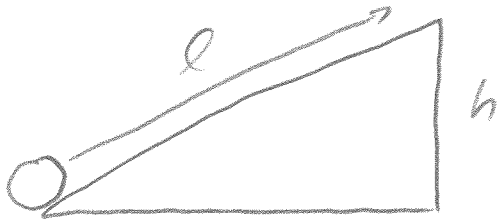
Physics 10154 - Exam #4a

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. (30 pts) A sphere rolls without slipping up a 27° inclined plane with an initial linear speed of 6.4 m/s. How far up the ramp does the sphere travel before stopping?



$$\Sigma W_F = W_{grav} = \Delta K$$

$$-mgh = 0 - \left(\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2\right)$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{v^2}{R^2}\right)$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{5}mv^2$$

$$mgh = \frac{7}{10}mv^2$$

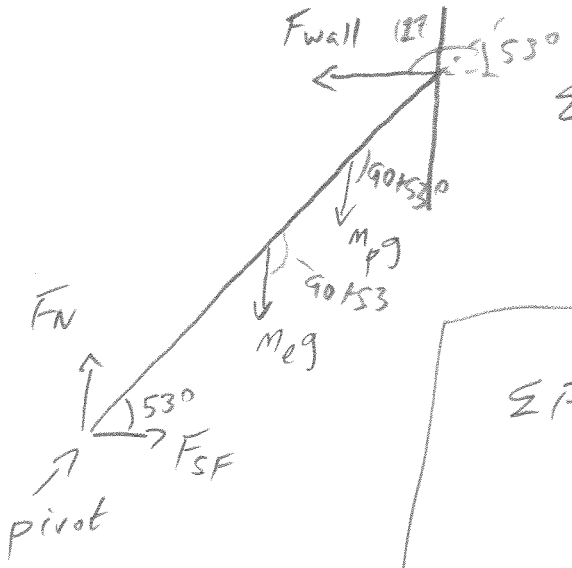
$$h = \frac{7v^2}{10g} = 2.926\,m$$

$$h = \ell \sin 27^\circ$$

$$\ell = \frac{h}{\sin 27^\circ} = 6.4\,m$$

25 kg

2. (35 pts) An 8.0 meter long uniform ladder rests against a frictionless, vertical wall. The ladder makes a 53° angle above the horizontal. The coefficient of static friction between the ladder and ground is 0.61. How far up the ladder can a 79 kg person climb before the ladder begins to slip?



$\Sigma F_x : F_{SF} - F_{wall} = 0$

use $F_{SF} = \mu_s F_N$ since "about to slip"

$\mu_s F_N - F_{wall} = 0$

$\Sigma F_y : F_N - (25)(9.8) - (79)(9.8) = 0$

$F_N = 1019.2$

$(0.61)(1019.2) = F_{wall} = 621.7\ N$

$\Sigma \tau = \tau_{ladder} + \tau_{person} + \tau_{wall} = 0$

$-(4.0)(25)(9.8)\sin(143°) - x(79)(9.8)\sin(143°)$

$+(8.0)(621.7)\sin(127°) = 0$

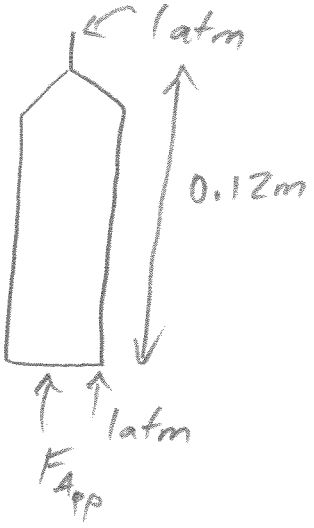
$-589.78 - 465.93x + 3972.09 = 0$

$465.93x = 3382.31$

$x = 7.3\ m$

3. (35 pts) A vertical syringe contains a 13 cm tall column of water. The plunger, on the bottom of the syringe, has a diameter of 8.0 mm and is pushed with a 1.3 N applied force. At the top, the needle through which the water flows out has a diameter of 1.0 mm. The syringe is surrounded on all sides with air. What is the flow rate (in mL/sec) of water from the needle tip?

1.0 mL = 1.0 cm^3.



$$P_{top} + \rho g y_{top} + \frac{1}{2}\rho v_{top}^2 = P_{bot} + \rho g y_{bot} + \frac{1}{2}\rho v_{bot}^2$$

$y_{top} = 0.12m$, $y_{bot} = 0$

Assume $v_{bot} = 0$ since $d_{bot} = 8 d_{top}$

so $v_{bot} = \frac{1}{8^4} v_{top}$

$$P_{top} = 101300$$

$$P_{bot} = 101300 + \frac{1.3}{\pi(.004)^2} = 127160$$

$$101300 + (1000)(9.8)(0.12) + 500 v_{top}^2 = 127160 + 0 + 0$$

$$500 v_{top}^2 = 24690$$

$$v_{top} = 7.027 \ m/s$$

$$Q = A_{top} v_{top} = \pi(.0005)^2(7.027) = 5.5 \times 10^{-6} \ m^3/s$$

$$5.5 \times 10^{-6} \ m^3/s \cdot 10^6 \ cm^3/m^3 \cdot 1 mL/1 cm^3 = 5.5 \ mL/sec$$