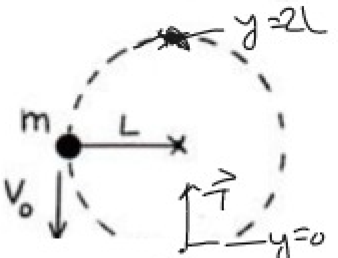
9. A light rigid rod of length L has a ball of mass m at one end. The other end is pivoted so that the rod and ball can travel in a vertical circle. Starting from the horizontal position as shown, the ball is given an initial downward velocity v_0 such that later it just barely makes it over the top of the circle. Under those conditions, what was the tension in the rod when the ball was at its lowest point? (A negative tension corresponds to compression).



Between beginning and top:

$$\Delta E = \Delta K + \Delta U_g$$

$$0 = \left(0 - \tfrac{1}{2}\cancel{m}v_0^2\right) + \underbrace{\left(2L\cancel{m}g - \cancel{m}gL\right)}_{gL}$$

$$V_0 = \sqrt{2gL}$$

Between beginning and bottom:

$$\Delta E = \Delta K + \Delta U_g$$

$$= \left(\tfrac{1}{2}\cancel{m}v_f^2 - \tfrac{1}{2}\cancel{m}v_0^2\right) + \left(0 - \cancel{m}gL\right)$$

$$v_f = \sqrt{4gL} = 2\sqrt{gL} = V_{bottom}$$

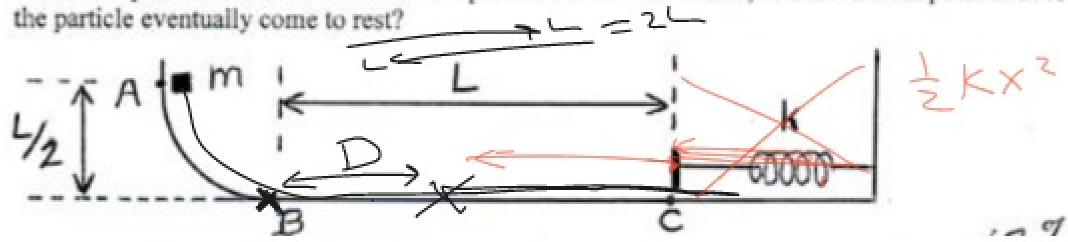
$$F_{net} = T_{bottom} - mg = \frac{mv_{bottom}^2}{r}$$

$$T_{bottom} = \frac{mv_{bottom}^2}{L} + mg$$

$$= \frac{m\,4g\cancel{L}}{\cancel{L}} + mg$$

$$= 5mg$$

8. A particle of mass m slides along a track in a vertical plane as shown. The upward curved part of the track is frictionless and the flat horizontal part from B to C of length L has a coefficient of kinetic friction μ_k = 0.250. The flat section to the right of C is frictionless and the ideal spring has k = 500 N/m. The particle is released from rest at point A as shown. Where, measured from point B does the particle eventually come to rest?



A to B: $\Delta E = \Delta K + \Delta U_g$

$$= \left(\tfrac{1}{2}\cancel{m}v_B^2 - 0\right) + \left(0 - \cancel{m}g\tfrac{L}{2}\right)$$

$$v_B = \sqrt{gL}$$

B to C: $W_{friction} = \Delta K$

$$|\vec{F}_{\mu_k} \cdot \vec{d}| = \tfrac{1}{2}mv_C^2 - \tfrac{1}{2}mv_B^2$$

$$= |\vec{F}_{\mu_k}||\vec{d}|\cos\theta =$$

$$= |\mu_k \vec{N}||\vec{d}|\cos\theta$$

$$= \mu_k mg\,L\cos(180°)$$

$$= -2\mu_k \cancel{m}gL = \tfrac{1}{\cancel{2}}\cancel{m}v_C^2 - \tfrac{1}{\cancel{2}}\cancel{m}v_B^2$$

$$v_C = \sqrt{v_B^2 + 2\mu_k gL}$$

$$= \sqrt{gL + 2\mu_k gL}$$

$$= \sqrt{gL(1+2\mu_k)}$$

$$W_{friction} = \Delta K$$

$$-2\mu_k \cancel{mg}x = 0 - \tfrac{1}{\cancel{2}}\cancel{m}\left(\cancel{g}L(1+2\mu_k)\right)$$

$$2\mu_k x = L(1+2\mu_k)$$

$$x = \frac{L(1+2\mu_k)}{2\mu_k} = \frac{L}{2\mu_k} + L$$

$$D = L - x = \frac{L}{2\mu_k} = \frac{L}{2(\frac{1}{4})} = 2L$$