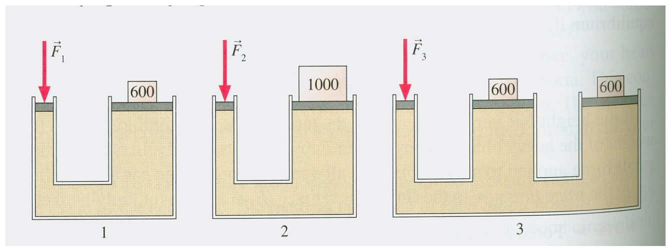
Name___________________________________
Physics 110 Quiz #6, May 21, 2010

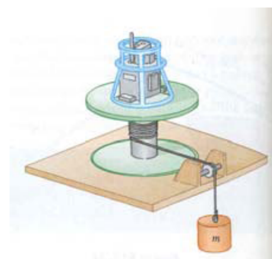
Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

1. Given the diagram on the right, three forces are applied on a piston of area A_1. This force is used to suspend the load on the right piston in each picture. The areas of the remaining pistons are each A_2 and the masses are in *kg*. From the diagram it can be concluded that



a. $F_1 = F_2 = F_3$
b. $F_1 < F_2 = F_3$
c. $F_1 > F_2 > F_3$
d. $F_1 = F_3 < F_2$

2. Suppose that you are given the following apparatus in which you want to experimentally determine the moment of inertia of an irregularly shaped object. A hanging mass $m = 200g$ is suspended from a rope that is passed over a frictionless, masslesss pulley and attached to a shaft of radius $r = \frac{1}{2}\ cm$. The hanging mass m is released from rest and falls a distance of $\Delta y = 1m$ in a time of $1s$.



a. Using Newton's 2nd Law of motion in rotational form, what is the moment of inertia of the object on the platform?

$$\tau = I\alpha \rightarrow rF_T = I\frac{a}{r}$$

$$F_T - m_h g = -m_h a \rightarrow F_T = m_h g - m_h a$$

$$y_f = y_i + v_{iy}t - \tfrac{1}{2}at^2 \rightarrow a = \frac{2(y_f - y_i)}{t^2} = \frac{2\times 1m}{1s^2} = 2\tfrac{m}{s^2}$$

$$\therefore I = \frac{r^2(m_h g - m_h a)}{a} = \left(\frac{g}{a} - 1\right)m_h r^2 = \left(\frac{9.8\frac{m}{s^2}}{2\frac{m}{s^2}} - 1\right)\times 0.2kg \times (0.005m)^2 = 1.95\times 10^{-5}\,kgm^2$$

b. Using conservation of energy ideas, what is the moment of inertial of the object on the platform?

$$\Delta E_{Total} = \Delta U_g + \Delta KE_T + \Delta KE_R = (m_h g y_f - m_h g y_i) + \left(\tfrac{1}{2}m_h v_f^2 - \tfrac{1}{2}m_h v_i^2\right) + \left(\tfrac{1}{2}I\omega_f^2 - \tfrac{1}{2}I\omega_i^2\right) = 0$$

$$v_f = r\omega_f \rightarrow \omega_f = \frac{v_f}{r};\ \ v_f^2 = v_i^2 + 2ay_i = 2ay_i$$

$$-m_h g y_i + \tfrac{1}{2}m_h v_f^2 + \tfrac{1}{2}I\left(\frac{v_f}{r}\right)^2 = 0$$

$$\therefore I = \left(\frac{g}{a} - 1\right)m_h r^2 = 1.95\times 10^{-5}\,kgm^2$$

Useful formulas:

Motion in the r = x, y or z-directions

$r_f = r_0 + v_{0r}t + \frac{1}{2}a_r t^2$

$v_{fr} = v_{0r} + a_r t$

$v_{fr}^2 = v_{0r}^2 + 2a_r\Delta r$

Uniform Circular Motion

$a_r = \frac{v^2}{r}$

$F_r = ma_r = m\frac{v^2}{r}$

$v = \frac{2\pi r}{T}$

$F_G = G\frac{m_1 m_2}{r^2}$

Geometry /Algebra

Circles	*Triangles*	*Spheres*
$C = 2\pi r$	$A = \frac{1}{2}bh$	$A = 4\pi r^2$
$A = \pi r^2$		$V = \frac{4}{3}\pi r^3$

Quadratic equation : $ax^2 + bx + c = 0$,

whose solutions are given by : $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors

$$\text{magnitude of a vector} = \sqrt{{v_x}^2 + {v_y}^2}$$

$$\text{direction of a vector} \rightarrow \phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)$$

Useful Constants

$g = 9.8 \, m/s^2 \qquad G = 6.67 \times 10^{-11} \, Nm^2/kg^2$

$N_A = 6.02 \times 10^{23} \, atoms/mole \qquad k_B = 1.38 \times 10^{-23} \, J/K$

$\sigma = 5.67 \times 10^{-8} \, W/m^2K^4 \qquad v_{sound} = 343 \, m/s$

Linear Momentum/Forces

$\vec{p} = m\vec{v}$

$\vec{p}_f = \vec{p}_i + \vec{F}\Delta t$

$\vec{F} = m\vec{a}$

$\vec{F}_s = -k\vec{x}$

$F_f = \mu F_N$

Work/Energy

$K_t = \frac{1}{2}mv^2$

$K_r = \frac{1}{2}I\omega^2$

$U_g = mgh$

$U_S = \frac{1}{2}kx^2$

$W_T = FdCos\theta = \Delta E_T$

$W_R = \tau\theta = \Delta E_R$

$W_{net} = W_R + W_T = \Delta E_R + \Delta E_T$

$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_S = 0$

$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_S = -\Delta E_{diss}$

Heat

$T_C = \frac{5}{9}\left[T_F - 32\right]$

$T_F = \frac{9}{5}T_C + 32$

$L_{new} = L_{old}(1 + \alpha\Delta T)$

$A_{new} = A_{old}(1 + 2\alpha\Delta T)$

$V_{new} = V_{old}(1 + \beta\Delta T)$: $\beta = 3\alpha$

$PV = Nk_BT$

$\frac{3}{2}k_BT = \frac{1}{2}mv^2$

$\Delta Q = mc\Delta T$

$P_C = \frac{\Delta Q}{\Delta t} = \frac{kA}{L}\Delta T$

$P_R = \frac{\Delta Q}{\Delta T} = \varepsilon\sigma A\Delta T^4$

$\Delta U = \Delta Q - \Delta W$

Rotational Motion

$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$

$\omega_f = \omega_i + \alpha t$

$\omega^2{}_f = \omega^2{}_i + 2\alpha\Delta\theta$

$\tau = I\alpha = rF$

$L = I\omega$

$L_f = L_i + \tau\Delta t$

$\Delta s = r\Delta\theta$: $v = r\omega$: $a_t = r\alpha$

$a_r = r\omega^2$

Fluids

$\rho = \frac{M}{V}$

$P = \frac{F}{A}$

$P_d = P_0 + \rho gd$

$F_B = \rho gV$

$A_1v_1 = A_2v_2$

$\rho_1A_1v_1 = \rho_2A_2v_2$

$P_1 + \frac{1}{2}\rho v^2{}_1 + \rho gh_1 = P_2 + \frac{1}{2}\rho v^2{}_2 + \rho gh_2$

Simple Harmonic Motion/Waves

$\omega = 2\pi f = \frac{2\pi}{T}$

$T_S = 2\pi\sqrt{\frac{m}{k}}$

$T_P = 2\pi\sqrt{\frac{l}{g}}$

$v = \pm\sqrt{\frac{k}{m}}A\left(1 - \frac{x^2}{A^2}\right)^{\frac{1}{2}}$

$x(t) = A\sin\left(\frac{2\pi t}{T}\right)$

$v(t) = A\sqrt{\frac{k}{m}}\cos\left(\frac{2\pi t}{T}\right)$

$a(t) = -A\frac{k}{m}\sin\left(\frac{2\pi t}{T}\right)$

$v = f\lambda = \sqrt{\frac{F_T}{\mu}}$

$f_n = nf_1 = n\frac{v}{2L}$

$I = 2\pi^2 f^2 \rho v A^2$

Sound

$v = f\lambda = (331 + 0.6T)\,\frac{m}{s}$

$\beta = 10\log\frac{I}{I_0}; \quad I_o = 1\times10^{-12}\,\frac{W}{m^2}$

$f_n = nf_1 = n\frac{v}{2L}; \quad f_n = nf_1 = n\frac{v}{4L}$