Name of the Student:_____
Max. Marks : 18 Marks **Time : 18 Minutes**

Mark Schemes

Q1.

(a) (The M of I decreases) because more mass closer to axis of rotation ✔1
$I\omega$/angular momentum constant since no external torque ✔2
since I decreases, ω must increase ✔3

For ✔1 must have the idea of mass distribution around axis of rotation. Do not accept answers which give only decrease in radius as reason for lower M of I.

For ✔2 condone answers which do not mention the condition of no external torque. ✔3 cannot be awarded if conservation of rotational kinetic energy used.

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(b) $I_1\omega_1 = I_2\omega_2$ ω_1 = 4.3 rad s^{-1} ✔

Accept the answer 4.3 rad s^{-1} if no working shown.

1

(c) Finds time for one rotation ✔
Divides 1.2 by time
AND
gives answer for complete rotations, not rounded up. ✔

time for 1 rotation = 2π/14.2 = 0.442 s
1.2/0.442 = 2.7 rotations/turns/somersaults.
OR Angle turned through = 14.2 × 1.2 = 17.04 rad
17.04/2π = 2.7 rotations

OR

Finds angle turned through in 1.2 s ✔
Divides by 2π
AND
gives answer for complete rotations, not rounded up. ✔

Expect to see 2 complete rotations/turns/somersaults.
For MP2 give CE for time or angle from MP1

2

(d) Any 2 from:
- build up a greater initial angular speed around the bar ✔
  so reaches a greater height/will rotate faster in tuck ✔
- release at a greater angle from the horizontal ✔
  so will rise to greater height giving more time for somersaults ✔

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- get into tuck position earlier/get out of tuck position later ✔
  so turning for more time ✔
- get into tighter tuck position ✔ reducing I_2, and increasing ω_2 ✔

Any 2

statement ✔ and correct reason ✔ scores 2 marks for each.

4

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Q2.

The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2 mark (**L1**), 3 or 4 mark (**L2**) and 5 or 6 mark (**L3**) answer.

Level 3 (5–6 marks)
6 marks: both areas of the question are covered (i.e. calculations and explanations) with all efficiencies calculated correctly and at least two of points 7,8,9.
5 marks: both areas covered but with one or two minor errors in calculations or explanations.

Level 2 (3–4 marks)
4 marks: all efficiencies calculated correctly with no explanation of usefulness of efficiencies OR a good attempt at calculating efficiencies and some explanation given of usefulness of efficiencies.
3 marks: Both areas covered partially or one area covered reasonably well but not fully. E.g may only be able to calculate correctly 2 of the three required efficiencies and give no explanation of their usefulness.

Level 1 (1–2 marks)
Student is likely to make one or two calculations (e.g input power and one efficiency) at any speed, but not likely to be able to explain the usefulness of efficiency.

0 marks
The student shows inadequate understanding of the graphs. Formulae may be quoted from the Formulae Booklet or from memory, but the student is unable to apply their meaning to the question.

(a) Numerical answers:

1. Peak brake power occurs at (6200 to 6600) rev min^{-1}
2. Input power = 136 kW
3. Overall efficiency = 0.29
4. Thermal efficiency = 0.35
5. Mechanical efficiency = 0.84
6. Friction power = 7.5 kW

General points:

7. Relates thermal efficiency to how well the calorific value of fuel is converted into work/power inside the engine.
8. Relates mechanical efficiency to work/power used in overcoming friction/viscosity inside engine and work/power to operate valves, water/oil pumps etc.
9. Overall efficiency gives an idea of how well energy in fuel is converted into useful work output.

If student uses peak <u>indicated</u> power points 1 to 5 become

1. Peak power occurs at (7200 to 7600) rev min^{-1}
2. Input power = 150 kW
3. Overall efficiency = 0.26
4. Thermal efficiency = 0.32
5. Mechanical efficiency = 0.80

Do not allow marks at Level 3.

6

(b) Links two quantities from Figure 4 at speeds above 7000 rev min^{-1} ✔

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Gives reason for not running engine at speeds above 7000 rev min^{-1} ✔

Examples of points expected for MP1:

- *brake power drops whilst input power continues to increase (as shown by fuel consumption curve)*
- *brake power drops whilst indicated power flattens off*
- *indicated power flattens off while fuel consumption increases*

Do not accept: the brake power gets less with no reference to other power(s).

MP2:

any of overall, thermal or mechanical efficiency decreases, or efficiency decreases.

friction or friction power increases at high engine speeds

breakdown of lubrication and/or greater work done against viscosity at high engine speeds.

Do not accept: damage to engine may occur -unless backed up by reason relating to friction/friction power.

Max 2

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