Name of the Student:_____
Max. Marks : 20 Marks **Time : 20 Minutes**

Mark Schemes

Q1.

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

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

3

(ii) Work done against friction = $T\theta$
= 5.2 × 40 = 210J ✓
Total work done = $\boldsymbol{W}$ = 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]

Q2.

(a) The ratio $\frac{\text{energy given to hot space/area to be heated}}{\text{work input}}$ ✓

OR COP = Q_{IN} / W with Q_{IN} and W explained / defined ✓

It must be clear that Q_{IN} is energy delivered to the area to be heated / hot space. Do not accept 'heat input' or any wording that is vague

1

(b) (i) $\eta_{max} = \frac{1600 - 290}{1600}$ = 0.82 / 82% ✓

input power = $\frac{\text{output power}}{\text{efficiency}} = \frac{80}{0.82}$ = 98 kW ✓

fuel flow rate × CV = 98 kW
fuel flow rate = 98000 / (49×10^6) = 2.0×10^{-3} ✓
kg s^{-1} ✓
OR 7.2 ✓ kg h^{-1} ✓

If first 2 steps in calculation are not seen and 80 kW used for input power give 1 mark for:

fuel flow rate = 80000 / (49×10^6) = 1.6×10^{-3} ✓

The unit mark is an independent mark

4

(ii) $COP_{HP} = \frac{Q_2}{W}$

So Q_2 =16 × 2.6 = 41.6 or 42 kW ✓
Q_1 = 98 − 80 = 18 kW ✓
Total $Q_1 + Q_2$ = 60 kW ✓

CE for Q_1 if incorrect input power from i is used, but NOT 80 −16 or 80 − 80

3

(iii) Heat pump delivers more heat energy than the electrical energy input ✓

Reason: it adds energy from external source to electrical energy input ✓

Accept $Q_{IN} = W + Q_{OUT}$ if explained correctly e.g. by diagram

2

[10]