A-level

Physics

PHYA5/2C – Applied Physics
Mark scheme

2450
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Version: 1.0 Final

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Question	Answers	Additional Comments/Guidance	Mark	ID details
1(a)	$F = 0.11 \times \cos 45$ (= 0.078 N) ✓ $T = F \times 0.12$ on each arm = 9.4×10^{-3} N m Total $T = 3 \times 9.4 \times 10^{-3} = 0.028$ N m ✓	Do not allow sin 45 instead of cos 45 but give CE for 2nd mark. No CE for 2nd mark if no attempt to resolve force i.e. no cos or sin.	2	
1(b)(i)	Initially friction torque < applied torque so spinner accelerates / frictional torque increases with speed ✓ Eventually applied torque = friction/resistive torque and spinner angular speed remains constant ✓	For a full answer is in terms of 'force' rather than 'torque' give max 1 mark.	2	
1(b)(ii)	240 rev min^{-1} = 25 rad s^{-1} OR use of $P = T\omega$ with attempt to convert rev min^{-1} to rad s^{-1} ✓ $P = T\omega$ $P = 0.028 \times 25 = 0.70$ W ✓	Accept attempt such as multiplying by π or dividing by π or 2π, or dividing 240 by 60 and not using 2π. No CE for incorrect ω T must be either 0.028 or 0.03 Nm 0.75 W if 3×10^{-2} used	2	
1(c)(i)	Use of $\theta = ½(\omega_1 + \omega_2)\, t$ OR $\theta = 13 \times 2\pi$ ✓ $= 0.5 \times 25 \times t$ $t = 6.5$ s ✓	CE for ω_1 from b ii	2	
1(c)(ii)	E_K = mean power × time = 0.35 × 6.5 = 2.3 J OR $E_K = T\theta = 0.028 \times 26\pi = 2.3$ J ✓	CE for values of θ and t from c i and P from b ii Allow use of $E_K = ½ I\omega^2$ with I from part c iii If T = 0.03 N m used, E_K = 2.4(5) J	1	
1(c)(iii)	$E_K = ½ I\omega^2$ $I = 2 E_K / \omega^2 = 7.3 \times 10^{-3}$ kg m^2 ✓	If 2 J used for E_K, $I = 6.3 \times 10^{-3}$ kg m^2 Alternative: use of $I = T / \alpha$ Where α = 25/ans c i When T = 3×10^{-2}, $I = 7.76 \times 10^{-3}$ kg m^2 CE for ω	1	

Total			10

question	answers	extra information	mark
2			6

Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 4 and apply a 'best-fit' approach to the marking.

0 marks	Level 1 (1–2 marks)	Level 2 (3–4 marks)	Level 3 (5–6 marks)
The information conveyed by the answer is sketchy, and neither relevant or coherent. *The candidate shows inadequate understanding of the concept of moment of inertia. Formulae may be quoted from the Formulae booklet, but the candidate is unable to apply their meaning to the question.*	The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. *The candidate shows little understanding of the factors which affect energy storage in a flywheel. They may relate rotational E_K to angular speed and/or M of I, but not confidently cover aspects of mass, and distribution of mass around the axis, and may not relate their answers well to the context of the question.*	The information conveyed in the answer may be less well organized and not fully coherent. There is less use of specialist vocabulary or specialist vocabulary may be used or spelled incorrectly. The form and style of writing is less appropriate. *The candidate may not tackle all of the bullet points in the question fully, but should have a fairly good idea of the factors that affect energy storage. Candidates are likely to relate E_K to angular speed^2 and to the way the mass is distributed around the axis.*	The information conveyed by the answer is clearly organized, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. *All three bullet points will be addressed. Answers will relate E_K to the factors that give high M of I, and means by which the angular speed can be increased, with sensible suggestions concerning the mechanism and/or reducing friction.*

examples of the points made in the response

- E_K proportional to ω^2
- E_K proportional to I

Shape

- I depends on mass and distribution of mass around axis.
- $I = \Sigma mr^2$ so arrange more m at outer edge of flywheel

extra information

Also allow

- use material of higher tensile strength
- for higher speeds without bursting/to withstand rotational stresses
- use magnet of greater mass
- answers in terms of lowering electromagnetic drag

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- By using heavy rim and spokes/thin centre web
- Increase thickness (to increase *m or I*)

<u>Material</u>

- Higher density material
- Gives greater mass for given size

<u>Mechanism</u>

Increase ω by:

- changing gear ratio/reduce size of small gears/give higher ω per push
- Longer rack segment or more teeth on rack
- Reduce friction at bearings or between gears
- use lubrication or roller bearings
- small increase in ω gives large increase in E_K (because ω^2)

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- sketches which convey correct info clearly
- use of 'depends on' for 'proportional to'

Level 3: 1st 2 points plus 6 other points from shape, material and mechanism

Level 2: between 4 and 7 points

Level 1 fewer than 4 points.

Quoting formulae alone is not enough.
Ignore references to strength of spring.

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Question	Answers	Additional Comments/Guidance	Mark	ID details
3(a)	$1.01 \times 10^5 \times (1.0 \times 10^3)^{1.4} = 8.25 \times 10^4 \times V_2^{1.4}$ ✓ Leading to $V_2 = 1.16 \times 10^3$ m^3 or 1160 m^3 ✓ 3 s f ✓	1st mark: or for rearranging the equation first and correct numbers seen. The sig fig mark is an independent mark but some working must be shown.	3	
3(b)	(25 °C = 298 K) $p_1V_1/T_1 = p_2V_2/T_2$ with correct *p, V, T* substituted OR $T_2 = p_2T_1/p_1V_1$ with correct *p, V, T* substituted ✓ T_2 = (282 K) = 9.0 °C ✓ 298 - 282 or 25 - 9 = 16 K 16/9.8 = 1.6(3) km ✓	Accept use of $p_1V_1 = kT_1$ and $T_2 = p_2V_2 / k$ Answer line requires T_2 in °C but accept in K if student has changed the unit on answer line to K. Allow CE for third mark using student's T_2 but must use temperature **change**.	3	
3(c)	$Q = \Delta U + W$ (in adiabatic expansion) $Q = 0$ ✓ *W* is +ve so $W = -\Delta U$ meaning internal energy decreases OR work is done at expense of internal energy [WTTE] ✓ (internal energy related to *T*) therefore *T* falls. ✓	For 1st mark do not allow *Q* is constant/no change Ignore Δ if used with *Q* or *W* Do not accept 'thermal' energy for internal energy.	3	
Total			9	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4(a)	Diesel: air only is drawn into cylinder Petrol: air and fuel is drawn into cylinder both points ✓ Diesel: ignition is by temperature rise during compression/compression ignition Petrol: ignition by means of spark (plug) both points ✓	Accept: heating at constant volume in (ideal) petrol engine and constant pressure in (ideal) diesel engine ✓ Do not allow: petrol engine has spark plug, diesel doesn't WTTE	2	
4(b)(i)	**X** marked on curved compression line between $p = 0.7 \times 10^6$ Pa and 1.7×10^6 Pa ✓		1	
4(b)(ii)	Indicated work =area of loop ✓ Appropriate method for finding area e.g. counting squares ✓ Correct scaling fact or used to give work per cycle of between 250 and 325 (J) ✓ (Calculates no cycles per s (½ × 2000/60) = 16.7) $P = 4 \times 16.7 \times 287 = 19.2$ kW ✓	Either stated explicitly or shown on Fig 5 e.g. by shading or ticking squares or subsequent correct working. 287 small squares is a good estimate. Scaling factor is 1 J per small square Allow 10 to 13 1 cm squares Scaling factor is 25 J per 1 cm square CE for 4th mark using incorrect work per cycle	4	
4(b)(iii)	Input power = CV × fuel flow rate $= 44 \times 10^6 \times (1.1 \times 10^{-3})$ (= 48.4 kW) ✓ $\eta_{thermal} = 19.2/48.4 = 0.40$ ✓	CE from 4 b ii unless $\eta_{thermal} > 1$	2	
4(c)	Tick against second answer line ✓		1	
Total			10	