AQA

A-level
Physics

7408/3BC-Paper 3 Section B – Engineering Physics
Mark scheme

June 2018

Version/Stage: 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.

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 <u>not</u> 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

Answers to questions in the practical sections (7407/2 – Section A and 7408/3A) should display an appropriate number of significant figures. For non-practical sections, 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).

An answer in surd form cannot gain the sf mark. An incorrect calculation **following some working** can gain the sf mark. For a question beginning with the command word 'Show that…', the answer should be quoted to **one more** sf than the sf quoted in the question eg 'Show that X is equal to about 2.1 cm' –

answer should be quoted to 3 sf. An answer to 1 sf will not normally be acceptable, unless the answer is an integer eg a number of objects. In non-practical sections, the need for a consideration will be indicated in the question by the use of 'Give your answer to an appropriate number of significant figures'.

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 Wb m^{-2} would both be acceptable units for magnetic flux density but 1 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/Guidelines	Mark
01.1	The (total) <u>angular</u> momentum (of a system) remains constant provided no external <u>torque</u> acts (on the system) ✓	Must see 'angular'. Condone 'is conserved' for 'is constant' Allow ang momtm before equals/is same as ang momtm after OR initial ang momtm = final ang momtm Allow $I\omega$ is constant if symbols explained Do not allow 'force' in place of 'torque'	1
01.2	Use of $I = I_{\mathrm{BODY}} + 2 \times mr^2$ ✓ $I_1 = (71 + 2 \times 5.0 \times 4.1^2) = 239\ \mathrm{kg\ m^2}$ ✓ $(\approx 240\ \mathrm{kg\ m^2})$	For 2 marks 239 must be seen	2
01.3	M of I decreases ✓ Because more mass closer to axis **OR** (for pods) $\underline{I = (\Sigma)mr^2}$ with r less ✓ $I\omega$ / angular momentum remains constant/is conserved (So as I decreases) ω must increase ✓	Condone 'inertia' for 'moment of inertia' 2nd mark is for the reason why I is decreasing. Answer must relate to pods or masses getting closer to the axis. 'radius decreasing' on its own is not enough. Accept: pods get closer to axis/body as this implies mass is getting closer. Both points needed for 3rd mark	3

Question	Answers	Additional Comments/Guidelines	Mark
01.4	(Applies conservation of angular momentum/ $I_1\omega_1 = I_2\omega_2$) $I_1\omega_1 = 240 \times 1.3 = (312\ (\text{N m s}))$ ✓ $312 = (71 + 2 \times 5.0 \times 0.74^2)\ \omega_2$ $\omega_2 = 4.08\ \text{rad s}^{-1}$ ✓ therefore max speed not reached OR arms can be retracted safely✓ **OR** $I_1\omega_1 = 240 \times 1.3 = (312\ (\text{N m s}))$ ✓ $312 = (71 + 2 \times 5.0 \times r_2^2)\ 4.2$ $r_2 = 0.57$ m ✓ so with *r* at circumference max speed not reached OR arms can be retracted safely✓ **OR** $I_1\omega_1 = 240 \times 1.3 = (312\ (\text{N m s}))$ ✓ $312 = 4.2\ I_2$ at safety limit $I_2 = 74(.3)\ \text{kg m}^2$ ✓ Actual $I_2 = 76.5\ \text{kg m}^2$ therefore max speed not reached OR arms can be retracted safely✓	Using 239 kg m^2 instead of 240 kg m^2 leads to $\omega^2 = 4.06\ \text{rad s}^{-1}$ Useful: $I_2 = 76.5\ \text{kg m}^2$ Only credit last mark if conservation of angular momentum is used. Allow a judgement based on incorrect working (eg AE) provided conservation of angular momentum is used. Using 239 kg m^2 instead of 240 kg m^2 leads to $r_2 = 0.55$ m	3

Total			9

Question	Answers	Additional Comments/Guidelines	Mark
02.1	To smooth out (fluctuations in) rotational speed ✓ **OR** to store (rotational kinetic) energy ✓ **OR** to smooth (fluctuations in) torque/power ✓	Any named form of energy must be (rotational) kinetic Do not allow an *application* (eg regenerative braking) unless one of the answers shown alongside is included.	1
02.2	Use of 0.075 sin 8º **or** 0.075 tan 8º **or** 0.075 (π − 3) to calculate h $h = 1.04 \times 10^{-2}$ (m) OR 1.05×10^{-2} (m) OR 1.06×10^{-2} (m) ✓ $mgh = 0.020 \times 9.81 \times 1.04 \times 10^{-2} = 2.04 \times 10^{-3}$ (J) ✓ $T\theta = 2.04 \times 10^{-3}$ (J) $T = 2.04 \times 10^{-3} / 3.00 = 6.80 \times 10^{-4}$ Nm ✓	1st mark for calculating h 2nd mark for calculating mgh. 3rd mark for dividing mgh by 3.00 rad. Use of tan gives $h = 1.05 \times 10^{-2}$ (m) Use of arc length gives $h = 1.06 \times 10^{-2}$ (m) 3rd mark only awarded for arriving at correct answer to more than 1 sig fig.	3
02.3	Attempt to use $0 = \omega_1^2 - 2\alpha\theta$ ✓ **or** $\theta = 573 \times 2\pi = 3600$ rad ✓ leading to $\alpha = 0.087$ (rad s^{-2}) ✓ $I = \frac{T}{\alpha} = 7.82 \times 10^{-3}$ kg m^2 ✓ **OR** Attempt to use $T\theta = ½ I (\omega_2^2 - \omega_1^2)$ ✓ **or** $\theta = 573 \times 2\pi = 3600$ rad ✓ $(I = 2T\theta/\omega_1^2)$ $= 2 \times 6.8 \times 10^{-4} \times 573 \times 2\pi/25^2$ ✓ $= 7.82 \times 10^{-3}$ kg m^2 ✓	1st mark for **either** use of equation **or** converting rotations to rad ECF for 3rd mark. The value of torque used must be a correctly calculated answer to 02.2 or 7×10^{-4} N m <u>For 2nd method</u> 1st mark for **either** use of equation **or** converting rotations to rad 2nd mark for correct substitution 3rd mark for calculating answer	3

Total			**7**

Question	Answers	Additional Comments/Guidelines	Mark
03.1	Energy is supplied to the air by heating only in process 2 → 3 ✓	Automarked	1
03.2	Claim A: Each square represents 10 J ✓ Area of loop 4→5→1→4 = 9 squares Giving increase in work done = 90 J ✓ Claim B: area enclosed by loop 1→2→3→4→1 = 55 sq /550 J ✓ (Each square represents 10 J) increase in efficiency = 9 sq/55 sq or 90 J/550 J = 16% ✓ So claim A not met, claim B efficiency better than claimed ✓ **OR** Claim B: area enclosed by loop 1 →2→3→ 4→1 = 55 sq /550 J ✓ divides 550 J and 640 J by any same value for (heat) input energy and calculates increase in efficiency ✓ draws correct conclusion for A and B for answers ✓	W done per square = $0.1 \times 10^{-3} \times 1.00 \times 10^{5} = 10$ J Allow 8 to 11 squares giving 80J to 110 J Accept answers where area 4→5→1→4 is approximated to a triangle giving 112(.5) J Allow 50 to 60 squares giving 500 to 600 J ECF from above areas if out of tolerance Allow last mark only if statements re claims agree with answers **Example** 550/1000 = 0.55 or 55%; 640/1000 =.64 or 64% Increase in efficiency = 9% Values for input energy must > 640 J	5

03.3	Q: 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 ΔU: increase/change in internal energy ✓ **OR** decrease if negative.	Do not allow 'heat' in place of 'energy' 'heat transferred' on its own is not enough Accept heat energy supplied but not heat supplied.	2
03.4	$W = p\Delta V = 1.0 \times 10^5 \times (3.00 - 1.50) \times 10^{-3}$ J (= 150 J) ✓ (Use of $Q = \Delta U + W$) gives $Q = -150 + (-374) = (-)\ 524$ J ✓	Check that sign convention is consistent for 2nd mark. Allow if − sign not seen on answer line	2
03.5	Attempt to use $pV = nRT$✓ Recognises max temperature is at point **3** in the cycle ✓ Substitution of p, V and n in $T = \frac{pV}{nR}$ for point 3 giving $T = 1310$ K ✓	2nd mark can be implied from values of p *and* V used in the equation. p from **14 .2 × 10⁵** to **14.8 × 10⁵** Pa V from **0.42 × 10⁻³** to **0.48 × 10⁻³** m³	3
Total			**13**

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td>04</td><td>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 marking this question.

<table>
<tr><th>Mark</th><th>Criteria</th><th>QoWC</th></tr>
<tr><td>6</td><td>Both bullets in question are answered. Answer includes 8 or more points taken from both lists opposite and table below including use of data. Comes to a conclusion or advice given..</td><td rowspan="2">The student presents relevant information coherently, employing structure, style and sp&g to render meaning clear. The text is legible.</td></tr>
<tr><td>5</td><td>A fair attempt to answer both bullets. Answer includes 7 points taken from both lists opposite and table below including use of data. Answers will not be as full as for 6 marks. Comes to a conclusion or advice given.</td></tr>
</table></td><td>Likely answer points:

First bullet

1. All heat engines must obey 2nd Law of thermodynamics

2. They must reject energy to a sink/surroundings (at low temperature)

3. Maximum efficiency determined by source and sink temperatures / formula quoted $\eta = T_H - T_C / T_H$

4. 100% efficiency would require $T_C = 0$ K and/or a small difference between T_H and T_C gives low efficiency

5. Allow: inefficiencies from nature of working cycle, friction, incomplete combustion etc.

Second bullet

6. 60 MW will cover electrical need (but not much margin for expansion)

7. input power = 57/0.36 = 158 MW (or 167 MW at 60 MW output)

8. max heat available for heat requirement = 101 MW (or 107 MW at 60 MW output)

9. and likely to/will be less than this</td><td>6</td></tr>
</table>

	4	Makes some attempt to use the numerical data correctly. Answer includes any 5 or 6 of the points opposite or in table below.	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.	10. this is not enough for heating requirement 11. (at least) 34 MW will need to come from National Grid. 12. power station input to give 198 MW to mill = 495 MW 13. Energy <u>that would otherwise be wasted</u> is utilised. Other answer points (other factors) for 2nd bullet are in the table below; credit sensible alternatives	
	3	Any 4 of the answer points opposite or in table below are given May not make use of numerical data.			
	2	2 or 3 answer points opposite or in table below are covered. May not make use of the numerical data.	The student presents some relevant information in a simple form. The text is usually legible. Sp&g allow meaning to be derived although errors are sometimes obstructive.		
	1	Any one pertinent statement.			
	0	No sensible statements made.	The student's presentation, spelling, punctuation and grammar seriously obstruct understanding.		

National Grid		CHP	
advantages	**disadvantages**	**advantages**	**disadvantages**
No need to build power plant in mill - capital saving.	Cost /kWh includes cost of waste heat at power station and transmission cost.	Can provide all (average) electric power and most of heating need.	Space/land needed for installation.
High probability of uninterrupted supply.	Subject to power cuts.	Independent of any National Grid supply problems.	Maintenance and depreciation costs.
		Can sell any excess electrical power to grid.	Not all heating need can be supplied by CHP.
		Gives lower overall carbon footprint	Spikes in production may require more than 60 MW