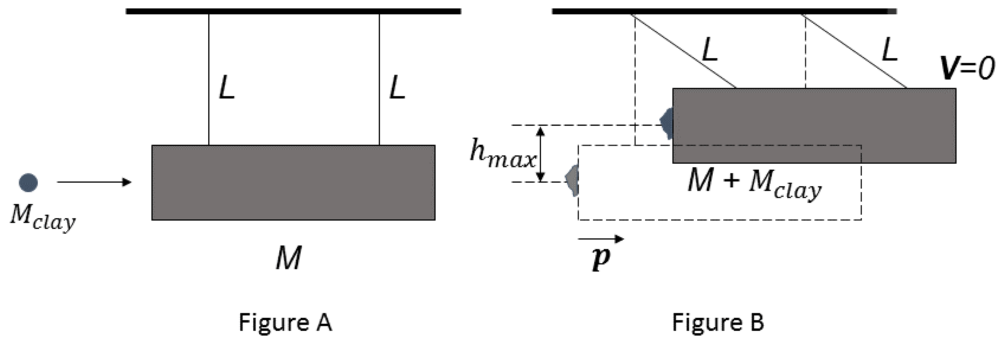

a. $F_B > F_C > F_A$
b. $F_A > F_B > F_C$
c. $F_A > F_C > F_B$
d. $F_C > F_B > F_A$
e. $F_B > F_A > F_C$

11) The inner radius of Cylinder A is $r_2 = 0.7\ m$ The magnitude of the force experienced by Cylinder A is:

a. *9.8 N*
b. *12 N*
c. *21 N*

**The next two questions pertain to the situation described below.**

A ball of clay of mass $M_{clay}$ =*1.4 kg* is thrown at the block of a ballistic pendulum as shown in Figure A. The ball travels with kinetic energy $KE_{ball}$ = *45 J*. The clay collides with the block and sticks as shown in Figure B.




12) Which statement below is true in the collision:

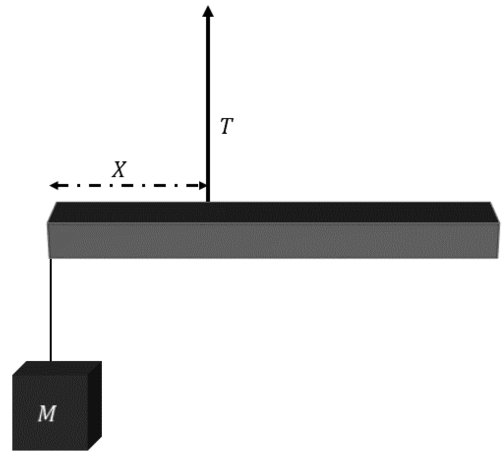
a. *Momentum is conserved and kinetic energy is not conserved.*
b. *Momentum is conserved and kinetic energy is conserved.*
c. *Momentum is not conserved and kinetic energy is not conserved.*

13) After the collision (Figure B) the block reaches a maximum height $h_{max}$ = *0.25 m*. What was the <u>momentum</u> of the ballistic pendulum immediately after the clay struck the block?

a. *11 kg m/s*
b. *7.9 kg m/s*
c. *45 kg m/s*

**The next two questions pertain to the situation described below.**

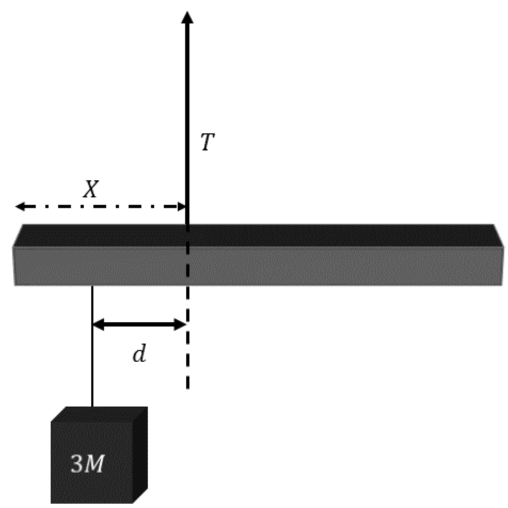
A uniform, one meter board with a mass of *12 kg* hangs by a rope $X = 0.2\ m$ from the left end of the board with tension $T$. A box of mass $M$ hangs from the left end of the board.




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

a. $M = 27\ kg$
b. $M = 18\ kg$
c. $M = 9\ kg$
d. $M = 13.5\ kg$
e. $M = 22.5\ kg$

15) The box is removed and replaced with a new box of mass $3M$ as shown in the figure. How far to the left of the tension string, $d$, should this box be hung?




a. $X = 0.067\ m$
b. $X = 0.2\ m$
c. $X = 0.13\ m$

**The next two questions pertain to the situation described below.**

Two identical blocks of mass $M = 5\ kg$ are travelling along the $x$-direction. One block travels at $v = 6\ m/s$ and the other at $v = -5\ m/s$. They collide. One of the blocks breaks into two identical pieces of mass $2.5\ kg$ each. The two pieces travel with equal and opposite speeds along the $y$-direction.

16) After the collision the unbroken block travels

a. *at an angle relative to the x-axis.*
b. *along the x-axis.*
c. *along the y-axis.*

17) After the collision the unbroken block travels with speed

a. $v = 1\ m/s$
b. $v = 2\ m/s$
c. $v = 1.5\ m/s$
d. $v = 0.5\ m/s$
e. $v = 0\ m/s$

**The next two questions pertain to the situation described below.**

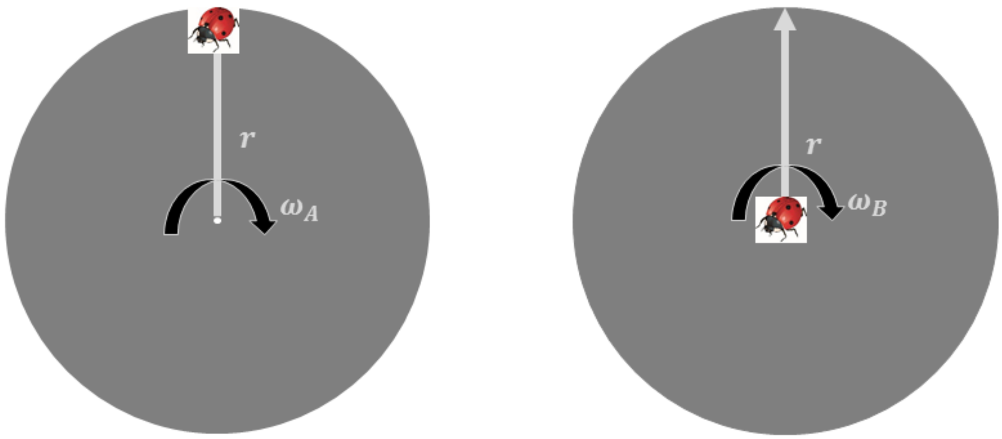



Figure A Figure B

A ladybug crawls along the radius of a rotating compact disk of mass $M = 0.01\ kg$ and radius $r = 0.06\ m$ ($I_{disk} = Mr^2/2$). The disk is initially rotating with angular speed $\omega_A = 31.4\ rad/s$ . The ladybug starts at the outer edge (Figure A) and ends at center (Figure B). At the end of the ladybug's travel the disk rotates with angular speed $\omega_B = 31.5\ rad/s$ .

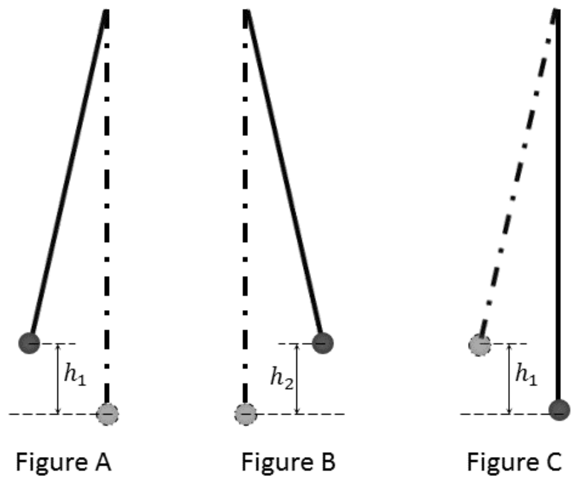
18) For this system angular momentum is conserved.

a. *False*
b. *True*

19) What is the mass of the ladybug?

a. $m_{lb} = 5020\ mg$
b. $m_{lb} = 31.8\ mg$
c. $m_{lb} = 7.94\ mg$
d. $m_{lb} = 63.5\ mg$
e. $m_{lb} = 15.9\ mg$

**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 $h_1$ (Figure A). It comes to rest at $h_2$ (Figure B).

20) Which statement correctly describes the net work done by gravity from $h_1$ to $h_2$?

a. $W_{net} < 0$
b. $W_{net} > 0$
c. $W_{net} = 0$

21) At the bottom of the pendulum's swing (Figure C)

a. $W_{net} = \Delta K$
b. $\Delta K = 0$
c. $W_{net} = 0$

22) If $h_1 = 0.5\ m$, what is the speed $v$ of the pendulum bob at the lowest point?

a. $v = 1.6\ m/s$
b. $v = 6.2\ m/s$
c. $v = 12\ m/s$
d. $v = 9.8\ m/s$
e. $v = 3.1\ m/s$

23) A car of mass $M = 1500\ kg$ is travelling horizontally at $20\ m/s$ when it goes off a cliff and crashes into a valley $250\ m$ below. How fast is the car going just before it crashes?

a. $v = 51.5\ m/s$
b. $v = 109\ m/s$
c. $v = 72.8\ m/s$
d. $v = 218\ m/s$
e. $v = 3.69 \times 10^6\ m/s$

# 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 = $2\pi$ 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

$P = F/A$ ,   $P(d) = P(0) + \rho g d$  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. = $1.01 \times 10^5$ 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   ($\sigma = 5.67 \times 10^{-8}\ J/(s{\cdot}m^2{\cdot}K^4)$)

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

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

$KE_{ave} = {}^3/_2 k_B T = {}^1/_2 m v_{rms}^2$   $U = {}^3/_2 N k_B T$ (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)

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