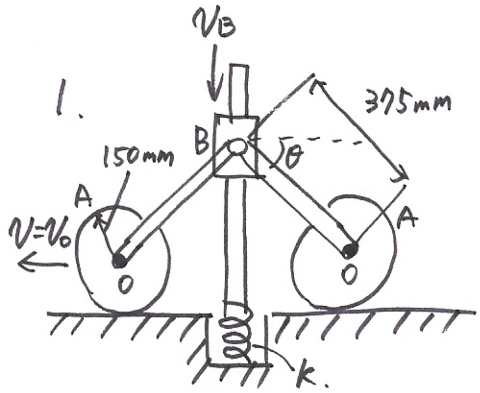
1.




wheel mass : 30 kg

radius of gyration : 100 mm

link OB mass : 10 kg.

Collar mass : 7 kg

$k = 30 \ kN/m$

from $\theta = 45°$

$$\Delta T = 2 \times \left[ \frac{1}{2} I_O \omega^2 - 0 \right]_{links} + \left[ \frac{1}{2} m v^2 - 0 \right]_{collar}$$

$$= \frac{1}{3} \times 10 \times 0.375^2 \left( \frac{v_B}{0.375} \right)^2 + \frac{1}{2} \times 7 \times v_B^2$$

$$= 6.83 \, v_B^2$$

The collar drops a distance $0.375/\sqrt{2} = 0.265 \ m$.

$$\Delta V = 0 - 2 \times m_{wheel} \times g \times \frac{0.265}{2} - m_{collar} \times g \times 0.265$$

$$= 0 - 2 \times 10 \times 9.81 \times \frac{0.265}{2} - 7 \times 9.81 \times 0.265$$

$$= -44.2 \ J$$

$\Delta T + \Delta V = 0$ $\quad \therefore \ 6.83 \, v_B^2 = 44.2$

(a) $\quad v_B = 2.54 \ m/s$

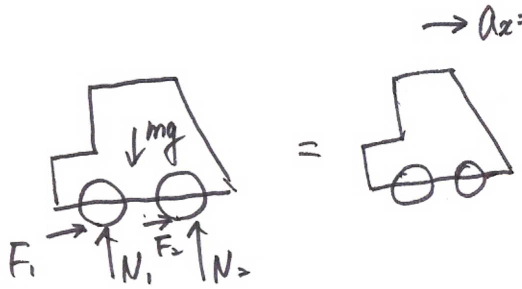
(b) the condition of maximum deformation $x$ will occur when $\Delta T = 0$.

$$U'_{1-2} = \Delta T + \Delta V_g + \Delta V_s$$

$$0 = 0 - 2 \times m_{wheel} \times g \times \left( \frac{0.265}{2} + \frac{x}{2} \right) - m_{collar} \times g (0.265 + x) + \frac{1}{2} k x^2$$

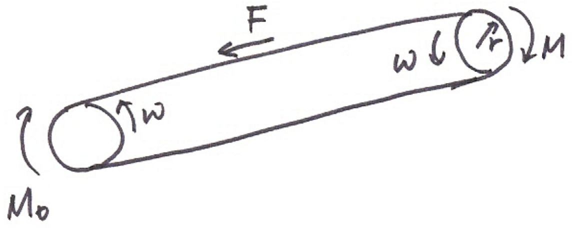
$$\therefore \ x = 60.1 \ mm$$

2.




$$\Sigma F_x = m a_x = 0$$

$$F = F_1 + F_2 = mg \sin\theta$$




For belt $dU = dT \quad dT = 0.$

$$Fr\,d\theta - M\,d\theta - M_0\,d\theta = 0$$

$$M = Fr - M_0$$

$$= mgr\sin\theta - M_0$$

$$\text{Power} = M\omega$$

$$= mgr\omega\sin\theta - M_0\omega$$

$$= mgv\sin\theta - M_0\frac{v}{r}$$

$$= \left(mg\sin\theta - \frac{M_0}{r}\right)v$$

3. 10 Mg bus

flywheel mass 1500 kg

radius of gyration 500 mm

Max speed 4000 rev/min

$0 \rightarrow 72$ km/h $\quad h = 20m$

$$\Delta T_{translation} = \frac{1}{2} m v^2 - 0$$

$$= \frac{1}{2} \times 10^4 \times \left(\frac{72}{3.6}\right)^2$$

$$= 2 \times 10^6$$

$$\Delta T_{rotation} = \frac{1}{2} I (w_2^2 - w_1^2)$$

$$= \frac{1}{2} \times 1500 \times 0.5^2 \times \left[w_2^2 - \left(\frac{4000 \times 2\pi}{60}\right)^2\right]$$

$$= 187.5 w_2^2 - 32.9 \times 10^6$$

$$\Delta E = 0.1 \times \Delta T_{rotation}$$

$$= 18.75 w_2^2 - 32.9 \times 10^5$$

$$\Delta V = mgh = 10^4 \times 9.81 \times 20$$

$$= 1.96 \times 10^6$$

$$\Delta E = \Delta T + \Delta V$$

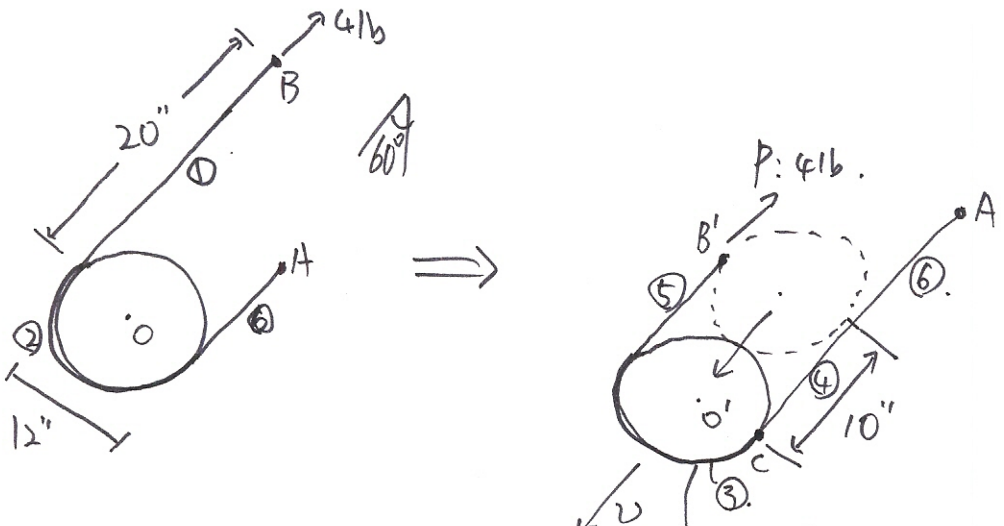
$$18.75 w_2^2 - 32.9 \times 10^5 = 2 \times 10^6 + 187.5 w_2^2 - 32.9 \times 10^6$$

$$168.75 w_2^2 = 25.65 \times 10^6$$

$$w_2^2 = 152000 \ (rad/s)^2$$

$$w_2 = 390 \ rad/s \qquad N = \frac{390 \times 60}{2\pi} = 3720 \ rev/min$$

4.




$$I_{③} = \frac{1}{2}(2mr^2) = \frac{1}{2}\left(2\,\frac{0.8\times 2\pi}{32.2}\cdot\frac{6}{12}\right)\left(\frac{6}{12}\right)^2$$

$\hookrightarrow g\,(ft/s^2)$

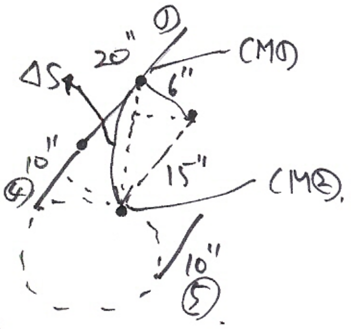
$$= \frac{0.039}{2} = 0.0195$$

$$U_P = \Delta T + \Delta V_g \quad \cdots ①$$

$$U_P = P\Delta s = -4lb\left(\frac{20}{12}ft\right) = -6.67\ ft\cdot lb. \quad \cdots ②$$

$$\Delta T \left( \begin{aligned} &\Delta T_{③} = \frac{1}{2} I_{③} \omega^2 = \frac{1}{2}(0.0195)\left(\frac{v}{6/12}\right)^2 = 0.039\,v^2 \\ &\Delta T_{⑤} = \frac{1}{2} m(v)^2 = \frac{1}{2}\,\frac{0.8\,(10/12)}{32.2}(v)^2 = 0.0414\,v^2 \\ &\Delta T_{wheel} = \frac{1}{2} I_{o}\omega^2 = \frac{1}{2}\left(m(k_o^2+r^2)\right)\omega^2 \\ &\qquad = \frac{1}{2}\left(\frac{15}{32.2}\left(\left(\frac{4}{12}\right)^2 + \left(\frac{6}{12}\right)^2\right)\right)\left(\frac{v}{6/12}\right)^2 = 0.336\,v^2 \end{aligned} \right) \cdots ③$$

$$\Delta V_g \left( \begin{aligned} &\Delta V_g(\text{bend})_{①\to④,⑤} = -0.8\left(\frac{20}{12}\right)\overbrace{\left(\frac{6}{12}\cos 60^\circ + \frac{15}{12}\sin 60^\circ\right)}^{\Delta S} \\ &\qquad = -1.777\ ft\cdot lb \\ &\Delta V_g(②\xrightarrow{\text{bend}}③) = -0.8\left(\frac{6}{12}\pi\right)\frac{10}{12}\sin 60^\circ = -0.907\,(ft\cdot lb) \\ &\Delta V_g(\text{wheel}) = -15\,\frac{10}{12}\sin 60^\circ = -10.83\ ft\cdot lb \end{aligned} \right) ④.$$

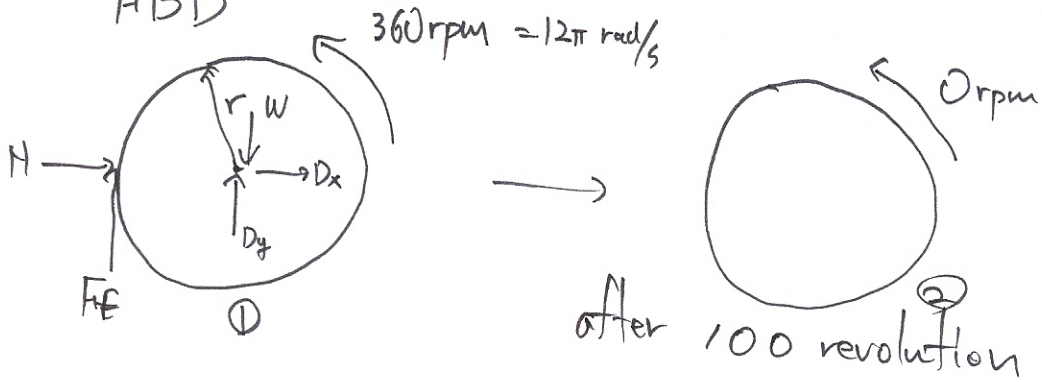



by ①, ②, ③, ④

$$-6.67 = (0.039v^2 + 0.414v^2 + 0.336v^2) - (1.777 + 0.907 + 10.83)$$

$$v^2 = 16.41\ (ft/sec)^2 \Rightarrow \underline{\underline{v = 4.05\ ft/sec}}\ //$$

5. FBD




$$U_{Ft} = \Delta T \quad \text{— ①}$$

- $\Delta T$ $\quad \omega_1 = 12\pi \, rad/s \quad \omega_2 = 0.$

$$T_1 = \frac{1}{2} I \omega^2 = \frac{1}{2} 19 (12\pi)^2 = 13.502 \times 10^3 J \quad T_2 = 0.$$

$$(T_2 - T_1) = \Delta T = -13.502 \times 10^3 J \quad \text{— ②}$$

- $U_{Ft}$ : 100 revolution $= 100 \times 2\pi = \underline{628.32 \, rad}.$

$$U_{Ft} = M_D \cdot \Delta\theta \quad (\overset{+}{\curvearrowleft} M_D = F_f \cdot 0.2)$$

$$= -F_f (0.2) \cdot 628.32 = -125.664 F_f \quad \text{— ③.}$$

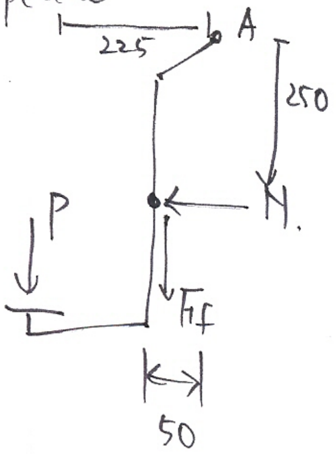
①, ②, ③

$$\Rightarrow 13.502 \times 10^3 = 125.664 F_f$$

$$F_f = 107.445 [N] \quad F_f = (0.35) N$$

$$N = 306.99 [N]$$

⓪ pedal

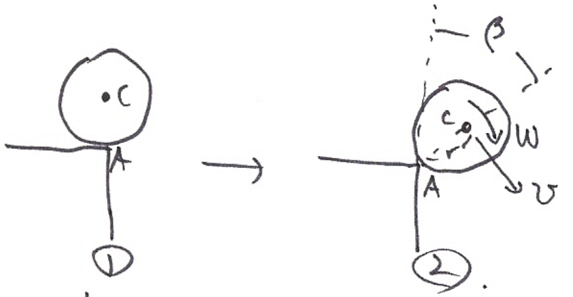



$$+\curvearrowleft \Sigma M_A = 0$$

$$: \; 0.225 P - (0.25)(306.99) + (0.05)(107.445) = 0$$

$$\underline{\underline{P = 317.22 \downarrow N}} \; //$$

6.




$I_c = \frac{2}{5} m r^2$

kinematics : $v = r\omega$

$\Delta V$ (potential) $= mgh = mgr(\cos\beta - 1)$

$\Delta T$ (kinetic) $= \frac{1}{2} m v^2 + \frac{1}{2} I \omega^2 = \frac{1}{2}\left(mr^2 + \frac{2}{5} mr^2\right)\omega^2 = \frac{7}{10} m r^2 \omega^2$

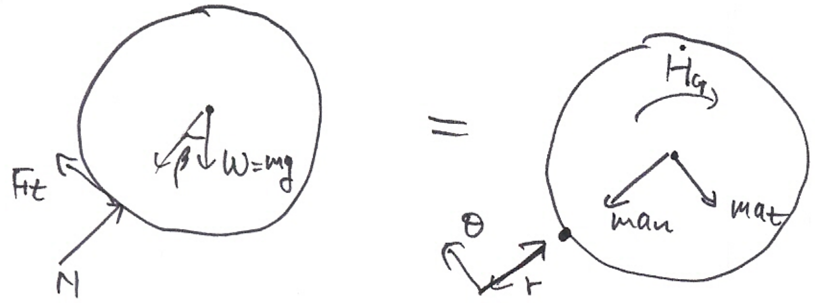
$\Delta V + \Delta T = 0.$

$mgr(\cos\beta - 1) + \frac{7}{10} m r^2 \omega^2 = 0$

$r\omega^2 = \frac{10}{7} gr(1 - \cos\beta)$

$\frac{v^2}{r} = \frac{10}{7} g(1 - \cos\beta)$

FBD at ② (contact is lost)




when contact is lost : $N = 0$ $F_t = 0.$

r-direction

$-mg\cos\beta = -m\frac{v^2}{r} = -\frac{10}{7} mg(1 - \cos\beta)$

(a) $\frac{17}{7}\cos\beta = \frac{10}{17}$ $\qquad \cos\beta = \frac{10}{17}$ $\qquad \beta = 54.0^\circ$

(b) $\bar{v}^2 = gr\cos\beta = \frac{10}{17} gr$ $\qquad v = 0.767\sqrt{gr}$ $\qquad v = 0.767\sqrt{gr}$ 54°