A-level
PHYSICS
7408/3BC

Paper 3 Section B Engineering physics

Mark scheme

June 2025

Version: 1.0 Final

256A7408/3BC/MS

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 Examiner.

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.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

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, ie 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	AO
01.1	Two correct substitutions with **consistent** signs✓ $\omega_1 = 0 = \omega_0 + \alpha t_1$ giving $t_1 = 0.32(3)$ (s) ✓	Mark MP1 and MP2 independently Allow their symbols. ω_1=0, ω_0 = 98 , α = -303 Allow use of $\frac{\Delta\omega}{\Delta t} = \alpha$ provided signs consistent and "0" is seen. Calculator value: 0.32343234…	2	AO2

Question	Answers	Additional comments/Guidance	Mark	AO
01.2	Two correct substitutions with **consistent** signs From t_1 to t_2 : $\omega_2^2 = \omega_1^2 + 2\alpha\theta$ OR $\omega_2 = \omega_1 + \alpha t$ AND $\theta = \omega_1 t + ½\ \alpha t^2$ OR $\theta = ½(\omega_1 + \omega_2)t$ OR Divdes **their** θ by 2π✓ Divides correct θ by 2π to get number (of rev) = 3.78 ✓	Expect to see $(-120)^2 = 2\ (-303)\theta$ $\theta = (-)23.8$ rad (or similar) with $\omega_2 = -120$, $\omega_1 = 0$ $\alpha = -303$ Condone one substitution error. All substitutions must have internally consistent signs. Condone "number of revolutions = 3" (1 sf only) on answer line if correct answer seen in working Accept 2 or more sf answers Condone final answer which has minus sign	2	AO2

Question	Answers	Additional comments/Guidance	Mark	AO
01.3	(Angular impulse = $\Delta(I\,\omega) = 9.6 \times 10^{-2} \times (-120 - 98)$) = (-) 21 (N m s) ✓	Calculator value: 20.928 Penalise rounding errors	1	AO2

Question	Answers	Additional comments/Guidance	Mark	AO
01.4	MAX 2 from ✓✓ • Calculates $r = (0.080 - 0.011 =)\ 0.069$ m • Determines T ($= Fr$) with their r and $F = 182$ or 364 N • Uses $\alpha = \frac{T}{I}$ with **their *T*** $\alpha = 249$ rad s^{-2} **AND** reversing connections provides greater deceleration than disc brake ✓	r = distance from axis to line of action of force NO POT penalty in bullet points. Do not accept a force for **their *T*** Allow 250 or answers that round to 248 or 249 Award 3 marks when correct α and correct conclusion seen Ignore minus sign	3	AO3

Total			8

Question	Answers	Additional comments/Guidance	Mark	AO
02.1	Equates E_P to $E_{Klinear}$ plus E_{Krot} ✓ Substitutes Amr^2 for I **and** $v = r\omega$ in some form to eliminate r and ω ✓ Cancels m **and** rearranges ✓	The award of each mark is contingent on the award of the previous mark. MP1: Accept words or symbols: $mgh = ½mv^2 + ½ I \omega^2$ MP2: $mgh = ½mv^2 + ½(Amr^2)\frac{v^2}{r^2}$ m cancels, r^2 cancels Condone missing $½mv^2$ in MP1 and MP2 but withhold MP2 if required answer is (incorrectly) derived. (expect to see $v = \sqrt{\frac{2gh}{A}}$)	3	1× AO1 2× AO2

Question	Answers	Additional comments/Guidance	Mark	AO
02.2	Idea that more of the mass is at greater distance from the axis (in the hollow sphere) (so moment of inertia greater) ✓	Accept idea that (for hollow sphere) mass is distributed further from axis Do not allow idea that **Q** has more mass or greater radius than **P**. Treat references to density as neutral.	1	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
02.3	Derives expression for v for any one object ✓1a Repeats for **all** other objects ✓2a (Order of descending v =) **P, R, Q, S** ✓3a OR $A = \frac{2}{5}, \frac{2}{3}, \frac{1}{2}, 1$ ✓1b Idea that the greater the value of A, the smaller the value of v ✓2b (Order of descending v =) **P, R, Q, S**✓3b	Expect to see: **P** solid sphere $v = \sqrt{\frac{10gh}{7}}$ (leading to: $v = 3.7 \times \sqrt{h}$ m s^{-1}) **Q** hollow sphere $v = \sqrt{\frac{6gh}{5}}$ (leading to: $v = 3.4 \times \sqrt{h}$ m s^{-1}) **R** solid cylinder $v = \sqrt{\frac{4gh}{3}}$ (leading to: $v = 3.6 \times \sqrt{h}$ m s^{-1}) **S** hollow cylinder $v = \sqrt{gh}$ (leading to: $v = 3.1 \times \sqrt{h}$ m s^{-1}) condone missing g and/or h in their calculations. In alternative ✓2b: allow reverse argument; condone idea that the greater value of I, the smaller the value of v. Do not accept argument based on angular acceleration or angular velocity without support in terms of v or t.	3	2× AO2 1× AO3
Total			**15**	

Question	Answers	Additional comments/Guidance	Mark	AO
03.1	A change (of state that occurs) at constant temperature ✓	Acceptable alternatives: process in which the temperature remains constant compression or expansion of a gas at constant temperature Treat reference to pressure and volume as neutral. **Do not allow** 'no change in internal energy' OR $\Delta U = 0$	1	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
03.2	Use of $n = \frac{pV}{RT}$ ✓ at **A** using $291\ \text{K}$ **OR** **B** or **C** using $536\ \text{K}$ giving $n = 4.97 \times 10^{-2}$ (mol) ✓	'Use of' is by substitution; condone value of R not substituted. Correct answer gains both marks. Allow either T in MP1 for any correct pair of pV values. Accept 4.96, 0.050 but not 0.05	2	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
03.3	$W = p\Delta V$ $= (-)101$ J ✓	For mark to be awarded, correct equation or correct substitution must be seen. E.g. accept $[1.00 \times] 10^5 \times (2.21 - 1.20) \times 10^{-3} = 100$ J Or $W = p\Delta V = (-)101$ J Ignore sign	1	AO1

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>03.4</td>
<td>Any row correct ✓ up to Max 3</td>
<td>
<table>
<tr><th></th><th>Q / J</th><th>W / J</th><th>ΔU / J</th></tr>
<tr><td>Process A → B</td><td>0</td><td>−253</td><td>253</td></tr>
<tr><td>Process B → C</td><td>473</td><td>473</td><td>0</td></tr>
<tr><td>Process C → A</td><td>−354</td><td>−101</td><td>−253</td></tr>
<tr><td>Whole cycle</td><td>119</td><td>119</td><td>0</td></tr>
</table>
Give ECF in C → A if their answer to 03.3 OR 100 (J) used for W.

If no sign take as +ve.

If no marks for rows look for any column in which whole cycle figure is consistent with process figures and award 1 Max.
</td>
<td>3</td>
<td>1× AO1
1× AO2
1× AO3</td>
</tr>
</table>

Question	Answers	Additional comments/Guidance	Mark	AO
03.5	Links criterion 1 to process **B → C** AND Links criterion 2 to process **C → A**✓ Criterion 1 met AND Criterion 2 not met ✓	Penalise incorrect physics. E.g. getting adiabatic and isothermal processes the wrong way round.	2	1× AO1 1× AO3

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr>
<td>03.6</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 in marking this question.
<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>6</td><td>All three areas (as grouped alongside) covered in some detail.
6 marks can be awarded even if there is an error and/or parts of one aspect missing, provided points 1 and 3 are included.</td></tr>
<tr><td>5</td><td>All three areas covered, at least two in detail.
Whilst there will be gaps, there should only be an occasional error.</td></tr>
<tr><td>4</td><td>Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be several gaps, there should only be an occasional error.</td></tr>
<tr><td>3</td><td>One area discussed and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.</td></tr>
<tr><td>2</td><td>Only one area discussed, or makes a partial attempt at two areas.</td></tr>
<tr><td>1</td><td>None of the three areas covered without significant error.</td></tr>
</table>
</td>
<td>
In each area, a partial answer is given for 1 statement and a full answer for more than half the statements.
Area 1 (1st two bullets in question)
1. max theoretical efficiency = $(536 - 291)/536 = 0.46$ or 46%
2. overall efficiency = $119/473 = 0.25$ or 25%
3. identifies that their theoretical efficiency is greater than their overall efficiency. Do not accept idea that max theoretical efficiency is 100%

Area 2 (3rd bullet)
4. AB / adiabatic stroke would have to be very fast to ensure no time for heat transfer
5. BC / isothermal stroke would have to be very slow to ensure constant temperature
6. very difficult to arrange a slow ‘stroke’ and a fast ‘stroke’ in one engine OR output speed would vary over a cycle
7. difficulty in arranging for end of expansion and start of compression to occur at one point OR idea of need for induction/exhaust/pumping strokes
8. engine valves take time/energy to open and close OR incomplete fuel combustion

Area 3 (4th bullet)
NO because:
9. idea that very low net work per cycle OR area of the loop is small
10. real efficiency will be much lower than their overall efficiency (and much lower than engines currently available) (due to friction etc.)
11. low speed or cycle s^{-1} hence low power
12. because power = cycle s^{-1} × work done per cycle
</td>
<td>6</td>
<td>1× AO1
2× AO2
3× AO3</td>
</tr>
</table>

	0 No relevant comments	Accept ideas shown by sketches.		

Total			**15**

Question	Answers	Additional comments/Guidance	Mark	AO
04.1	Idea of the ratio $\frac{\text{energy delivered to hot space}}{\text{work input}}$ ✓	Direction of energy transfer is needed. Do not accept $\frac{Q_H}{W}$ on without the terms defined, or answers in terms of temperatures only. Treat mention of efficiency as neutral.	1	AO1

Question	Answers	Additional comments/Guidance	Mark	AO
04.2	Refers to / uses $COP_{hp} = \frac{T_H}{(T_H - T_C)}$ OR states that COP_{hp} depends on/inversely proportional to temperature difference ✓1 1st bullet: EITHER shows COP_{hp} varies from 11.2 to 6.5 AND idea that statement is **correct** OR states that COP_{hp} will vary greatly because temperature varies greatly AND idea that statement is **correct** ✓2 2nd bullet: (T_H is constant and) idea that the lower T_C is, the lower the COP_{hp} So more (electrical) energy needed AND idea that statement is **incorrect** ✓3	If no other mark given: award **MAX 1** for idea that first statement correct AND second statement incorrect. Allow a.e. in one calculation of COP_{hp} but no ecf for conclusion. An a.e. does **not** include failure to convert the T_H on the top of the fraction to kelvin. For ✓3 : allow reverse argument accept idea that for lower T_C more work needed (per second) to raise water temp to 40 °C, so greater energy cost.	3	1× AO1 2× AO3

Question	Answers	Additional comments/Guidance	Mark	AO
04.3	Tick in second box only ✓ 384 kW h		1	AO2
Total			**5**	