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. (40 pts) A spool of thin cable of radius 35 cm has a moment of inertia of 15 kg-m^2. Starting from rest, the cable is pulled tangent to the edge of the wheel by a constant force of 11 Newtons. A frictional torque of 1.4 N-m opposes the spool's motion. If the cable is 120 meters long, how many seconds does it take for the cable to completely unspool?

$$\Sigma \tau = \tau_{App} - \tau_{Fric} = I\alpha$$

$$+(.35)(11)\sin 90 - 1.4 = 15\alpha$$

$$3.85 - 1.4 = 15\alpha$$

$$\alpha = 0.163 \ rad/s^2$$

$$a_{tan} = R\alpha = .0572 \ m/s^2$$

$\Delta s = 120$

$v_0 = 0$

$v = ?$

$a = 0.0572$

$t = ?$

$$120 = 0 + \frac{1}{2}(.0572)t^2$$

$$\boxed{t = 65 \ s}$$

2. (30 pts) A lump of unknown metal weighs 220 Newtons in air and 170 Newtons when immersed completely in water. What is the density of the metal?

$$\rho_0 g V_0 = 220$$

$$\rho_0 g V_0 - \rho_f g V_0 = 170$$

↑ sub V_0 for V_f since it is 100% submerged

$$220 - (1000)(9.8) V_0 = 170$$

$$-9800 V_0 = -50$$

$$V_0 = .0051 \ m^3$$

$$\rho_0 (9.8)(.0051) = 220$$

$$\boxed{\rho_0 = 4400 \ kg/m^3}$$

3. (30 pts) An upright cylindrical reservoir of diameter 6.0 meters is filled with water to a depth of 12 meters. A small hole develops in the bottom of the tank, and water leaks out at a rate that fills a one gallon can in 45 seconds. What is the diameter of the hole, in millimeters?

$P_{TOP} = P_{BOT}$ and $v_{TOP} \approx 0$, so

$$\rho g h = \frac{1}{2}\rho v_{BOT}^2$$

$$v_{BOT} = \sqrt{2gh} = 15.34 \text{ m/s}$$

$$Q = Av$$

$$Q = \frac{1 \text{ gal}}{45 \text{ sec}} \cdot \frac{3.786 \times 10^{-3} \text{ m}^3}{\text{gal}} = 8.41 \times 10^{-5} \frac{\text{m}^3}{\text{sec}}$$

$$A = \frac{8.41 \times 10^{-5}}{15.34} = 5.485 \times 10^{-6}$$

$$= \pi r^2$$

$$r = 1.32 \times 10^{-3} \text{ m}$$

$$\boxed{d = 2.6 \text{ mm}}$$