

Name of the Student: _____

Max. Marks : 23 Marks

Time : 23 Minutes

Mark Schemes

Q1.

- (a) (i) energy: kinetic energy = $\frac{1}{2}I\omega^2$, $\rightarrow$ small stored energy
 [or less work/energy needed to produce change]
 power = rate of energy change, fast change $\rightarrow$ high power
 torque: $T = I\alpha$, α large so large torques needed unless I small,
 momentum, impulse: $L = I\omega$, impulse = ΔL so unless I small, large
 angular impulses are needed
marking: for any **one** of the above:
 for correct consideration **(1)**
 for mathematical justification **(1)**

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- (ii) explanations based on $I = mr^2$ **(1)**
 low **mass**, small diameter **(1)**

(b) (i) $\alpha = \frac{\omega_1 - \omega_2}{t} = \frac{120 + 120}{50 \times 10^{-3}} = 4.8 \times 10^3 \text{ rad s}^{-2}$ **(1)**

(ii) $T = I\alpha = 4.4 \times 10^{-5} \times 4.8 \times 10^3 = 0.21(1) \text{ N m}$ **(1)**

(allow C.E. from incorrect value of α from (i))

- (iii) impulse = torque $\times$ time = $0.21 \times 50 \times 10^{-3} = 1.1 \times 10^{-2} \text{ N m s}$ **(1)**
 $(1.05 \times 10^{-2} \text{ N m s})$
 (allow C.E. for value of T from (ii))
 [or $\Delta L = I(\omega_2 - \omega_1) = 4.4 \times 10^{-5} \times 240 = 1.1 \times 10^{-2} \text{ N m s}$]

(iv) $\theta = \left(\frac{\omega_1 + \omega_2}{2} \right) t = \left(\frac{120 + 0}{2} \right) 25 \times 10^{-3} = 1.5 \text{ rad}$ **(1)**

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[8]**Q2.**

- (a) (i) $110 \text{ rpm} = \left(\frac{110 \times 2\pi}{60} \right) = 11.5 \text{ (rad s}^{-1}\text{)}$ **(1)**
 kinetic energy = $\frac{1}{2}I\omega^2 = 0.5 \times 150 \times 11.5^2 = 9.9(2) \text{ kJ}$ **(1)**
 (use of 12 for conversion above gives 10.8 kJ)

(ii) average useful $P_{\text{out}} = \frac{9.92 \times 10^3}{15} = 660 \text{ W}$ **(1)** (661 W)

(use of k.e. = 10.8 kJ gives 720 W)

$$(iii) \quad P_{av} = T_{acc} \omega_{av} \text{ gives } T = \left(\frac{661}{11.5/2} \right) = 115 \text{ N m (1) } \square (1) \text{ (for } \omega_{av})$$

(use of $P_{out} = 720 \text{ W}$ gives 125 N m)

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$$(b) \quad \text{work done against friction} = T_r \theta \text{ and } T_r = \frac{9.95 \times 10^3}{35 \times 2\pi} \quad (1)$$

$$= 45(.2) \text{ N m (1)}$$

[or use of $\omega_2^2 = \omega_1^2 + 2\alpha\theta$, $T = I\alpha$

i.e. $0 = 11.5^2 + (2\alpha \times 2\pi \times 35)$ gives $\alpha = 0.301 \text{ (rad s}^{-2})$

$$T (= I\alpha) = 150 \times 0.301 = 45(.1) \text{ N m}]$$

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[7]

Q3.

(a) moment of inertia of the rockets

$$= (2 \times 0.54 \times (0.80)^2) + (2 \times 0.54 \times (0.50)^2) = 0.96 \text{ (kg m}^2) \quad (1)$$

$$\text{total moment of inertia} = 0.96 + 0.14 \text{ (kg m}^2) \quad (1) \quad (= 1.10 \text{ kg m}^2)$$

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$$(b) \quad (i) \quad \text{torque} = (2 \times 3.5 \times 0.80) + (2 \times 3.5 \times 0.50) = 9.1 \text{ N m (1)}$$

$$(ii) \quad \alpha \left(= \frac{T}{I} \right) = \frac{9.1}{1.1} = 8.3 \text{ rad s}^{-2} \quad (1) \quad (8.27 \text{ rad s}^{-2})$$

(allow C.E. for value of torque from (i))

$$(iii) \quad \text{one turn} = 6.28 \text{ rad (1)}$$

$$\theta = \omega_1 t + \frac{1}{2} \alpha t^2 \text{ gives } 6.28 = 0.5 \times 8.3 \times t^2 \text{ and } t = 1.2(3) \text{ s (1)}$$

(allow C.E. for value of α from (ii))

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(c) frictional couple (due to air resistance) increases as angular speed increases (1)

when frictional couple = driving torque [or when no resultant torque], then no acceleration (1)

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[8]