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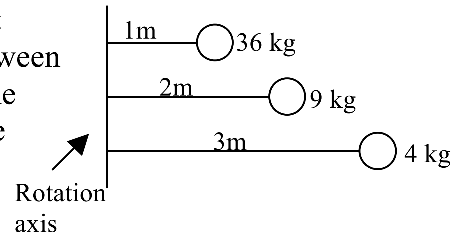
Physics 110 Quiz #5, October 26, 2011

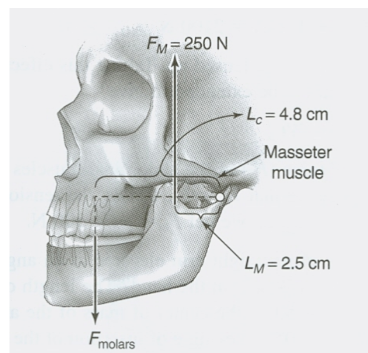
Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

1. The figure below shows three small point mass spheres that rotate about a vertical axis. The perpendicular distance between the axis and the center of each sphere is given. Which of the following must be true if the moments of inertia? (Hint, the rods connecting the spheres to the rotation axis have no mass.)



a. $I_1 = I_2 = I_3$ b. $I_1 < I_2 < I_3$ c. $I_1 = I_2 < I_3$ d. $I_1 > I_2 = I_3$

2. The *masseter* muscle is one of the muscles involved in the process of chewing. Measurements indicate that the *masseter* muscle exerts an upward force of *250 N* at a distance of *2.5cm* from the pivot, called the *temporomandibular joint* (*TMJ*). If the linear distance between the *TMJ* and the molar is *4.8cm*, what magnitude of force (in pounds, where *1N = ¼ lb*) does your molar exert on food during the chewing process?



$$\sum \tau : \; r_{molar} F_{molar} - r_{masseter} F_{masseter} = 0$$

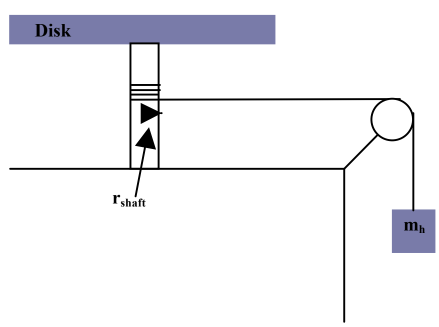
$$\rightarrow r_{molar} F_{molar} = r_{masseter} F_{masseter}$$

$$\therefore F_{molar} = \frac{r_{masseter}}{r_{molar}} F_{masseter} = \frac{2.5cm}{4.8cm} 250N = 130N$$

3. Suppose that we have the set-up shown below consisting of a shaft of radius r_{shaft} = *0.5cm* around which a massless string is wound and a disk of moment of inertial I is placed. The string is passed over a massless pulley where a mass m_h = *200g* is hung and allowed to fall from rest through a height h = *1m* acquiring a speed of v = *1.84m/s.* Using conservation of energy, what is the moment of inertia of the disk?

$$\Delta KE_T + \Delta KE_R + \Delta U_g = \tfrac{1}{2} m v_f^2 + \tfrac{1}{2} I \omega_f^2 - mgy_i = 0$$

$$I = \left(\frac{2gy_i}{v_f^2} - 1 \right) m_h R_{sh}^2 = \left(\frac{2 \times 9.8 \frac{m}{s^2} \times 1m}{\left(1.84 \frac{m}{s}\right)^2} - 1 \right) \times 0.2kg \times (0.005m)^2 = 2.4 \times 10^{-5} kgm^2$$



Useful formulas:

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

$$r_f = r_i + v_{ir}t + \tfrac{1}{2}a_r t^2$$

$$v_{fr} = v_{ir} + a_r t$$

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

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: $C = 2\pi r$, $A = \pi r^2$

Triangles: $A = \tfrac{1}{2}bh$

Spheres: $A = 4\pi r^2$, $V = \tfrac{4}{3}\pi r^3$

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

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

Vectors

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

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

Useful Constants

$$g = 9.8\,{}^{m}\!/\!_{s^2} \qquad G = 6.67\times10^{-11}\,{}^{Nm^2}\!/\!_{kg^2}$$

$$N_A = 6.02\times10^{23}\,{}^{atoms}\!/\!_{mole} \qquad k_B = 1.38\times10^{-23}\,{}^{J}\!/\!_{K}$$

$$\sigma = 5.67\times10^{-8}\,{}^{W}\!/\!_{m^2K^4} \qquad v_{sound} = 343\,{}^{m}\!/\!_{s}$$

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

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

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

$$U_g = mgh$$

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

$$W_T = FdCos\theta = \Delta E_T$$

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

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

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

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

Heat

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

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

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

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

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

$$PV = Nk_BT$$

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

$$\Delta Q = mc\Delta T$$

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

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

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

Rotational Motion

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

$$\omega_f = \omega_i + \alpha t$$

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

$$\tau = I\alpha = rF$$

$$L = I\omega$$

$$L_f = L_i + \tau\Delta t$$

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

$$a_r = r\omega^2$$

Fluids

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

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

$$P_d = P_0 + \rho gd$$

$$F_B = \rho gV$$

$$A_1v_1 = A_2v_2$$

$$\rho_1A_1v_1 = \rho_2A_2v_2$$

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

Simple Harmonic Motion/Waves

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

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

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

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

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

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

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

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

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

$$I = 2\pi^2f^2\rho vA^2$$

Sound

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

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

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