Physics 10154 - Exam #4a

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (25 pts) A cylindrical turntable has a mass of 25 kg and a radius of 55 cm. It is initially spinning at a rate of 17 rev/min. A 5.0 kg ball of sticky clay is dropped from its initial resting point a very short distance above the turntable. The clay ball lands 42 cm from the axis of rotation and sticks to the turntable, moving with the turntable at the same speed. What is the new rotation speed of the turntable, in rad/sec?

$I_T = \frac{1}{2} M_T R_T^2 = \frac{1}{2}(25)(.55)^2 = 3.78\ kg \cdot m^2$ $\quad I_{Ti} = I_{Tf}$

$I_C = M_C R_C^2 = (5.0)(.42)^2 = 0.882\ kg \cdot m^2$ $\quad I_{Ci} = I_{Cf}$

$\omega_{Ti} = 17 \frac{rev}{min} = 1.78\ rad/s$

$\omega_{Ci} = 0$

$\omega_{Tf} = \omega_{Cf} = ?$

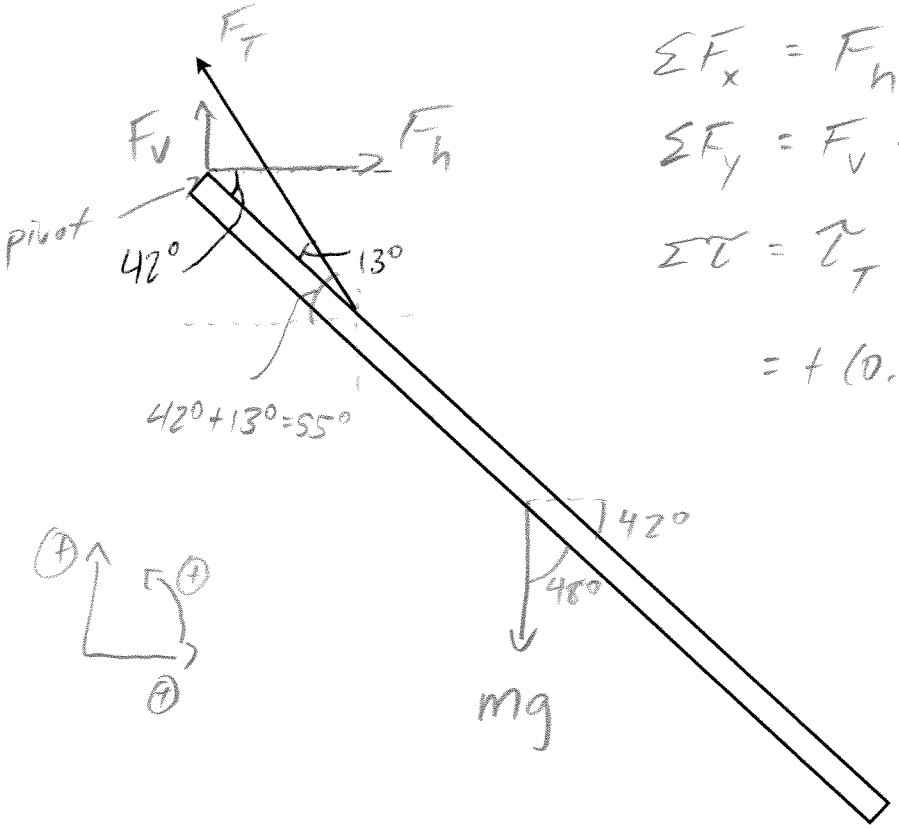
$I_T \omega_{Ti} + I_C \omega_{Ci} = (I_T + I_C)\omega_f$

$(3.78)(1.78) + 0 = (3.78 + .882)\omega_f$

$6.73 = 4.66\,\omega_f$

$\omega_f = 1.4\ rad/sec$

2. (40 pts) A human arm can be approximated as a uniform thin rod with a length of 76 cm and mass 14 kg. In the figure below, the arm makes an angle of 42° below the horizontal. At the top left end, the arm is attached to the shoulder, and the shoulder exerts a horizontal and vertical reaction force on the arm. Also, the deltoid muscle attaches to the arm at a distance 16 cm from the shoulder, making an angle of 13° above the arm. Find (a) the tension in the deltoid muscle, (b) the horizontal component, and (c) the vertical component of the shoulder's reaction force.



$$\Sigma F_x = F_h - F_T \cos 55° = 0$$

$$\Sigma F_y = F_V + F_T \sin 55 - mg = 0$$

$$\Sigma \tau = \tau_T + \tau_{mg} = 0$$

$$= +(0.16) F_T \sin 167°$$

$$-(0.38)(14)(9.8)\sin 48° = 0$$

$$\Sigma \tau = .036 F_T - 38.74 = 0 \quad \Rightarrow F_T = \frac{38.74}{.036} = 1080\ N$$

$$\Sigma F_x = F_h - 1080 \cos 55° \quad \Rightarrow F_h = 617\ N$$

$$\Sigma F_y = F_V + 1080 \sin 55° - (14)(9.8) \Rightarrow F_V = -744 N$$

$F_T = 1100\ N$

$F_h = 620\ N, +x$

$F_V = 744\ N, -y$

3. (35 pts) A pipe with a circular cross section is open to the air at both ends. At the bottom end of the pipe, a pump is attached to provide additional pressure to move the water through the pipe. At the top end of the pipe, 3.5 meters above the bottom end, water flows out and fills up a 1.0 gallon container in 8.0 seconds. The diameter of the pipe is ~~3.0 cm~~ 0.45 cm. Assuming the water is initially at rest when entering the bottom of the pipe, what is the pump's pressure, in Pascals?

$$\text{Flow rate} = Av = \frac{\text{Volume}}{\text{time}}$$

$$A = \frac{\pi(.0045)^2}{4} = 1.59 \times 10^{-5}\ m^2$$

$$\text{Volume} = 1.0\ \text{gal.} \frac{3.786\ L}{\text{gal}} \times \frac{1000\ cm^3}{L} \cdot \frac{1\ m^3}{1000000\ cm^3}$$

$$= 3.786 \times 10^{-3}\ m^3$$

$$(1.59 \times 10^{-5})\ v = \frac{3.786 \times 10^{-3}}{8}$$

$$v = 29.76\ m/s = V_{TOP}$$

$$P_{bot} + \rho g y_{bot} + \frac{1}{2}\rho V_{BOT}^2 = P_{TOT} + \rho g y_{TOP} + \frac{1}{2}\rho V_{TOP}^2$$

$$(101300 + P_{pump}) + 0 + 0 = 101300 + (1000)(9.8)(3.5) + \tfrac{1}{2}(1000)(29.8)^2$$

$$P_{pump} = 34300 + 443000$$

$$= \boxed{480000\ Pa}$$