ENGINEERING PHYSICS

1-1 Angular acceleration

1. $\omega_1 = 0$, $\omega_2 = 12$ rads^{-1}, t = 60 s

(a) $\alpha = \frac{\omega_2 - \omega_1}{t} = \frac{12 - 0}{60}$ = 0.20 rads^{-2}

(b) (i) $\theta = ½ (\omega_1 + \omega_2)t = ½ (0 + 12) \times 60 = 360$ rad

OR

$\omega^2 = \omega_0^2 + 2\alpha\theta$ therefore $\theta = \frac{\omega^2 - \omega_0^2}{2\alpha} = \frac{12^2 - 0}{2 \times 0.20} = 360$ rad

OR

$\theta = \omega_0 t + ½ \alpha t^2 = 0 + ½ \times 0.20 \times 60^2 = 360$ rad

(ii) No of turns = $\frac{\theta}{2\pi} = \frac{360}{2\pi}$ = 57.295…. = 57

2. f = 12 Hz, $\omega_2 = 0$ rads^{-1}, t = 50 s

(a) $\omega_1 = 2\pi f = 2\pi \times 12 = 75.398 = 75$ rads^{-1} to 2 sf (24π rads^{-1})

(b) $\alpha = \frac{\omega_2 - \omega_1}{t} = \frac{0 - 75}{50}$ = - 1.507…. rads^{-2} when it is decelerating

Angular deceleration = + 1.5 rads^{-2} to 2 sf

(c) Angle turned through = $\theta = ½ (\omega_1 + \omega_2)t = ½ (75 + 0) \times 50$ (= 1875 rad)

No of turns = $\frac{\theta}{2\pi} = \frac{½ (75 + 0) \times 50}{2\pi}$ = 298.41… = 300

3. $\omega_1 = 0$,

ω_2 = 1100 revolutions per second = $2\pi \times 1100 = 2200\pi = 6911.5 = 6910$ rads^{-1} to 3 sf

t = 50 s

(a) $\theta = ½ (\omega_1 + \omega_2)t = ½ (0 + 6910) \times 50 = 1.73 \times 10^5$ rad

(b) No of turns = $\frac{\theta}{2\pi} = \frac{1.73 \times 10^5}{2\pi} = 2.75 \times 10^4$

4. d = 0.45 m, so r = 0.225 m, u = 24 ms^{-1}, v = 0 ms^{-1}, s = 60 m

Circumference = $2\pi r = 2\pi \times 0.225$ = 1.4137… m

(a) $v = r\omega$ therefore $\omega = \frac{v}{r} = \frac{24}{0.225}$ = 107 rads^{-1}

(b) (i) $s = ½ (u + v)t$ therefore $t = \frac{2s}{u+v} = \frac{2 \times 60}{24+0}$ = 5.0 s

OR (more long-winded)

$v^2 = u^2 + 2as$ therefore $a = \frac{v^2 - u^2}{2s} = \frac{0^2 - 24^2}{2 \times 60}$ = -4.8 ms^{-2}

$v = u + at$ therefore $t = \frac{v - u}{a} = \frac{0 - 24}{-4.8}$ = 5.0 s

(ii) no of turns = $\frac{s}{2\pi r} = \frac{60}{1.4137...} = 42.6$

OR

$\theta = ½ (\omega_1 + \omega_2)t = ½ (107 + 0) \times 5 = 267.5$ rad

no of turns $= \frac{267.5}{2\pi} = 42.6$

(c) angular speed one second before it stopped = angular speed at 4.0 s

$\omega_0 = 107$ rad s^{-1} from (a)

$\alpha = \frac{\omega_2 - \omega_1}{t} = \frac{0 - 107}{5.0} = -21.4$ $rads^{-2}$

$\omega = \omega_0 + \alpha t = 107 + (-21.4 \times 4.0) = 107 - 85.6 = 21.4$ $rads^{-1}$

OR

$a = \frac{v - u}{t} = \frac{0 - 24}{5} = -48$ ms^{-2}

$v = u + at = 24 + (-4.8 \times 4) = 4.8$ ms^{-1}

$\omega = \frac{v}{r} = \frac{4.8}{0.225} = 21.3$ $rads^{-1}$

5. (a) From fig 2 the maximum angular velocity is when the gradient is steepest, so taking a tangent

$\omega = \frac{30 - 0}{3 - 0.86} = \frac{30}{2.2} = 14.01869... = 14$ $rads^{-1}$ this figure will vary significantly depending on how the tangent to a not very accurate graph is drawn.

(b) (i) From fig 3 the maximum angular acceleration is when the gradient is steepest, so taking a tangent to the first section

$\alpha = \frac{12 - 0}{2.36 - 0} = \frac{12}{2.36} = 5.0847... = 5.1$ $rads^{-2}$

(When decelerating the maximum value is

$\alpha = \frac{0 - 12}{4.46 - 2.36} = \frac{-12}{2.1} = 5.714... = -5.7$ $rads^{-2}$)

(ii) The angular displacement can be estimated from the area under the line

Each 'square' is 2 x 1 = 5 rad

No of 'squares' is approx. 14.5 giving 13.5 x 2 = 29 rad = 30 rad to 1 sf (15 'squares' gives 30 rad)

no of turns $= \frac{29}{2\pi} = 4.6$ (30 rad gives 4.8)