A-level
PHYSICS
(7408/3BC)

Paper 3 – Section B (Engineering Physics)

Mark scheme

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.

Further copies of this mark scheme are available from aqa.org.uk

Physics - Mark scheme instructions to examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.

2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.

2.3 Alternative answers acceptable for a mark are indicated by the use of **or**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which candidates have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of errors / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

3.2 Marking procedure for calculations

Full marks can usually be given for a correct numerical answer without working shown unless the question states 'Show your working'. However, if a correct numerical answer can be evaluated from incorrect physics then working will be required. The mark scheme will indicate both this and the credit (if any) that can be allowed for the incorrect approach.

However, if the answer is incorrect, mark(s) can usually be gained by correct substitution / working and this is shown in the 'extra information' column or by each stage of a longer calculation.

A calculation must be followed through to answer in decimal form. An answer in surd form is never acceptable for the final (evaluation) mark in a calculation and will therefore generally be denied one mark.

3.3 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.4 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are likely to be restricted to calculation questions and should be shown by the abbreviation ECF or *conseq* in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.5 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited (eg fizix) **unless** there is a possible confusion (eg defraction/refraction) with another technical term.

3.6 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.7 Ignore / Insufficient / Do not allow

'Ignore' or 'insufficient' is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

'Do **not** allow' means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.8 Significant figure penalties

An A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the **final** answer in a calculation to a specified number of significant figures (sf). This will generally be assessed to be the number of sf of the datum with the least number of sf from which the answer is determined. The mark scheme will give the range of sf that are acceptable but this will normally be the sf of the datum (or this sf -1).

3.9 Unit penalties

An A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the correct unit for the answer to a calculation. The need for a unit to be quoted will be indicated in the question by the use of 'State an appropriate SI unit for your answer ‘. Unit answers will be expected to appear in the most commonly agreed form for the calculation concerned; strings of fundamental (base) units would not. For example, 1 tesla and 1 weber/metre^2 would both be acceptable units for magnetic flux density but 1 $\mathrm{kg\ m^2\ s^{-2}\ A^{-1}}$ would not.

3.10 Level of response marking instructions.

Level of response mark schemes are broken down into three levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are two marks in each level.

Before you apply the mark scheme to a student’s answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Determining a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student’s answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level. i.e. if the response is predominantly level 2 with a small amount of level 3 material it would be placed in level 2.

The exemplar materials used during standardisation will help you to determine the appropriate level. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student’s answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner’s mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional Comments/Guidance	Mark	ID details
01.1	The (total) angular momentum (of a system) remains constant provided no external torque acts (on the system) ✓	Do not accept ‘force’ in place of ‘torque’	1	
01.2	I is the sum of the $m r^2$ products for point masses m at radius r ✓ OR $\Sigma m r^2$ with m and r defined OR I is a measure of the mass and the way the mass is distributed about an axis More of the satellite’s mass is at greater radius ✓ (Small change in r) gives large change in r^2, hence large change in I OR even though m of panels is small, much of m is at a greater radius and radius is squared ✓	Or WTTE Not m is the mass and r the radius – must refer to point or small masses or distribution of mass For 2nd mark must refer to effect of r^2.	1 1 1	
01.3	Angular momentum = 110 × 5.2 = 572 ✓ N m s **OR** kg m^2 s^{-1} ✓	accept kg m^2 rad s^{-1}	1 1	
01.4	(Use of conservation of ang momtm) 572 = 230 × ω_2 ✓ ω_2 = 572/230 = 2.49 rad s^{-1} ✓		1 1	

02.1	(Gravitational potential energy of falling mass) is converted to linear/translational ke of mass and rotational ke of wheel ✓ and internal energy in bearings/air around wheel ✓		1 1	
02.2	(Use of $mgh = ½mv^2 + ½I\omega^2 + T\theta$) $(0.200 \times 9.81 \times 1.50) = (0.5 \times 0.200 \times 2.22^2) + (0.5 \times I \times 6.73^2)$ $+ (7.5 \times 10^{-3} \times 4.55)$ E_P <u>or</u> E_K correct ✓ All E_P, E_K and *Tθ correct* ✓ Leading to $I = 2.41(3)/22.6$ ✓ ($= 0.107$ kg m^2)	$mgh = 2.94$ J $½mv^2 = 0.493$ J $T\theta = 0.0728$ J If friction torque not worked out out, give up to max 2 marks. Give full marks if friction torque worked out and stated as negligible. Gives $I = 0.108$ kg m^2	 1 1 1	
02.3	$\alpha = T/I = 7.5 \times 10^{-3} / 0.107 = 0.0701$ rad s^{-2} ✓ substitution of $\omega_2 = 0$, $\omega_1 = 6.73$ and α into $\omega_2^2 = \omega_1^2 - 2\alpha\theta$ leading to $\theta = 323$ rad ✓ **OR** $½I\omega^2 = T\theta$ $0.5 \times 0.107 \times 6.73^2 = 7.5 \times 10^{-3}\,\theta$ ✓ $\theta = 323$ rad ✓	Give CE if $I = 0.108$ kg m^2 used	1 1	

03.1	($Q = \Delta U + W$) For adiabatic $Q = 0$ ✓ $W = -\Delta U$ W is +ve, so internal energy/temperature must fall✓ **OR** negative sign shows internal energy decrease ✓ Temperature related to internal energy, so T falls✓		1 1 1	
03.2	**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** / **QoWC** Mark: 6 Criteria: All three aspects covered: An appreciation that because the input valve is open for longer, that the air consumption approximately doubled with reference to the relevant sections of Fig 4 and Fig 5. An understanding that the output power is given by the area within the diagram, with an approximate increase of 25% from fig 4 to fig 5. Furthermore, a discussion of an understanding of the link between power and torque including the assumption that QoWC: The student presents relevant information coherently, employing structure, style and sp&g to render meaning clear. The text is legible	The following statements are likely to be present: Rate of consumption of air • On fig 4 air enters from A to C, but on figure 5 from A to X • Air consumption, (hence input power,) is increased because input valve open for longer • Air consumption roughly doubled Output torque and power • Output power is increased because area of diagram is greater • Output power increased but not as much as doubled • Output power roughly increased by 25% • Average pressure greater, so torque greater • ω same as before so from P = Tω, output power greater, comparison only valid if speed same as before Overall efficiency • efficiency is output power/input power	6	

		the angular frequency does not change.		• Input power roughly doubled but output power increased only by about 25% • Hence efficiency decreased	
	5	Two of the three aspects fully covered, with some detail missing from the third.			
	4	One aspect fully covered, with some detail missing from the other two Or Two aspects fully covered, with little or no relevant information about the third.	The student presents relevant information and in a way which assists the communication of meaning. The text is legible. Sp&g are sufficiently accurate not to obscure meaning.		
	3	All three aspects partially covered, with some detail missing from each Or One aspect fully covered, with little or no relevant information about the other two			
	2	Two aspects partially covered, with little or no relevant information about the third.	The student presents some relevant information in a		

	1	One aspect partially covered, with little or no relevant information about the other two.	simple form. The text is usually legible. Sp&g allow meaning to be derived although errors are sometimes obstructive.		
	0	Little or no relevant information about any of the three aspects.	The student's presentation, spelling punctuation and grammar seriously obstruct understanding.		

03.3	Work done (per cycle) = area of indicator diagram✓ Appropriate method for finding area eg counting squares✓ Correct scaling factor leading to area = 64 J ± 5 J✓ $P = 64 \times 20 = 1280$ W✓	1 small sq = 0.1 J 641 small squares 1 large sq = 2.5 J 27 large squares Other methods accepted eg strips	1 1 1 1	
03.4	Indicated power (is developed by air in cylinder and) does not take into account frictional losses at bearings/between cylinder and piston/in opening valves✓	WTTE Answer must give some indication of where friction acts. Friction power alone is not enough.	1	

04.1	η = (1450-310)/1450 = 0.79 / 79%✓		1	
04.2	Claim 1: input power = 55.5 × 10^6 × 5.00 × 10^{-3} = 278 kW ✓ actual claimed efficiency = 210/278 = 0.76/ 76% ✓ claim not justified because actual efficiency too close to max theoretical. ✓ **OR** claim would be justified if engine ran at max efficiency (giving 218 KW electrical power) ✓ Claim 2: 278 kW – 210 kW = 68 kW ✓ Judgement: claim justified because 55 kW < 68 kW ✓ (and allows for some unwanted energy loss to surroundings) **OR** for claim2: any efficiency lower than 79% will give more than 68 kW of heating (WTTE) so claim justified✓		1 1 1 1 1	

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