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

6.3 × 2π = 39.8 rad or 40 rad ✓

OR

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

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 rad s^{-1} ✓

1

(c) (i) $E = ½I\omega^2 + ½mv^2 + mgh$
= (0.5 × 7.4 × 25^2)
+ (0.5 × 85 × 2.2^2)
+ (85 × 9.81 × 3.5)
= 2310 ✓
+ 206 ✓
+ 2920 ✓
(= 5440 J or 5400 J)

CE from 1b
$½ I \omega^2 + ½mv^2$ = 2310 + 210 = 2520 J
$½ I \omega^2 + mgh$ = 2310 + 2920 = 5230 J
$½mv^2 + mgh$ = 210 + 2920 = 3130 J
Each of these is worth 2 marks

3

(ii) Work done against friction = $T\theta$
= 5.2 × 40 = 210J ✓
Total work done = ***W*** = 5400 + 210
= 5600J ✓ 2 sig fig ✓

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 = 3.2s ✓

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

$P_{max} = P_{ave} \times 2 = 3500$ W ✓

OR accelerating torque = $T = W / \theta$
= 5600 / 40 = 140 N m ✓
P = $T\,\omega_{max}$ = 140× 25 = 3500 W ✓

CE from ii

1780 W if 5650 J used

2

[10]

M2.(a) (i) 8.3 rev = 8.3 × 2π rad ✓ (= 52 rad)

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

$0 = 6.4^2 + 2 \times \alpha \times 52$ ✓

If eqtn(s) of motion used correctly with θ = 8.3 (giving α = 2.5), give 2 out of first 3 marks.

OR use of $\theta = ½(\omega_1 + \omega_2)t$ leading to t = 16.25 s and $\omega_2 = \omega_2 + \alpha t$

α = (−) 0.39 ✓ rad s^{-2} ✓

Accept: s^{-2}

Unit mark is an independent mark

4

(ii) $T = I\alpha$

$= 8.2 \times 10^{-3} \times 0.39 = 3.2 \times 10^{-3}$ N m ✓

Give CE from a i

1

(b) (i) ($W = T\theta$ *or* $W = T\omega t$) where $\theta = 0.78 \times 270$ √ (= 210 rad)

$= 3.2 \times 10^{-3} \times 210 = 0.67$ J ✓

Give CE from a ii

2

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

$= 3.6 \times 10^5$ ✓

CE from b i. Must be in the form: number × 10^5 with number *calculated correctly.*

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

1 mark for <u>only</u> writing 3.6 × 10^5

2

(Total 9 marks)

M3. (a) (i) $T = Fr$ = 32 × 0.15

= 4.8 N m ✓

1

(ii) ω = 2600 × 2π/60 (= 270 rad s^{-1}) ✓ accept 272 rad s^{-1}

total torque = 4.8 + 1.2 = 6.0 N m ✓

$P = T\omega$

= 6.0 × 270 = 1620 W ✓

3

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

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

OR use of $\Theta = ½(\omega_2 + \omega_1)t$ (= 1150 rad) ✓

and $½I\omega^2 = T\Theta$ leading to I = 0.038 ✓ kg m^2 ✓

3

(c) $E = ½I\omega^2$

= 0.5 × 0.038 × 270^2 = 1400 J ✓

$P = E/t$ = 1400/ 0.005 = 280 kW ✓

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 rad s^{-2} **(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

[8]