Name of the Student:_____
Max. Marks : 16 Marks **Time : 16 Minutes**

Mark Schemes

Q1.

(a) The (total) angular momentum (of a system) remains constant provided no external torque acts (on the system) ✔

Must see 'angular'. Condone 'is conserved' for 'is constant'

Allow ang momtm before equals/is same as ang momtm after OR initial ang momtm = final ang momtm

Allow $I\omega$ is constant if symbols explained

Do not allow 'force' in place of 'torque'

1

(b) Use of $I = I_{BODY} + 2 \times mr^2$ ✔

$I_1 = (71 + 2 \times 5.0 \times 4.1^2) = 239$ kg m^2 ✔

(≈ 240 kg m^2)

For 2 marks 239 must be seen

2

(c) M of I decreases ✔

Because more mass closer to axis **OR** (for pods) $I = (\sum)mr^2$ with r less ✔

$I\omega$ / angular momentum remains constant/is conserved

(So as I decreases) ω must increase ✔

Condone 'inertia' for 'moment of inertia'

2nd mark is for the reason why I is decreasing. Answer must relate to pods or masses getting closer to the axis. 'radius decreasing' on its own is not enough. Accept: pods get closer to axis/body as this implies mass is getting closer.

Both points needed for 3rd mark

3

(d) (Applies conservation of angular momentum/ $I_1\omega_1 = I_2\omega_2$)

$I_1\omega_1 = 240 \times 1.3 = (312$ (N m s)) ✔

$312 = (71 + 2 \times 5.0 \times 0.74^2)\ \omega_2$

$\omega_2 = 4.08$ rad s^{-1} ✔

Therefore max speed not reached OR arms can be retracted safely✔

OR

$I_1\omega_1$ = 240 × 1.3 = (312 (N m s)) ✔

312 = (71 + 2 × 5.0 × r_2^2) 4.2

r_2 = 0.57 m ✔

So with *r* at circumference max speed not reached OR arms can be retracted safely ✔

OR

$I_1\omega_1$ = 240 × 1.3 = (312 (N m s)) ✔

312 = 4.2 I_2 at safety limit

I_2 = 74(.3) kg m^2 ✔

Actual I_2 = 76.5 kg m^2

Therefore max speed not reached OR arms can be retracted safely ✔

Using 239 kg m^2 instead of 240 kg m^2 leads to
ω^2 = 4.06 rad s^{-1}
Useful: I_2 = 76.5 kg m^2
Only credit last mark if conservation of angular momentum is used
Allow a judgement based on incorrect working (eg AE) provided conservation of angular momentum is used
Using 239 kg m^2 instead of 240 kg m^2 leads to
r_2 = 0.55 m

3

[9]

Q2.

(a) To smooth out (fluctuations in) rotational speed ✔

OR to store (rotational kinetic) energy ✔

OR to smooth (fluctuations in) torque/power ✔

Any named form of energy must be (rotational) kinetic
Do not allow an application (eg regenerative braking) unless one of the answers shown alongside is included

1

(b) Use of 0.075 sin 8° **or** 0.075 tan 8° **or** 0.075 (π − 3) to calculate *h*

h = 1.04 × 10^{-2} (m) **OR** 1.05 × 10^{-2} (m) **OR** 1.06 × 10^{-2} (m) ✔

mgh = 0.020 × 9.81 × 1.04 × 10^{-2} = 2.04 × 10^{-3} (J) ✔

Tθ = 2.04 × 10^{-3} (J)

T = 2.04 × 10^{-3} /3.00 = 6.80 × 10^{-4} Nm ✔

1st mark for calculating h
2nd mark for calculating mgh.

3rd mark for dividing mgh by 3.00 rad.

Use of tan gives h = 1.05 × 10^{-2} (m)

Use of arc length gives h = 1.06 × 10^{-2} (m)

3rd mark only awarded for arriving at correct answer to more than 1 sig fig

3

(c) Attempt to use $0 = \omega_1^2 - 2\alpha\theta$ ✔

Or $\theta = 573 \times 2\pi = 3600$ rad ✔

Leading to $\alpha = 0.087$ (rad s^{-2}) ✔

$I = \frac{T}{\alpha}$ = 7.82 × 10^{-3} kg m^2 ✔

OR

Attempt to use $T\theta = \frac{1}{2} I (\omega_2^2 - \omega_1^2)$ ✔

or $\theta = 573 \times 2\pi = 3600$ rad ✔

($I = 2T\theta/\omega_1^2$)

$= 2 \times 6.8 \times 10^{-4} \times 573 \times 2\pi/25^2$ ✔

= 7.82 × 10^{-3} kg m^2 ✔

*1st mark for **either** use of equation **or** converting rotations to rad*

ECF for 3rd mark

The value of torque used must be a correctly calculated answer to part (b) or 7 × 10^{-4} N m

<u>For 2nd method</u>

2nd mark for correct substitution

3rd mark for calculating answer

3

[7]