Name of the Student:_____
Max. Marks : 26 Marks **Time : 26 Minutes**

Mark Schemes

Q1.

(a) energy supplied/transferred/input to system/gas (by heating/heat transfer) ✔

OR

energy transferred/lost/output from system/gas (by cooling heat transfer) if *Q* negative

Do not allow 'heat' in place of 'energy'
Do not accept 'heat transferred' on its own
Accept 'heat energy supplied' but not 'heat supplied'.

1

(b) Tick against top line only

-10.8 0 10.8

1

(c) Use of $p_1V_1^{1.4} = p_2V_2^{1.4}$ ✔

'use of' means by substitution or manipulation to make p_2 the subject of the equation eg $p_2 = p_1\left(\frac{V_1}{V_2}\right)^{1.4}$ *seen*
Accept γ for 1.4.

Giving $p_2 = 2.32 \times 10^6$ (Pa) ✔

T_2 $\left(= \frac{p_2V_2T_1}{p_1V_1}\right)$ = 710(K) ✔

$T_2 = \frac{2.32\times10^6 \times \left(3.19\times10^{-9}\right)\times 293}{1.05\times10^5 \times 2.91\times10^{-8}}$

ECF for T_2 using their p_2

3

(d) Slow change means internal energy remains (nearly) constant due to energy loss by heat transfer

OR

Slow change means (nearer to) isothermal change ✔

(Therefore)

the work done would be lower because the area under the graph would be lower

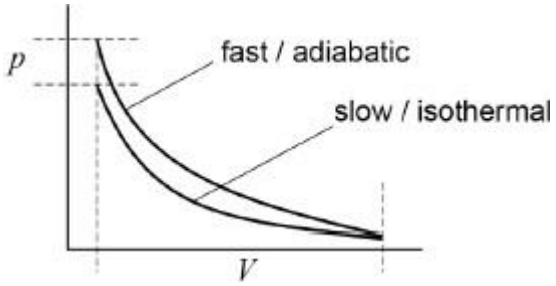
OR

the work done would be lower because the pressures are lower ✔

(Therefore, cyclist is not correct)

Allow reverse argument from fast change perspective.

Accept answers where shown in a diagram:



Alternative MP2: smaller (average) p for same ΔV will give less W

Max 2

[7]

Q2.

(a) Attempt at calculating area above or below *t* axis or both ✔

(Ang displacement =) 2.80 + 2.10 − 3.15 = 1.75 rad

($\frac{1.75}{12.0}$ =) 0.15 (rad s^{-1}) ✔

Method must be valid

MP2: correct answer only

(calculator value = 0.145833)

MAX1 if counting square method used and answer rounds to 0.15 (rad s^{-1})

2

(b) $P = T\omega$ giving 546 (W) ✔

Allow ecf for 590 (W) from

using ω_1 = 1.5 rad s^{-1}

1

(c) Selects steepest part of graph and

determines gradient α = $\frac{1.40 - -0.90}{5.0}$ = 0.46 (rad s^{-2}) ✔$_1$

$T = I\alpha$ = 9660 N m ✔$_2$

Adds friction torque to give 10 100 (N m) ✔$_3$

Accept any correct calculation of steepest graph slope: eg from 2 s to 5 s

$a = \frac{1.4}{3.0}$ *= 0.467 giving T = 9800 N m*

or 5 s to 7 s

$a = \frac{0.9}{2.0}$ *= 0.45 giving T = 9450 N m*

Allow ECF from MP2 to MP3

Treat 10 000 (Nm) as a 2 sf answer if consistent with their working.

3

(d) (net) $T \times t = 9660 \times 5.0 = 4.8 \times 10^4$ (N m s) ✔

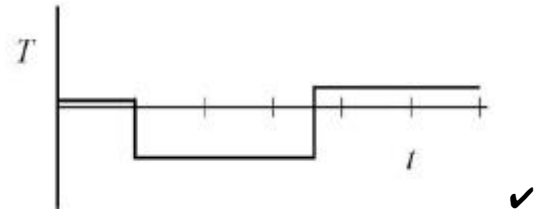
OR

$\Delta(I\omega) = 2.1 \times 10^4 (1.40 - (-0.90)) = 4.8 \times 10^4$ (N m s) ✔

*For first method allow ECF for torque ✔$_2$ from **(c)**, but not for ✔$_3$ value (calculator value = 48300)*

1

(e)



✔

Tick (✔) against 3rd box

1

[8]

Q3.

(a) Attempt to use work done = force × distance with either incline work or resistance work or both ✔$_1$

Work done by flywheel

= [(1.46 × 10^4 × 9.81 × sin 5°) + 1.18 × 10^3] × 500 ✔$_2$

(= 6.83 × 10^6 J)

1/2 $I\omega^2$= 6.83 × 10^6 giving ω = 468 (rad s^{-1}) ✔$_3$

MP1: award mark for valid attempt to calculate
mgh or F × s or both
mgh = 6.24 × 10^6 J
F × s = 5.9 × 10^5 J
MP2 for correct calculation of work done
MP3 for using their work done and 1/2 $I\omega^2$ to calculate ω
ECF for ✔$_3$

3

(b) ✔$_1$ for idea of use of flywheel as brake

✔$_2$ for idea of storing and reusing this energy

E_p change of tram can be converted to E_k of flywheel so less energy transferred to brakes/brakes last longer/tram will not reach a high speed ✔$_1$
OR
Energy otherwise dissipated/lost in brakes can be fed back to flywheel ✔$_1$

Fly wheel is charged/stores energy and energy can be used for later acceleration/driving ✔2

OR

Fly wheel is charged/stores energy and at next stop less recharging energy will be needed. ✔2

Give two marks if both points covered in their answer to part 1

Treat as neutral answers in terms of providing a smoother ride or less wear on parts due to connecting and reconnecting flywheel.

If no other marks are given, allow 1 MAX for a correct reference to regenerative braking.

2

(c) **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.**
Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question.

Mark	Criteria
6	The factors which affect E_k and all three areas of shape, material and design for high ω will be covered in some detail. 6 marks can be awarded even if there is an error and/or if parts of one aspect are missing.
5	The factors which affect E_k and all three areas will be covered, at least two in detail.
4	Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be gaps, there should only be an occasional error.
3	One area discussed and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.
2	Only one area discussed or makes a partial attempt at two areas.
1	None of the three areas covered without significant error.
0	No relevant analysis.

examples of the points made in the response

- E_k proportional to ω^2
- E_k proportional to I
- for same mass of tram I or ω increased but not mass of flywheel

<u>Shape</u>

- I depends on mass and distribution of mass around axis
- ($I = \sum mr^2$ so) arrange more m at outer edge of flywheel
- by using heavy rim and spokes/thin centre web
- increase radius

<u>Material</u>

- use higher density material at rim
- use material of higher tensile strength / breaking stress

- for higher speeds without bursting/to withstand rotational/centripetal stresses
- eg titanium, CFRP

Design for high ω - increase ω by:
- reduce friction at bearings
- use lubrication or roller bearings/air bearings/magnetic bearings
- smooth outer surfaces / encase in vacuum
- small increase in ω gives large increase in E_k (because ω^2)

Also allow
- sketches which convey correct info clearly
- use of 'depends on' for 'proportional to'
- need for perfect balance
- gyroscopic effects

6

[11]