1) $E_A = E_e + E_g$

$$= \frac{1}{2}kx^2 + mgh$$

$$= \frac{1}{2}k(\sqrt{2}R - R)^2 + mg(2R)$$

$$= \frac{(\sqrt{2}-1)^2}{2}kR^2 + 2mgR$$

$$E_B = E_A = mgh_B + \frac{1}{2}mv_B^2$$

$$\frac{(\sqrt{2}-1)^2}{2}kR^2 + 2mgR = mgR + \frac{1}{2}mv_B^2$$

$$mv_B^2 = (\sqrt{2}-1)^2kR^2 + 2mgR$$

$$v_B = \sqrt{2gR + \frac{(\sqrt{2}-1)^2kR^2}{m}}$$

$$E_c = E_A = \frac{1}{2}mv_c^2$$

$$\frac{(\sqrt{2}-1)^2}{2}kR^2 + 2mgR = \frac{1}{2}mv_c^2$$

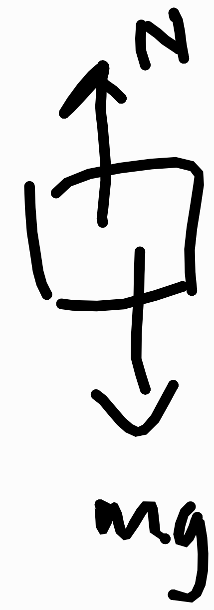
$$v_c^2 = (\sqrt{2}-1)^2\frac{kR^2}{m} + 4gR$$

$$v_c = \sqrt{4gR + (\sqrt{2}-1)^2\frac{kR^2}{m}}$$

1) $N - mg = mr\omega^2$

$$N - mg = \frac{mv^2}{r}$$

$$N - mg = \frac{m\left(4g\cancel{R} + (\sqrt{2}-1)^2 \frac{kR^{\cancel{2}}}{m}\right)}{\cancel{R}}$$



$$N = mg + 4mg + (\sqrt{2}-1)^2 kR$$

$$= 5mg + (\sqrt{2}-1)^2 kR$$

2) $E_k = mg(L - 2(L-a))$

$$\frac{1}{2}\cancel{m}v^2 = \cancel{m}g(2a - L)$$

$$v^2 = 2g(2a - L)$$

$$v = \sqrt{2g(2a-L)}$$

$$\frac{\cancel{m}v^2}{r} = \cancel{m}g$$

$$\frac{2g(2a-L)}{(L-a)} = \cancel{g}$$

$$4a - 2L = L - a$$

$$5a = 3L$$

$$a = 0.6L$$

3) $E_e = \frac{1}{2}kx^2$

$= \frac{1}{2}(300)(0.2)^2$

$= 6\,Nm$

$\frac{1}{2}m_B v_B^2 + \frac{1}{2}m_c v_c^2 = E_e$

$\frac{1}{2}(50)v_B^2 + \frac{1}{2}(75)v_c^2 = 6$

$25v_B^2 + 37.5v_c^2 = 6 \quad -(1)$

$m_B v_B + m_c v_c = 0$

$50v_B = -75v_c$

$v_B = -1.5v_c \quad -(2)$

Sub (2) into (1)

$25(-1.5v_c)^2 + 37.5v_c^2 = 6$

$93.75v_c^2 = 6$

$v_c = 0.2529822128$

$\vec{v}_c \approx -0.253\,\underset{\sim}{i}\ ms^{-1}$

$\vec{v}_B = -1.5\vec{v}_c$

$= 0.3794733192\underset{\sim}{i}$

$\approx 0.379\,\underset{\sim}{i}\ ms^{-1}$

$\vec{v}_B = \vec{v}_c + \vec{v}_{B|c}$

$\vec{v}_{B|c} = \vec{v}_B - \vec{v}_c$

$= 0.632455532\underset{\sim}{i}$

$\approx 0.632\,\underset{\sim}{i}\ ms^{-1}$

4) $\vec{v}_B = -v_B \underset{\sim}{i}$

$$\vec{v}_P = \vec{v}_B + \vec{v}_{P/B}$$

$$= v_B \underset{\sim}{i} + v_{P/B} \angle(-30^\circ)$$

$$= v_{P/B}\cos(-30^\circ)\underset{\sim}{i} - v_B \underset{\sim}{i} + v_{P/B}\sin(-30^\circ)\underset{\sim}{j}$$

$$E_1 = mgh$$

$$= 4(2)g$$

$$= 8g$$

$$E_2 = \frac{1}{2}m_B v_B^2 + \frac{1}{2}m_P v_P^2$$

$$= \frac{1}{2}(20)v_B^2 + \frac{1}{2}(4)\left[\left(v_{P/B}\cos(-30^\circ) - v_B\right)^2 + \left(v_{P/B}\sin(30^\circ)\right)^2\right]$$

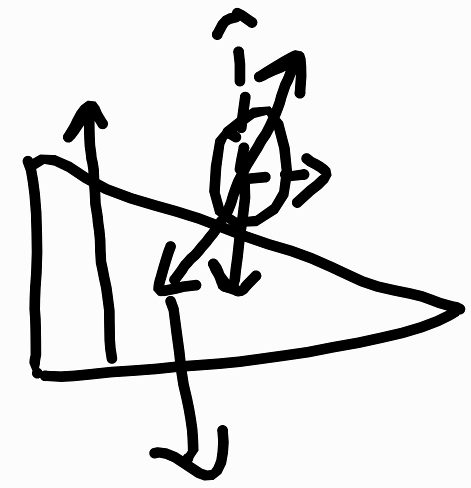
$$= 10v_B^2 + 2\left[v_B^2 - 2v_{P/B}v_B\cos(-30^\circ) + 0.75v_{P/B}^2 + 0.25v_{P/B}^2\right]$$

$$= 10v_B^2 + 2v_B^2 - 2\sqrt{3}\,v_{P/B}v_B + 2v_{P/B}^2$$

$$= 12v_B^2 + 2v_{P/B}^2 - 2\sqrt{3}\,v_{P/B}v_B$$

$$\therefore 12v_B^2 + 2v_{P/B}^2 - 2\sqrt{3}\,v_{P/B}v_B = 8g \quad - (1)$$

4) Applying conservation of linear momentum in the x-direction:



$$m_P\left(\frac{\sqrt{3}}{2}v_{P/B} - v_B\right) - m_B v_B = 0$$

$$2\sqrt{3}\,v_{P/B} - 4v_B - 20v_B = 0$$

$$v_{P/B} = \frac{12}{\sqrt{3}}v_B \quad -(1)$$

Sub (2) into (1)

$$12v_B^2 + 2\left(\frac{12}{\sqrt{3}}v_B\right)^2 - 2\sqrt{3}\left(\frac{12}{\sqrt{3}}v_B\right)v_B = 8g$$

$$84v_B^2 = 8g$$

$$v_B = 0.966584561\mathrm{4}$$

$$\approx 0.967\ \mathrm{ms^{-1}}$$

$$v_{P/B} = \frac{12}{\sqrt{3}}(0.967)$$

$$= 6.69669428$$

$$\approx 6.697\ \mathrm{ms^{-1}}$$

$$\vec{v}_B \approx -0.967\,\underset{\sim}{i}\ \mathrm{ms^{-1}}$$

$$\vec{v}_P = v_{P/B}\cos(-30^\circ)\,\underset{\sim}{i} - v_B\,\underset{\sim}{i} + v_{P/B}\sin(-30^\circ)\,\underset{\sim}{j}$$

$$= 4.832922807\,\underset{\sim}{i} - 3.34834714\,\underset{\sim}{j}$$

$$\approx 4.83\,\underset{\sim}{i} - 3.35\,\underset{\sim}{j}\ \mathrm{ms^{-1}}$$