Q1

December 15, 2021 12:24 AM

a) $m_e = 3850\ kg$

$\mathcal{E} = 0.78$

$m_c = 1600\ kg$

$a = uniform = a_c$

$V_\emptyset = 0.35\ m/s$

$V = 3.6\ m/s$

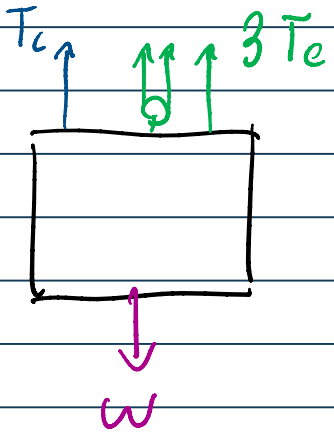
$t = 7\ s$

$V = V_\emptyset + a\ t$

$3.6 = 0.35 + a\ (7)$

$a = 0.464\ m/s^2$

b)



$T_c = ?$

$\uparrow \Sigma F_y = m\ a$

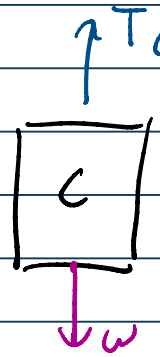
$w = 9.81 \cdot 3850$

$\uparrow \Sigma F_y = ma$ $\qquad w = 9.81 \cdot 3850$

$(3850)(0.464) = T_c + 3T_e - w$

$1786.4 = T_c + 3T_e - 37768.5$

(1) $39554.9 = T_c + 3T_e$



$w = 1600 \cdot 9.81$

$\uparrow \Sigma F_y = ma$

$(1600)(0.464) = T_c - 1600 \cdot 9.81$

$T_c = 16438.4\ N$

$\underline{T_c = 16438\ N}$

C) $T_e = ?$

(1) $39554.9 = T_c + 3T_e$

$39554.9 = 16438.4 + 3T_e$

$$T_c = 7705.5\ N$$

$$\underline{T_c \doteq 7706\ N}$$

d) $P_{AVG} = \vec{F} \cdot \vec{V}_{AVG}$

$$P_{AVG} = 3(7706) \cdot \left(\frac{0.35 + 3.6}{2}\right)$$

$$\underline{P_{AVG} \doteq 45658\ W}$$

$$P_{max} = \vec{F} \cdot \vec{V}_{max}$$

$$P_{max} = 3(7706) \cdot (3.6\ m/s)$$

$$\underline{P_{max} \doteq 83225\ W}$$

e) $P_{electrical} = P_{in}$

$$\mathcal{E} = \frac{P_{out}}{P_{in}} = 0.78$$

$$0.98 = \frac{45658}{(P_{in})_{avg}}$$

$(P_{in})_{avg} \doteq 58536\ W$

$(P_{in})_{max} = \frac{83225}{0.78}$

$(P_{in})_{max} = 106\ 699\ W$

f) $V = \omega r \rightarrow r = 0.18\ m$

$\omega = \frac{V_{max}}{r} = \frac{3.6}{0.18} = 20\ rad/s$

$\omega_{rpm} = \frac{20 \times 60}{2\pi} = 191\ rev/min$

Q2

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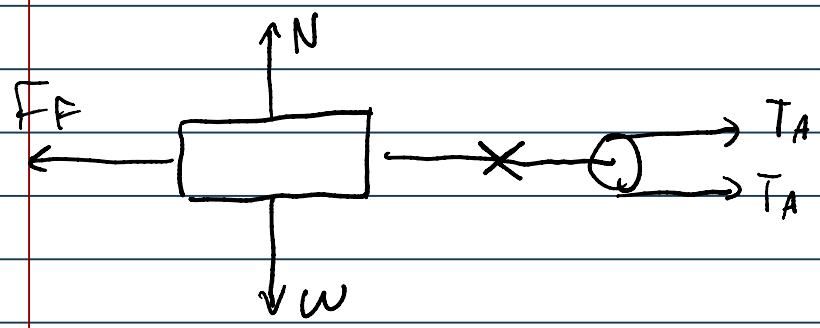
$m = 15\ kg \qquad \bar{T} = 25\ t^{1.5}$

$\mu_s = 0.68 \qquad V(0) = 0$

$\mu_a = 0.32$

a) $\bar{T}_A = ?$



$\Sigma F = 0$

$\Sigma F_y = 0 \rightarrow N = w = (9.81)(15)$

$N = 147.15\ N$

$\Sigma F_x = 0 = 2T_A - F_F \qquad \star F_F = \mu_s N$

$0 = 2T_A - 0.68(147.15)$

$T_A = 50.0\ N$

b) $\emptyset = 2T_A - F_F$

$\emptyset = 50 t_b^{3/2} - 0.68(147.15)$

$t_b = \left(\frac{0.68(147.15)}{50}\right)^{2/3}$

$\underline{t_b = 1.59\ s}$

c) $t = 2.1(1.59) = 3.34\ s$

$\Sigma F_x = ma = 2T_A - F_F \rightarrow F_F = \mu_k N$

$25 \cdot a = 50 t^{3/2} - 0.32(147.15)$

$a = (2t^{3/2} - 1.883)\ m/s^2$

$\frac{d}{dt} a = v \rightarrow V = \int a\, dt$

$V = \int (2t^{3/2} - 1.883)\, dt$

$V = 2\left(\frac{2}{5}\right) t^{5/2} - 1.883t$

$V(3.34) = \frac{4}{5}(3.34)^{5/2} - 1.883(3.34)$

$V(3.34) = 10.02 \text{ m/s}$

d) $V = \frac{ds}{dt}$

$\int V\,dt = s$

$s(t) = \int \left(\frac{4}{5} t^{5/2} - 1.883\, t\right) dt$

$s(t) = \frac{4}{5}\int t^{5/2} - 1.883 \int t\,dt$

$s(t) = \frac{4}{5}\left(\frac{2}{7}\right) t^{7/2} - \frac{1.883}{2} t^2$

$s(t) = \frac{8}{35} t^{7/2} - 0.9415\, t^2$

$s(3.34) = \frac{8}{35}(3.34)^{7/2} - 0.9415(3.34)^2$

$s(3.34) = 5.06 \text{ m}$

Q3

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$m = 125\ kg$
$k = 5250\ N/m$
$c = 1400\ Ns/m$

a) $\omega_d = ?$ & $f_d = ?$

$$\omega_d = \sqrt{\frac{k}{m} - \left(\frac{c}{2m}\right)^2}$$

$$\omega_d = \sqrt{\frac{2 \cdot 5250}{125} - \left(\frac{1400}{2 \cdot 125}\right)^2}$$

$$\omega_d = 7.26\ rad/s$$

$$f_d = \frac{\omega_d}{2\pi} = \frac{7.26}{2\pi}$$

$$f_d = 1.15\ Hz$$

b) motion in terms of time

position $\rightarrow y = D\left[e^{-(c/2m)t} \sin(\omega_d t + \phi)\right]$

velocity $\rightarrow \dot{y} = D\left[e^{-(c/2m)t} \omega_d \cos(\omega_d t + \phi) - \frac{c e^{-(c/2m)t} \sin(\omega_d t + \phi)}{2m}\right]$

accel $\rightarrow \ddot{y} = D\left[c^2 e^{-(c/2m)t} \sin(\omega_d t + \phi) - 4c\omega_d m e^{-(c/2m)t} \cos(\omega_d t + \phi) - 4m^2 \omega_d^2 e^{-(c/2m)t} \sin(\omega t + \phi)\right] / (4m^2)$

Initial conditions: $\dot{y}(0) = 0$, $y(0) = 0.08$

$$y(\emptyset) = 0.08 = D\left[e^{-(1400/(2\cdot 125))\emptyset} \sin(7.26(\emptyset) + \phi)\right]$$

(1) $0.08 = D\sin(\phi)$

$$\dot{y}(\emptyset) = \dot{\emptyset} = D\left[e^{-(1400/(2\cdot 125))\emptyset}(7.26)\cos(7.26\cdot\emptyset + \phi) - \frac{(1400)\, e^{-(1400/(2\cdot 125))\emptyset} \sin(7.26\cdot\emptyset + \phi)}{2\cdot 125}\right]$$

$$\frac{\dot{\emptyset}}{D} = \frac{D(7.26\cos(\phi) - 5.6\sin(\phi))}{D} \quad (2)$$

(3) $\frac{0.08}{D} = \sin(\phi)$ ★ $D \neq \emptyset$

(4) $\dot{\emptyset} = 7.26\cos(\phi) - 5.6\sin(\phi)$

$\dot{\emptyset} = 7.26\sin(\phi + \frac{\pi}{2}) - 5.6\sin\phi$

Solve (4) for ϕ

$\phi = 0.91377$

$\phi = 0.914$ radians

$D = \frac{0.08}{\sin(0.914)} = 0.101$

$$y = 0.101\left[e^{-5.6t}\sin(7.26t + 0.914)\right]$$

$$\dot{y} = 0.101\left[e^{-5.6t}\cdot 7.26\cdot\cos(7.26t + 0.914)\right.$$

$$\left. - 1400\, e^{-5.6t}\sin(7.26t + 0.914)\right]$$

$$\ddot{y} = 0.101\left[(1.96\times10^{6})e^{-5.6t}\sin(7.26t + 0.914)\right.$$

$$-(5.98\times10^{6})e^{-5.6t}\cos(7.26t + 0.914)$$

$$\left.-(3.29\times10^{6})e^{-5.6}\sin(7.26t + 0.914)\right]/(6.25\times10^{4})$$

c) no vibration = overdamped or critically damped

$$c \geq c_c$$

$$c \geq 2m\omega_n$$

$$c \geq 2(125)\sqrt{2.5250/125}$$

$$\underline{c \geq 2291.3\ \text{Ns/m}}$$