

M1.(a) $\frac{3.5}{(2\pi \times 0.088)} = 6.3 \text{ rev}$

$6.3 \times 2\pi = 39.8 \text{ rad or } 40 \text{ rad } \checkmark$

OR

$\frac{3.5}{0.088} = 39.8 \text{ or } 40 \text{ rad } \checkmark$

*If correct working shown with answer 40 rad give the mark
Accept alternative route using equations of motion*

1

(b) $\omega = v/r = 2.2 / 0.088 = 25 \text{ rad s}^{-1} \checkmark$

1

(c) (i) $E = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 + mgh$
 $= (0.5 \times 7.4 \times 25^2)$
 $+ (0.5 \times 85 \times 2.2^2)$
 $+ (85 \times 9.81 \times 3.5)$
 $= 2310 \checkmark$
 $+ 206 \checkmark$
 $+ 2920 \checkmark$
 $(= 5440 \text{ J or } 5400 \text{ J})$

CE from 1b

$\frac{1}{2} I \omega^2 + \frac{1}{2}mv^2 = 2310 + 210 = 2520 \text{ J}$

$\frac{1}{2} I \omega^2 + mgh = 2310 + 2920 = 5230 \text{ J}$

$\frac{1}{2}mv^2 + mgh = 210 + 2920 = 3130 \text{ J}$

Each of these is worth 2 marks

3

(ii) Work done against friction = $T\theta$
 $= 5.2 \times 40 = 210\text{J } \checkmark$
 Total work done = $W = 5400 + 210$
 $= 5600\text{J } \checkmark$ 2 sig fig \checkmark

CE if used their answer to i rather than 5400J

Accept 5700 J (using 5440 J)

Sig fig mark is an independent mark

3

(d) Time of travel = distance / average speed = $3.5 / 1.1 = 3.2\text{s } \checkmark$

5600

$$P_{\text{ave}} = \frac{5600}{3.2} = 1750 \text{ W}$$

$$P_{\text{max}} = P_{\text{ave}} \times 2 = 3500 \text{ W} \quad \checkmark$$

OR accelerating torque = $T = W / \theta$

$$= 5600 / 40 = 140 \text{ N m} \quad \checkmark$$

$$P = T \omega_{\text{max}} = 140 \times 25 = 3500 \text{ W} \quad \checkmark$$

CE from ii

1780 W if 5650 J used

2

[10]

M2.(a) (i) $8.3 \text{ rev} = 8.3 \times 2\pi \text{ rad} \quad \checkmark (= 52 \text{ rad})$

Use of $\omega_2^2 = \omega_1^2 + 2\alpha\theta$

$$0 = 6.4^2 + 2 \times \alpha \times 52 \quad \checkmark$$

If eqtn(s) of motion used correctly with $\theta = 8.3$ (giving $\alpha = 2.5$), give 2 out of first 3 marks.

OR use of $\theta = \frac{1}{2}(\omega_1 + \omega_2)t$ leading to $t = 16.25 \text{ s}$ and $\omega_2 = \omega_1 + \alpha t$

$$\alpha = (-) 0.39 \quad \checkmark \text{ rad s}^{-2} \quad \checkmark$$

Accept: s^{-2}

Unit mark is an independent mark

4

(ii) $T = I\alpha$

$$= 8.2 \times 10^{-3} \times 0.39 = 3.2 \times 10^{-3} \text{ N m} \quad \checkmark$$

Give CE from a i

1

(b) (i) ($W = T\theta$ or $W = T\omega t$) where $\theta = 0.78 \times 270 \quad \checkmark (= 210 \text{ rad})$

$$= 3.2 \times 10^{-3} \times 210 = 0.67 \text{ J} \quad \checkmark$$

Give CE from a ii

2

$$\text{ratio} = \frac{900 \times 270}{0.67} \quad \text{or} \quad \frac{2.4(3) \times 10^5}{0.67} \quad \checkmark$$

(b) (ii) $= 3.6 \times 10^5 \quad \checkmark$

CE from b i. Must be in the form: number $\times 10^5$ with number

calculated correctly.

900×270 or $2.4(3) \times 10^5$ or equivalent must be seen for 1st mark

1 mark for only writing 3.6×10^5

²
(Total 9 marks)

M3. (a) (i) $T = Fr = 32 \times 0.15$

$$= 4.8 \text{ N m } \checkmark$$

1

(ii) $\omega = 2600 \times 2\pi/60$ ($= 270 \text{ rad s}^{-1}$) \checkmark accept 272 rad s^{-1}

$$\text{total torque} = 4.8 + 1.2 = 6.0 \text{ N m } \checkmark$$

$$P = T\omega$$

$$= 6.0 \times 270 = 1620 \text{ W } \checkmark$$

3

(b) $\alpha = \frac{270 - 0}{8.5} = 32 \text{ rad s}^{-2} \checkmark$

$$I = T/\alpha = \frac{1.2}{32} = 0.038 \checkmark \text{ kg m}^2 \checkmark$$

OR use of $\Theta = \frac{1}{2}(\omega_2 + \omega_1)t$ ($= 1150 \text{ rad}$) \checkmark

and $\frac{1}{2}I\omega^2 = T\Theta$ leading to $I = 0.038 \checkmark \text{ kg m}^2 \checkmark$

3

(c) $E = \frac{1}{2}I\omega^2$

$$= 0.5 \times 0.038 \times 270^2 = 1400 \text{ J } \checkmark$$

$$P = E/t = 1400/0.005 = 280 \text{ kW } \checkmark$$

2

[9]

M4. (a) (i) $T = Fr = 7.0 \times 0.075$
 $= 0.53$ (1) N m (1)

2

(ii) $P = T\omega$
 $= 0.53 \times 120 = 64$ W (1)

1

(b) use of equation(s) of motion:

$\theta = \frac{1}{2}(120 + 0) \times 6.2 = 370$ rad (1)

$370/2\pi = 59$ rotations (1)

2

[5]

M5.(a) (i) two correct points from straight line (e.g. (0,0) and (300,150)) (1)

$$\alpha \left(= \frac{\omega_2 - \omega_1}{t} \right) = \frac{150 - 0}{0.3} = 500 \text{ rad s}^{-2} \text{ (1)}$$

(ii) $T (= I\alpha) = 4.20 \times 10^{-7} \times 500 = 2.1 \times 10^{-4}$ N m (1)

3

(b) (i) resistive torque is negligible at low speeds (1)
 resistive torque increases as speed increases (1)
 resultant accelerating torque decreases so α decreases (1)
 until resistive torque = applied torque (1)
 zero net torque, so constant angular speed (1)
 (any three)

(ii) (use of $P = T\omega$ gives) $P = 2.1 \times 10^{-4} \times 225 = 4.73 \times 10^{-2}$ W (1)
 (allow C.E. for value of T)

(iii) $E (= Pt) = 4.73 \times 10^{-2} \times 60 = 2.84$ J (1)

5

