P219 15, 17, 19–21, 23–27, 29, 33, 43, 45, 47, 71

(15) $\alpha = \frac{\Delta\omega}{\Delta t}$ $\omega = 2\pi f = 2\pi\left(\frac{15000 \text{ rpm}}{60 \text{ s min}^{-1}}\right) = 1570.8 \text{ rad s}^{-1}$

$\alpha = \frac{(1570.8 \text{ rad s}^{-1})}{220 \text{ s}} = 7.14 \text{ rad s}^{-2}$

$\theta = \cancel{\omega_i t} + \frac{1}{2}\alpha t^2$

$= \frac{1}{2}(7.14 \text{ rad s}^{-2})(220 \text{ s})^2$

$= 172788 \text{ rad}$

1 revolution $= 2\pi$ rad.

$\frac{172788 \text{ rad}}{2\pi} = 27500$ revolutions $= \underline{2.8 \times 10^4 \text{ revolutions}}$

(17) (a) $\theta = \cancel{\omega_i t} + \frac{1}{2}\alpha t^2$

$\alpha = \frac{2\theta}{t^2} = \frac{2(20 \text{ rev})(2\pi \text{ rad rev}^{-1})}{(60 \text{ s})^2} = \underline{0.0698 \text{ rad s}^{-2}}$

(b) $\omega_f = \omega_i + \alpha t$

$= (0.0698 \text{ rad s}^{-1})(60 \text{ s}) = 4.19 \text{ rad s}^{-1}$

convert to rpm

$\frac{4.19 \text{ rad s}^{-1}}{2\pi \text{ rad rev}^{-1}}(60 \text{ s min}^{-1}) = \underline{40. \text{ rpm}}$

(19) $\omega_i = 2\pi f = 2\pi \left(\frac{850 \text{ rev min}^{-1}}{60 \text{ s min}^{-1}}\right) = 89.0 \text{ rad s}^{-1}$

$\omega_f = 0$

$\theta = 1500 \text{ rev}(2\pi \text{ rad rev}^{-1}) = 9424.78 \text{ rad}$

(a) $\omega_f^2 = \omega_i^2 + 2\alpha\theta$

$$\alpha = \frac{\omega_f^2 - \omega_i^2}{2\theta} = \frac{-(89.0 \text{ rad s}^{-1})^2}{2(9424.78 \text{ rad})} = \underline{-0.42 \text{ rad s}^{-2}}$$

(b) $\omega_f = \omega_i + \alpha t$

$$t = \frac{\omega_f - \omega_i}{\alpha} = \frac{-89.0 \text{ rad s}^{-1}}{(-.42 \text{ rad s}^{-2})} = \underline{210 \text{ s}}$$

(20) (a) linear velocity at the contact point is equal

$v_{small} = \omega_s r_s$ $\qquad v_{pottery} = \omega_p r_p$

$$v_{small} = v_{pottery}$$
$$\omega_s r_s = \omega_p r_p$$

$\alpha_s = \frac{\omega_s}{\Delta t}$ $\qquad \alpha_p = \frac{\omega_p}{\Delta t}$ $\qquad \Delta t$ is the same.

$$\frac{\omega_s}{\alpha_s} = \frac{\omega_p}{\alpha_p}$$

$$\alpha_p = \frac{\omega_p \alpha_s}{\omega_s} = \frac{r_s \alpha_s}{r_p} = \frac{.02 \text{ m}}{.25 \text{ m}}(7.2 \text{ rad s}^{-2})$$

$\underline{\alpha_{pottery} = 0.58 \text{ rad s}^{-2}}$

(b) $\omega_f = 2\pi f = 2\pi \left(\frac{65 \text{ rpm}}{60 \text{ s min}^{-1}}\right) = 6.81 \text{ rad s}^{-1}$

$\omega_f = \omega_i + \alpha t$

$$t = \frac{\omega_f}{\alpha} = \frac{6.81 \text{ rad s}^{-1}}{0.58 \text{ rad s}^{-2}} = \underline{12 \text{ s}}$$

(21) (a) $\omega_f^2 = \omega_i^2 + 2\alpha\theta$ $\qquad v = \omega r$ $\qquad v = 45\ kmh^{-1} = 12.5 ms^{-1}$

$\omega = \frac{v}{r}$ $\qquad u = 95\ kmh^{-1} = 26.4 ms^{-1}$

$$\alpha = \frac{\omega_f^2 - \omega_i^2}{2\theta}$$

$$= \frac{\left(\frac{12.5 ms^{-1}}{.4m}\right)^2 - \left(\frac{26.4 ms^{-1}}{.4m}\right)^2}{2(2\pi 65)}$$

$$= \underline{-4.1\ rad\, s^{-2}}$$

(b) $\omega_f = \omega_i + \alpha t$

$$t = \frac{\omega_f - \omega_i}{\alpha} = \frac{-\frac{12.5 ms^{-1}}{.4m}}{-4.1 rad s^{-1}} = \underline{7.6s}$$

(23) $\Gamma = Fr \sin\theta$

(a) $\Gamma = Fr = (55N)(.74m) = \underline{41\ Nm}$

(b) $\Gamma = Fr \sin\theta = (55N)(.74m) \sin 45 = \underline{29\ Nm}$

(24) $\Gamma = Fr \sin\theta$

$\Gamma_1 = (28N)(.24m) = 6.72\ Nm$ ccw

$\Gamma_2 = (35N)(.12m) = 4.2\ Nm$ cw

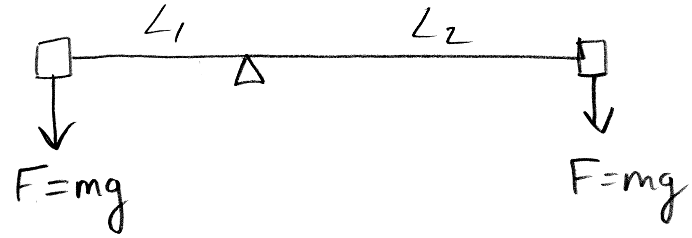
$\Gamma_3 = (18N)(.24m) = 4.32\ Nm$ cw

$\Gamma_1 + \Gamma_2 + \Gamma_3 = -6.72Nm + 4.2Nm + 4.32Nm = 1.8\ Nm$ cw

$\Gamma_f = .4\ Nm$ ccw

$\Gamma_{net} = 1.8Nm - .4Nm = \underline{1.4\ Nm\ cw}$

(25)



$\Gamma_{cw} = mgL_2$

$\Gamma_{ccw} = mgL_1$

$\Gamma_{net} = mg(L_2 - L_1)$ clockwise

(26) $\Gamma = Fr$

$F_{wrench} = \dfrac{\Gamma}{r} = \dfrac{88\ Nm}{.28\ m} = \underline{310\ N}$

$F_{bolt} = \dfrac{1}{6}\dfrac{\Gamma}{r} = \left(\dfrac{1}{6}\right)\dfrac{88\ Nm}{7.5\times10^{-3}\ m} = \underline{2.0\times10^{3}\ N}$

(27) $I = \frac{2}{5}mr^2 = \frac{2}{5}(10.8\ kg)(.648\ m)^2 = 1.81\ kgm^2$

(29) (a) $I = mr^2 = (.650\ kg)(1.2\ m)^2 = \underline{0.94\ kgm^2}$

(b) $\Gamma = I\alpha - F_f r$ $\qquad \alpha = 0$ because constant ω

$\Gamma = F_f r$

$= (0.020 N)(1.2 m)$

$\underline{\Gamma = 0.024\ Nm}$

(33) $\Gamma = Fr = I\alpha$

$\omega_f = \cancel{\omega_i} + at$

$\alpha = \dfrac{\omega_f}{t}$ $\qquad \omega_f = 2\pi f \qquad f = \dfrac{32\text{ rpm}}{60\text{ s min}} = 0.533\text{ Hz}$

$= \dfrac{2\pi f}{t}$

$Fr = I\alpha$

$Fr = \left(\frac{1}{2}mr^2\right)\left(\frac{2\pi f}{t}\right) = \dfrac{(3600\text{ kg})(4.0\text{ m})\,\pi\,(0.533\text{ Hz})}{(300\text{ s})} = 80\text{N}$

for each individual rocket

$F = \frac{80}{4} = \underline{20.\text{ N}}$

(43) $E_{k\,rot} = \frac{1}{2}I\omega^2$ $\qquad \omega = 2\pi f$

$= 2\pi \dfrac{(8250\text{ rpm})}{60\text{ s min}^{-1}}$

$= 863.9\text{ rad s}^{-1}$

$= \frac{1}{2}(3.75\times10^{-2}\text{ kgm}^2)(863.9\text{ rad s}^{-1})^2$

$= \underline{1.4\times10^4\text{ J}}$

(45) $E_{k\,total} = E_{k\,rot} + E_k$

$v = \omega r$

$\omega = \frac{v}{r}$

$= \frac{1}{2} I \omega^2 + \frac{1}{2} m v^2$

$= \frac{1}{2} I \frac{v^2}{r^2} + \frac{1}{2} m v^2$

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

$= \frac{1}{\cancel{2}}\left(\frac{\cancel{2}}{5} m \cancel{r^2}\right)\frac{v^2}{\cancel{r^2}} + \frac{1}{2} m v^2$

$= \frac{7}{10} m v^2 = \frac{7}{10}(7.3\,kg)(3.3\,ms^{-1})^2$

$= \underline{56\ J}$

(47) $W = E_{k\,rot} = \frac{1}{2} I \omega^2$

$\omega = 2\pi f$

$f = \frac{1\ rev}{8\ s}$

$I = \frac{1}{2} m r^2$

$= \frac{1}{\cancel{2}}\left(\frac{1}{\cancel{2}} m r^2\right) \cancel{4}\pi^2 \left(\frac{1}{8}\right)^2$

$= \frac{m r^2 \pi^2}{64} = \frac{(1640\ kg)(7.5\ m)\pi^2}{64}$

$= \underline{1.42 \times 10^4\ J}$

(71) $\Gamma = I\alpha$

$I = \frac{1}{2}mr^2$

$\omega_f = \omega_i + \alpha t$

$\alpha = \frac{\omega_f \cancel{- \omega_i}}{t}$

$\alpha = \frac{2\pi f}{t}$

$\Gamma = \left(\frac{1}{2}mr^2\right)\left(\frac{2\pi f}{t}\right)$

$= \frac{1}{2}(1.4\,kg)(.2\,m)^2 \frac{2\pi\,(1800\,Hz)}{6\,s}$

$= \underline{53\,Nm}$