Name:____ Do you want your grade posted?___

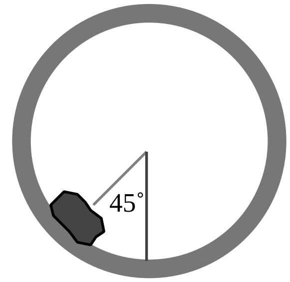
Physics 4A **FINAL EXAM** **Fall 1993**

Solve the following problems in the space provided. Use the back of the page if needed. Each problem is worth 10 points. You must show your work in a logical fashion starting with the correctly applied physical principles which are on the last page. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

1. A rescue worker wants to drop a package of relief supplies from an airplane that is 150m above the ground traveling at 50.0m/s. Assuming no air resistance, find (a)the time it takes the package to fall and (b)the horizontal distance it will travel during the fall. (c)Assuming the plane continues on course will the pilot see the package land in front of the plane, behind the plane, or right below the plane? Explain.

2. A student drags a 5.00kg bag of dirty laundry at a constant speed of 0.820m/s into the laundromat. The student is pulling on the bag at an angle of 53˚ above the horizontal and the coefficient of friction is 0.200. Find the force exerted by the student.

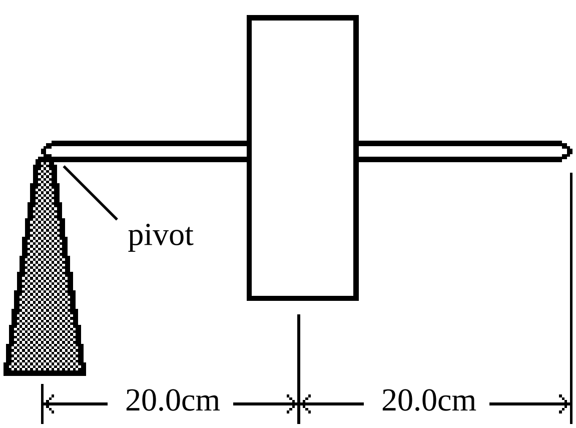
3. A piece of pipe of mass 1.00kg and radius 15.0cm has a 100g mass attached to its inside. The pipe is rotated until the mass is at a 45˚ angle with the vertical then it is released from rest. Find the velocity of this mass when it gets back to the bottom.



4. Why is it important to calculate uncertainties when conducting a laboratory experiment?

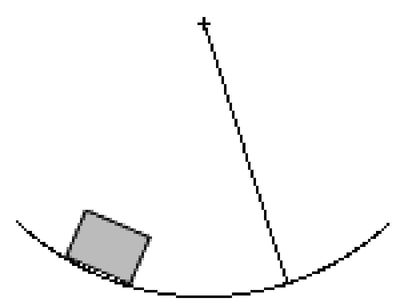
5. Investigators studying the damage caused by a terrorist pipe bomb discover that when it blew up only three pieces of pipe came flying out. The bomb had been placed in the center of a room 20.0m on a side. The investigators found one piece of mass 410g in the center of the north wall. They found the second piece of mass 260g in the center of the west wall. From the amount that the pieces penetrated the wall they estimated the velocity of the first piece at 180m/s and the velocity of the second piece at 370m/s. Where did they find the third piece?

6. The 3.00kg gyroscope shown below is horizontal and in the plane of the paper. It spins at 600rpm with the part facing you moving downward and has a rotational inertia of $0.0500 \text{kg}\cdot\text{m}^2$. (a)Find the angular momentum of the gyroscope and indicate its direction in the sketch below. (b)Name the forces that act on the gyroscope and indicate them in the sketch. (c)Find the torque on the gyroscope about the pivot and indicate the direction of the torque. Make sure the direction of the vectors is made clear.



7. The pipe in example 3 is held in the position shown by a person touching it at the top. Show all the forces that act on the system and find the frictional force exerted by the person.

8. A piece of ice of mass m is in a circular bowl of radius R. When the ice is displaced by a small amount from the bottom, show that motion is simple harmonic and find the period of oscillations.



9. The "radius" of a black hole is actually zero, but astrophysicists often talk about the "event horizon.". The event horizon is the radius at which light cannot escape from the black hole. In other words, the escape velocity from this radius is equal to the speed of light ($3.00x10^8$m/s). Find the event horizon for a black hole with a mass equal to the mass of the sun ($1.99x10^{30}$kg).

10. A mobile home owner makes the mistake of closing all the windows during a hurricane. The roof of the mobile home is 3.00m by 10.0m. Estimate the force (magnitude and direction) on the roof of the mobile home caused by a 120km/h wind. Why does opening the windows help?

Laws, Principles, Useful Relationships, and Other Information

$\vec{v} \equiv \frac{d\vec{r}}{dt}$ $\vec{a} \equiv \frac{d\vec{v}}{dt}$ $\omega \equiv \frac{d\theta}{dt}$ $\alpha \equiv \frac{d\omega}{dt}$ $s = r\,\theta$ $v_t = r\,\omega$ $a_t = r\,\alpha$ $a_c = \frac{v^2}{r} = \omega^2 r$

$\frac{x - x_o}{t} = \frac{1}{2}(v + v_o)$ $x = x_o + v_o t + \frac{1}{2} a t^2$ $v = v_o + a t$ $v^2 = v_o^2 + 2a(x - x_o)$

$\sum \vec{F} = m\vec{a}$ $F_g = m g$ $F_g = G\frac{m_1 m_2}{r^2}$ $F_{fr} = \mu F_n$ $F_B = m_f g$ $F_s = k x$

$W \equiv \int \vec{F} \cdot d\vec{s}$ $W_{net} = \Delta\varepsilon_k$ $\varepsilon_k \equiv \frac{1}{2} m v^2$ $P \equiv \frac{dW}{dt}$ $\Delta\varepsilon_k + \Delta\varepsilon_p = W_{nc}$

$\varepsilon_p \equiv - W_c$ $\varepsilon_p = m g y$ $\varepsilon_p = \frac{1}{2} k x^2$ $\varepsilon_p = - G\frac{M m}{r}$

$\Sigma\vec{F} = \frac{d\vec{p}}{dt}$ $\vec{p} \equiv m\vec{v}$ $\vec{\mathbb{I}} \equiv \int_0^t \Sigma\vec{F}\,dt$ $\vec{\mathbb{I}} \equiv \Delta\vec{p}$ $\vec{r}_{cm} \equiv \frac{1}{M}\int \vec{r}\,dm$

$\vec{\tau} \equiv \vec{r} \times \vec{F}$ $\Sigma\vec{\tau} = I\,\vec{\alpha} = \frac{d\vec{L}}{dt}$ $\vec{L} \equiv \vec{r} \times \vec{p} = I\,\vec{\omega}$ $I \equiv \int r^2\,dm$ $\varepsilon_k = \frac{1}{2} I\,\omega^2$

$x = A\cos(\omega t + \delta)$ $v = - A\,\omega\sin(\omega t + \delta)$ $a = - A\,\omega^2\cos(\omega t + \delta)$ $v = \omega\sqrt{A^2 - x^2}$ $a = - \omega^2 x$

$\omega = 2\pi f$ $f = \frac{1}{T}$ $\omega = \sqrt{\frac{k}{m}}$ $\omega = \sqrt{\frac{g}{L}}$ $\omega = \sqrt{\frac{\kappa}{I_p}}$ $\omega = \sqrt{\frac{m g r}{I_p}}$

$\rho \equiv \frac{m}{V}$ $P \equiv \frac{F}{A}$ $\Delta P = \rho g \Delta y$ $P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$

Moments of Inertia (about the center of mass unless otherwise specified)

hoop: $m r^2$	disk: $^1/_2\ m r^2$	solid sphere: $^2/_5\ m r^2$
hollow sphere: $^2/_3\ m r^2$	rod: $^1/_{12}\ m l^2$	rod about one end: $^1/_3\ m l^2$

Physical Constants:	$g = 9.80\ m/s^2$	$G = 6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2$
Earth - mass: 5.98×10^{24} kg	radius: 6.38×10^6 m	Earth - moon distance: 3.84×10^8 m
Moon - mass: 7.4×10^{22} kg	radius: 1.74×10^6 m	Sun - Earth distance: 1.50×10^{11} m
Sun - mass: 2.0×10^{30} kg	radius: 7×10^8 m	

Dot Product: $\vec{A}\cdot\vec{B} = A B\cos\theta = A_x B_x + A_y B_y + A_z B_z$

Cross Product: $\vec{A} \times \vec{B} = A B \sin\theta\ n = (A_y B_z - A_z B_y)i + (A_z B_x - A_x B_z)j + (A_x B_y - A_y B_x)k$

Volumes and Areas: cube: $V = a^3$ $A = 6 a^2$

sphere: $V = \frac{4}{3}\pi r^3$ $A = 4\pi r^2$ cylinder: $V = \pi r^2 h$ $A = 2\pi r h + 2\pi r^2$