Physics 10154 - Exam #4b

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. (30 pts) A thin string is wrapped around a spool with moment of inertia I = 2.5 kg-m^2 and radius 75 cm. A constant tension force pulls on the string tangent to the spool so that the spool begins to accelerate in an angular sense. The spool is fixed in space but free to rotate, and it has a frictional torque of 2.2 N-m opposing any motion. 15 meters of string unwinds in 9.0 seconds. What is the tension force pulling on the string?

$$\Delta\theta = \frac{\Delta s}{r} = \frac{15}{.75} = 20 \text{ rad}$$

$\omega_0 = 0$

$\omega = ?$

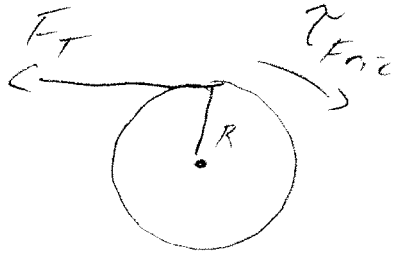
$\alpha = ?$

$t = 9.0 \text{ s}$

$$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$20 = 0 + \frac{1}{2}\alpha (9)^2$$

$$\alpha = .494 \text{ rad/s}^2$$



$$\Sigma\tau = I\alpha$$

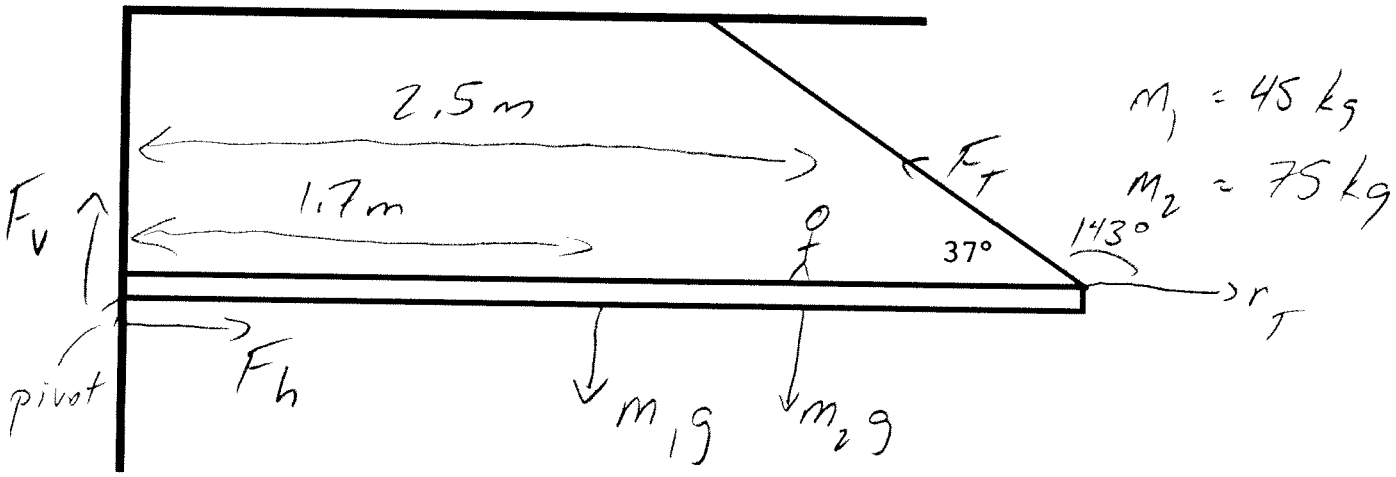
$$\tau_T + \tau_{Fric} = I\alpha$$

$$+RF_T \sin 90 - 2.2 = I\alpha$$

$$(0.75)F_T = (2.5)(.494) + 2.2$$

$$\boxed{F_T = 4.6 \text{ N}}$$

2. (30 pts) A thin, uniform 45 kg metallic plank is welded to a wall. The plank is supported by a thin rope as shown. A 75 kg person stands 2.5 meters from the wall, and the plank itself is 3.4 meters long. If the system is in equilibrium, what are the values of F_h, F_v and F_T? F_h, F_v are the horizontal and vertical components of the reaction force exerted by the wall on the plank.



$$\Sigma F_x = F_h - F_T \cos 37^\circ = 0$$

$$\Sigma F_y = F_v + F_T \sin 37^\circ - m_1 g - m_2 g = 0$$

$$\Sigma \tau = \tau_1 + \tau_2 + \tau_T = 0$$

$$\tau_1 = -(1.7)(45)(9.8)\sin 90^\circ = -750\ N$$

$$\tau_2 = -(2.5)(75)(9.8)\sin 90^\circ = -1838\ N$$

$$\tau_T = +(3.4) F_T \sin 143^\circ = 2.046 F_T$$

$$2.046 F_T - 750 - 1838 = 0 \Rightarrow \boxed{F_T = 1300\ N}$$

$$F_h = F_T \cos 37^\circ = \boxed{1000\ N}$$

$$F_v = m_1 g + m_2 g - F_T \sin 37 = \boxed{410\ N}$$

3. (40 pts) Suspended in air, an object's weight is measured to be 150 N. When placed in water, the object floats in such a way that 65% of the object is submerged.

a) What is the volume of the object?

b) How much additional weight can be placed on top of this object before it begins to sink?

$$\rho_o V_o g = 150\,N$$

Floating: $\Sigma F_y = \rho_f V_f g - \rho_o V_o g = 0$

$$\rho_f (.65) V_o g - 150 = 0$$

65% submerged

$$V_o = \frac{150}{\rho_f (.65) g} = \boxed{.024\,m^3}$$

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b) $\Sigma F_y = \rho_f V_o g - \rho_o V_o g - mg = 0$

submerged

$$mg = \rho_f V_o g - 150$$

$$= (1000)(.024)(9.8) - 150$$

$$= \boxed{85\,N}$$