Q1

$w = ?$

$$w = \frac{\partial\theta}{\partial t} = \frac{\Delta\theta}{\Delta t}$$

$$t = 1\ \text{year} = 365.25\ \text{day} * \frac{24\,h}{1\ \text{day}} * \frac{60\ \text{min}}{1\,h} * \frac{60\,s}{1\ \text{min}}$$

$$= 31557600\,s$$

$$\therefore\ w = \frac{2\pi}{31557600\,s} = 1.99 \times 10^{-7}\ \text{rad/s}$$

Q2

$t = ?$

$w_0 = 0$

$\theta = 10$ revelutions

$\alpha = \pi\ \text{rad/s}^2$

$$\theta = w_0 t + \tfrac{1}{2}\alpha t^2$$

$$10(2\pi) = 0 + \tfrac{1}{2}\pi t^2$$

$$40 = t^2 \Rightarrow t = \sqrt{40} = 6.3\,s$$

Q3

$w_i = 30\ \text{rev/s}$

$= 60\pi\ \text{rad/s}$

$w_f = 0$

$t = 10\,s$

a) $\alpha = ?$

b) $\theta = ?$

a) $w = w_0 + \alpha t$

$$\Rightarrow \frac{0 - 60\pi}{10} = \alpha = -6\pi\ \text{rad/s}^2$$

b) $\theta = w_0 t + \tfrac{1}{2}\alpha t^2$

$= (60\pi)(10) + \tfrac{1}{2}(-6\pi)(10)^2$

$= 600\pi - 300\pi$

$= 300\pi\ \text{rad}$

Q4

$\theta(t) = 4.0t - 3.0t^2 + t^3$

a) $w_{t=2s}$, $w_{t=4s}$

b) $\alpha_{avg} = ?\ t = 2 \to t = 4\,s$

c) $\alpha_{inst}(2) = ?$

$\alpha_{inst}(4) = ?$

a

$$w = \frac{\partial\theta}{\partial t} = 4 - 6t + 3t^2$$

$w_2 = 4 - 12 + 12 = 4\ \text{rad/s}$

$w_4 = 4 - 24 + 48 = 28\ \text{rad/s}$

b $\alpha_{avg} = \dfrac{\Delta w}{\Delta t} = \dfrac{28 - 4}{2} = 12\ \text{rad/s}^2$

c $\alpha_{inst} = \dfrac{\partial w}{\partial t} = -6 + 6t$

$\alpha_{inst}(2) = -6 + 12 = 6\ \text{rad/s}^2$

$\alpha_{inst}(4) = -6 + 24 = 18\ \text{rad/s}^2$

Q5 $\theta(t) = -1 - 0.6t + 0.250t^2$

at what time$_{min}$ θ reach the minimum value

$\theta'(t) = w(t) = -0.6 + 0.5t$

$w(t) = 0 \Rightarrow -0.6 + 0.5t = 0$

$\Rightarrow t = \frac{0.6}{0.5} = \boxed{1.2\,s}$

$\therefore \boxed{\theta(1.2) = 1.36 \text{ rad}}$

Q6 $w_i = 100 \frac{rev}{min} * \frac{1\,min}{60\,s} * \frac{2\pi\,rad}{1\,rev} = 10.5 \text{ rad/s}$

$w_f = 0$

$\alpha = -2 \text{ rad/s}^2$

(a) $t = ?$ $w = w_0 + \alpha t$

$0 = 10.5 - 2t$

$\boxed{\therefore t} = \frac{-10.5}{-2} = \boxed{5.2\,s}$

(b) $\theta = ??$

$\theta = w_0 t + \frac{1}{2}\alpha t^2$

$\boxed{\theta} = (10.5)(5.2) + \frac{1}{2}(-2)(5.2)^2 = \boxed{27.5 \text{ rad}}$

Q7 $r = 6\,cm = 0.06\,m$

(a) $w = 1200 \frac{rev}{min} * \frac{2\pi\,rad}{1\,rev} * \frac{1\,min}{60\,s} = 40\pi \text{ rad/s}^2$

$= 40\pi = 125.7 \text{ rad/s}^2$

$a_r = \frac{v^2}{R}$ but $w = \frac{v}{R} \Rightarrow a_r = \frac{w^2R^2}{R} = w^2R$

$= (125.7)^2(0.06)$

$= 947.8 \text{ m/s}^2$

(b) $a_t = 0$ Since w is const

Q8

$\omega_0 = 0$
$\omega_f = \omega$
$\theta = 2\,rev$
$\alpha = ?$

$\omega^2 = \omega_0^2 + \frac{1}{2}\alpha\theta$
$\omega^2 = 0 + 2\left(2\,rev \times \frac{2\pi}{1\,rev}\right)\alpha$
$\alpha = \frac{\omega^2}{8\pi}\ rad/s^2$

Q9

$R = 275\,m$
$v = 51.5\,m/s$
$\omega = ?$

$\omega = \frac{v}{R}$
$= \frac{51.5}{275} = 0.19\ rad/s$

$a = \frac{v^2}{R} = \frac{\omega^2 R^2}{R}$

$a_t = zero$

$a_R = \omega^2 R = (0.19)^2(275) = 9.6\ m/s^2$

Q10

$D = 1.65\,m$
$R = 0.825\,m$
$\alpha = 3.70\ rad/s^2$ constant
$\theta_{t_0} = 57.3°$
at $t = 2s$ find
a) $\omega_{t=2} = ?$
b) $v_T = ?$
c) $a = ?$
$\theta_{t=2} = ?$

$\theta_0 = 57.5° \times \frac{2\pi\ rad}{360°} \approx 1\ rad$

a
$\omega = \omega_0 + \alpha t$
$\omega = 0 + (3.70)(2) = 7.4\ rad/s$

b $v_t = \omega R = (7.4)(0.825) = 6.11\ m/s$

c $a_t = \alpha R = (3.7)(0.825) = 3.05\ m/s^2$
$a_R = \frac{v^2}{R} = \frac{6.11^2}{0.825} = 45.18\ m/s^2$
$a = \sqrt{a_t^2 + a_R^2} = 45.28\ m/s^2$

$\theta_{t=2} \Rightarrow \Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$
$\theta_f - (1\ rad) = 0 + \frac{1}{2}(3.7)(4)$
$\therefore \theta_f = 8.4\ rad$

Q11

$I = ?$
$KE = 24400\,J$
$\omega = 602\ \frac{rev}{min} \times \frac{1\,min}{60\,s} \times \frac{2\pi\ rad}{1\,rev}$
$= 63\ rad/s$

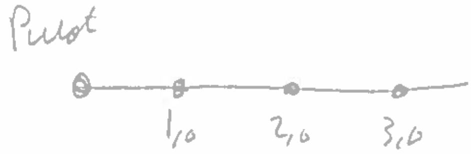
$KE = \frac{1}{2} I \omega^2$
$\frac{24400 \times 2}{63^2} = I$
$\therefore I = 12.3\ kg \cdot m^2$

$\boxed{Q_{12}}$

$m = 1.5\,kg$

$I = ?$

$I = \sum m_i R_i^2$



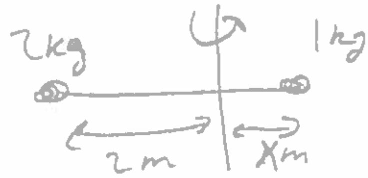
$= (1.5)(1)^2 + (1.5)(2)^2 + (1.5)(3^2)$

$= 1.5 + 6 + 12.5 = 21\,kg\,m^2$

$\boxed{Q_{13}}$ $I = 10\,kg\,m^2$

$X = ?$

$I = mR^2$



$I = m_1 X^2 + m_2 (2)^2$

$10 = 1X^2 + 2(4)$

$2 = X^2$

$\therefore X = 1.14\,m$

$\boxed{Q_{14}}$ $\dfrac{KE_{tn}}{KE_R} = ?$

$KE_{tn} = \frac{1}{2} m v^2$

$KE_R = \frac{1}{2} I \omega^2 = \frac{1}{2}(mR^2)(v/R)^2$

$\therefore \dfrac{KE_{tn}}{KE_R} = \dfrac{\cancel{\frac{1}{2}} \cancel{m} \cancel{v^2}}{\cancel{\frac{1}{2}}(\cancel{m} \cancel{R^2})(\frac{\cancel{v^2}}{\cancel{R^2}})} = 1$

$\boxed{Q_{15}}$ $I = I_{Rod} + I_{Rod} + I_{hoop}$

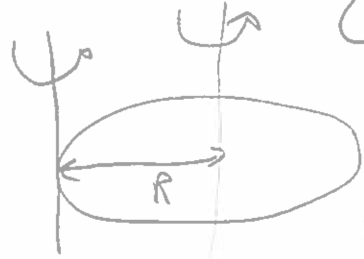
$= \left(\frac{1}{12} ML^2\right)(2) + M\left(\frac{L}{2}\right)^2$

$= \frac{5}{12} ML^2$

$I_{hoop} = MR^2$

Q16

$$I = I_{com} + MD^2$$
$$= \frac{1}{2}MR^2 + MR^2$$
$$= \frac{3}{2}MR^2$$



Q17

$m = 0.85\,kg$

$M = 1.2\,kg$

$d = 5.6\,cm = 0.056\,m$

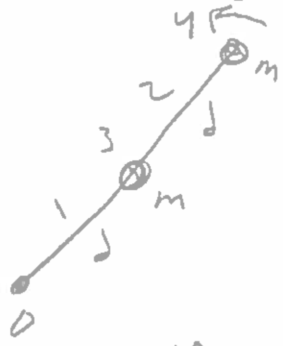
$w = 0.3\,rad/s$

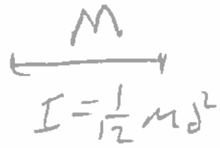
(a) $I = ?$

(b) $KE_{rot} = ?$

(a)

$$I_0 = I_1 + I_2 + I_3 + I_4$$
$$I_1 = \frac{1}{12}Md^2 + M\left(\frac{d}{2}\right)^2$$
$$I_2 = \frac{1}{12}Md^2 + M\left(\frac{3}{2}d\right)^2$$
$$I_3 = md^2$$
$$I_4 = m(2d)^2$$
$$I_0 = 0.023\,kg\,m^2$$





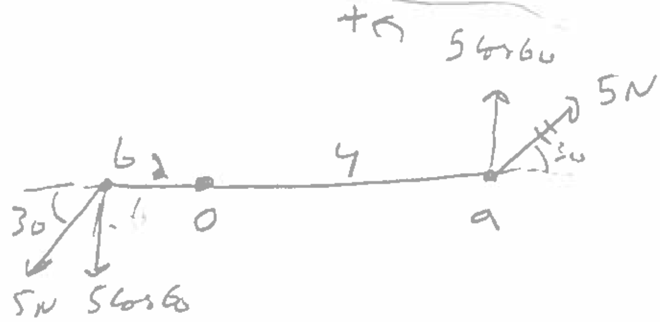
$I = MR^2$

(b) $KE_{rot} = \sum \frac{1}{2}Iw^2 = \frac{1}{2}(0.023)(0.3)^2 = 1.035 \times 10^{-3}\,J$

Q18

$\tau_{net} = ??$

$$\vec{\tau}_{net} = \vec{\tau}_a + \vec{\tau}_b$$
$$= (5\sin 60)(4) + (5\cos 60)(2)$$
$$= 15\,N\text{-}m \text{ (+k direction)}$$



19

$R = 50\,cm = 0.5\,m$

$M = 4\,kg$

steady $F = 10\,N$

$a_T = ?$

$F_{net} = ma = 0$ (1)

$F = T = 10\,N$

$\tau_{net} = I\alpha$ (2)

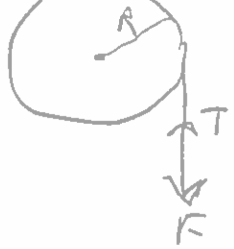
$TR = \frac{1}{2}MR^2\alpha$ (2')

(1) in (2') ⇒

$$\frac{(10)(0.5)(2)}{(4)(0.5)^2} = \alpha$$
$$\alpha = 10\,rad/s^2$$

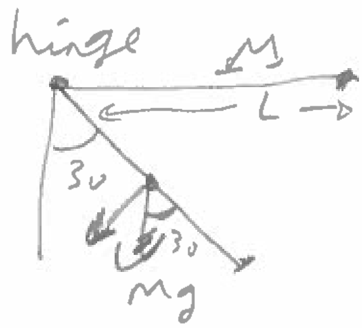
$$\Rightarrow \alpha = \frac{a}{R}$$
$$\therefore a = \alpha R = (10)(0.5)$$
$$\boxed{a = 5\,m/s^2}$$

$I_{com} = \frac{1}{2}MR^2$



clockwise

Q20



$I = \frac{1}{3} M L^2$

$\alpha_{inst} = ?$ at $\theta = 30^\circ$

$\tau_{net} = I\alpha = \vec{R} \times \vec{F}$

$$\therefore \alpha = \frac{\vec{R} \times \vec{F}}{I}$$

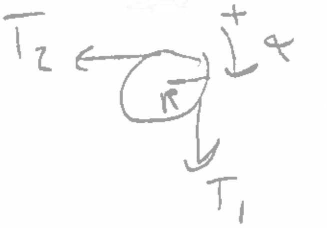
$$= \frac{(\frac{1}{2}L)\, Mg \cos 60}{\frac{1}{3} M L^2}$$

$$= \frac{3}{2} \frac{g \sin 30}{L} = \boxed{\frac{3g}{4L}} \text{ clockwise}$$

Q21

$F_{net} = ma$

$m_1 = 5\,kg$
$m_2 = 4\,kg$
$R = 5\,cm$
$M = 2\,kg$



$I = \frac{1}{2} M R^2$

$\Rightarrow m_1 g - T_1 = m_1 a$ (1)

$T_2 = m_2 a$ (2)

$\tau_{net} = I\alpha = \vec{R} \times \vec{F} = \tau_1 + \tau_2$

$\Rightarrow T_1 R - T_2 R = I\alpha = I \frac{a}{R}$ (4)

$(T_1 - T_2) = \frac{1}{2} M R^2 \frac{a}{R^2}$ (5)

(1) and (2) $\Rightarrow$
$m_1 g - T_1 + T_2 = (m_1 + m_2) a$ (3)

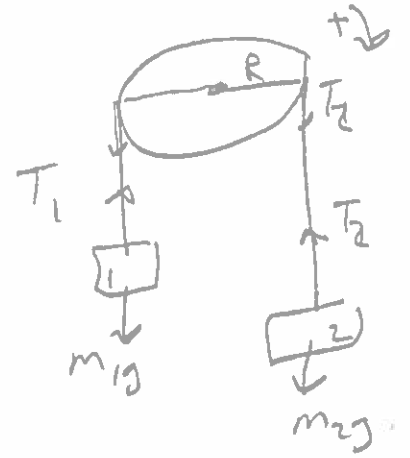
(3) and (5) $\Rightarrow m_1 g = \frac{1}{2} M a + (m_1 + m_2) a$

$49 = 1a + 9a = 10a$

$\therefore a = \frac{49}{10} = 4.9\ m/s^2$

Q22 (a) $a = ?$

$m_1 = 0.76\,kg$
$m_2 = 0.5\,kg$
$R = 0.05\,m$
$X = 75\,cm$
$t = 5\,s$
$u_0 = 0$



$X = u_0 t + \frac{1}{2} a t^2$

$0.75 = 0 + \frac{1}{2} a (5)^2$

$\boxed{\therefore a = 6 \times 10^{-2}\, m/s^2}$

(b) $F_{net} = m a$

$m_2 g - T_2 = m_2 a$ (1) $\Rightarrow T_2 = m_2 (g - a) = 4.87\,N$

(c) $T_1 - m_1 g = m_1 a$ (2) $\Rightarrow T_1 = m_1 (g + a) = 4.54\,N$

(d) $\alpha = \frac{a}{R} = \frac{6 \times 10^{-2}}{5 \times 10^{-2}} = 1.2\, rad/s^2$ clockwise

(e) $I = ?$

$\vec{\tau}_{net} = \vec{\tau}_1 + \vec{\tau}_2 = I\alpha$

$\therefore -T_1 R + T_2 R = I\alpha$

$\therefore I = \frac{R(T_2 - T_1)}{\alpha} = 1.38 \times 10^{-2}\, kg\text{-}m^2$

Q23 $P = ?$

$\omega_f = 0$
θ $10\,rev = (10)(\pi)(2)$
$\omega_i = 300\,rpm = 300 \frac{rev}{min} \times \frac{2\pi\, rad}{1\, rev} \times \frac{1\, min}{60\, s} = 18 \times 10^3 = 100\pi$
$I = 0.01\,kg\,m^2$

$u = \frac{X}{t}$

$\omega = \frac{\theta}{t}$

$\therefore t = \frac{\theta}{\omega} = \frac{20\pi}{100\pi}$

$\boxed{t = 0.2\,s}$

$W = \Delta KE = \frac{1}{2} I \omega^2 = \frac{1}{2}(0.01)(100\pi)^2 = 493.5\,J$

$P = \frac{\Delta K}{\Delta t} = \frac{493.5}{0.2} = 2.47 \times 10^3\, W$

Q24

$KE = KE_1 + KE_2 + KE_R$

$= \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 + \frac{1}{2} I \omega^2$

$= 22 J$

$u_1 = u_2 = u = 2 m/s$

$\omega = \frac{u}{R} = \frac{2}{0.03} = 66.7 \, rad/s$

$m_1 = 2 kg$

$m_2 = 4 kg$

$R = 0.03 m$

$I = 0.0045 kg.m^2$

8

Q25

$F_{net} = ma \Rightarrow$

$mg - 2T = ma$ (1)

$\tau_{net} = I\alpha \Rightarrow$

$I\alpha = (2T)(r)$ (2)

$\alpha = \frac{a}{R}$ (3)

$m = 2 kg$

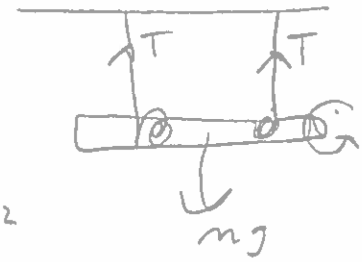
$r = 0.15 m$

$a = ?$

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

$= \frac{1}{2}(2)(0.15)^2$

$= 0.0225 kg.m^2$



(1) $\Rightarrow T = \frac{m(g-a)}{2}$ (4)

(4) in (2) $\Rightarrow$

$I\alpha = \cancel{2}\left(\frac{m(g-a)}{\cancel{2}}\right)(r)$

$I \frac{a}{R} = m(g-a) R$

$\frac{0.0225}{(0.15)^2} a = (2)(9.8 - a)$

$a = 2(9.8) - 2a$

$\therefore 3a = 39.2$

$\therefore \boxed{a = 6.53 \, m/s^2}$