A-LEVEL
Physics
7408/3BC

PAPER 3 SECTION B – Engineering physics

Mark scheme

June 2017

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.

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 weber/metre^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.

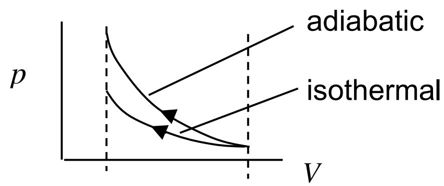
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme

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

Question	Answer	Additional Comments/Guidance	Mark
01.1	**Translational dynamics** / **Rotational dynamics** force / torque ✓ mass / moment of inertia ✓	Do not allow 'inertia'	2
01.2	$I_T = 2.6 \times 10^7 + (2.2 \times 10^3 \times 35^2)$ $= 2.9 \times 10^7$ (kg m^2) ✓	Mark only awarded for arriving at correct answer to more than 1 sf.	1
01.3	Use of (total) area under graph = (angular) displacement/distance ✓ $\omega_{max}((½ \times 30) + 20 + (½ \times 45)) = 4.7$ $\omega_{max} = 0.082$ (rad s^{-1}) ✓	Alternative route is area of trapezium $½\ \omega_{max}\ (20 + 95) = 4.7$	2
01.4	moment of inertia of rotating jib + load increases as trolley moves outwards ✓ reference to $T = I\alpha$ with T constant, so α decreases ✓ decreased α means longer time to stop(than 95 s) ✓		3
Total			**8**

Question	Answer	Additional Comments/Guidance	Mark
02.1	$T = 6.0 \times 0.036 = 0.22$ (N m) ✓		1
02.2	power cannot increase ✓ $P = T\omega$ so if ω is 4 x greater, T cannot be more than 1/4✓ **OR** Work done by (torque) on C cannot be greater than work done (by torque) on B ✓ $W = T\theta$, if θ is 4 x greater, T cannot be more than 1/4✓ *Or* $T_C \times 4\theta_B = T_B\theta_B$ so $T_C = T_B/4$ **OR** Force same on both/force cannot increase/ r_C is ¼ r_B ✓ $F \times r_C = F \times r_B/4$ so $T_C = T_B/4$ Or Because radius is ¼, torque on C must be ¼ ✓	Accept other valid argument e.g using knowledge that radius of C is 1/4 radius of B, or velocity *v* at point of mesh of gears is the same for both. Do not allow 'it is not possible' (WTTE) unless backed up by valid argument.	2
02.3	$\alpha = 76/2.1 = 36$ (rad s^{-1}) (36.2 rad s^{-1}) ✓ $I = T/\alpha = \frac{0.054}{36} = 1.5 \times 10^{-3}$ (kg m^2) ✓	ECF for 2nd mark for AE or transposing error.	2
02.4	angular impulse = ang. momentum change = $T\Delta t$ ✓ Reference to (large) $\Delta(I\omega)$ in small Δt gives large T✓ ($T = F \times r$) so large F on gear teeth. ✓	1st mark for statement defining angular impulse 2nd for relating momentum change in small t to high T 3rd for relating high T to high force	3

Total			**8**

Question	Answer	Additional Comments/Guidance	Mark
03.1	$p_1 V_1^{1.4} = p_2 V_2^{1.4}$ $p_2 = p_1 (V_1/V_2)^{1.4}$ $= 1.2\times 10^6 (9.0/6.8)^{1.4}$ ✓ $= 1.8 \times 10^6$ (Pa) ✓ $T_2 = \frac{p_2 V_2 T_1}{p_1 V_1} = \frac{1.8 \times 10^6 \times (6.8\times 10^{-5}) \times 290}{1.2 \times 10^6 \times (9.0 \times 10^{-5})}$ ✓ $T_2 = 328$ (K) ✓ **OR** use of $p_1 V_1 = nRT_1$ to find n or nR ✓ and substitute in $p_2 V_2 = nRT_2$ to find T_2 ✓	1st mark for substituting correct values into either equation 2nd mark for answer p_2 3rd mark for substituting correct values into $p_1 V_1/T_1 = p_2 V_2/T_2$ or $T_2 = \frac{p_2\ V_2\ T_1}{p_1\ V_1}$ 4th mark for answer T_2 ECF for p_2 With rounding answers range from 320 to 330 K	4
03.2	in adiabatic compression there is no heat transfer/$Q = 0$ ✓ If compression is quick there is no time for heat transfer ✓ (so can be considered adiabatic)		2
03.3	For isothermal compression (for same volume change) (final) pressure not as high **OR** adiabatic compression curve is steeper (on p - V diagram) than isothermal ✓ Area under a p-V curve between same volumes would be less **OR** addition of all $p\Delta V$ during compression will be less ✓ So less work done ✓	Give credit for these ideas shown with help of a diagram or diagrams.  Award last mark only if either or both of first two marks have been given.	3

Total			**9**

<table>
<tr>
<td rowspan="2">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 in marking this question.</td>
<td rowspan="2">The following statements are likely to be present.
First bullet: differences between cycles
• Real engine needs induction and exhaust strokes/ pumping loop
• Ideal cycle needs no pumping loop/same air used repeatedly

• Corners rounded on real cycle
• Reason: valves take finite time to open and close/combustion not instantaneous

• Heating/cooling cannot occur at constant volume in real cycle
• Reason: piston would have to stop

• In real cycle expansion & compression are not adiabatic
• Reason: heat transfer takes place to cooling medium during these strokes

• In ideal cycle air only is taken through cycle (repeatedly)/gas is ideal
• In real engine some exhaust gas/fuel vapour is present/gas is not ideal

• Max pressure is lower in real engine
• Fuel may not be completely burnt

• Ideal cycle makes no reference to any mechanism
• In real engine a mechanism is necessary e.g. for</td>
<td rowspan="2">6</td>
</tr>
<tr>
<td>

Mark	Criteria	QoWC
6	Both bullets in question are answered. Answer includes 9 or more points taken from both lists opposite with reasons mainly matching differences Allow for answers which state the events in both cycles, provided points alongside are covered and some reasons given for differences.	The student presents relevant information coherently, employing structure, style and SP&G to render meaning clear. The text is legible.
5	A fair attempt to answer both bullets. Answer includes 7or 8 points taken from both lists, including at least two matching reasons for differences. Answers will not be as full as for 6 marks.	
4	Comparisons are less complete but good understanding is shown of the differences between the diagrams. Answer includes 5 or 6 of the points opposite with at least one taken from each part.	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	The student will address 4 or 5 of the points listed but reasons may not be given with confidence or reasons may not match the differences	

</td>
</tr>
</table>

2	Fewer than 4 points are covered. The student is more likely to state the differences rather than explain them. The answer addresses one or both bullets in the question but with limited scope. They are likely to refer to 'heat losses' or 'friction' without detail.	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	Some attempt is made to compare the cycles.	
0	No relevant analysis.	The student's presentation, SP&G seriously obstruct understanding.

valve operation, generation of spark

Second bullet: why work output less

- Area of loop is smaller for real engine, so less work done per cycle
- Area of pumping loop has to be subtracted from main loop, reducing work done
- Friction between moving surfaces/between piston & cylinder/in bearings has to be overcome
- energy is expended in driving oil and water pumps, opening and closing valves overcoming fluid viscosity etc

Accept other reasonable answers in lieu. (eg variation in γ during expansion and compression)

Question	Answer	Additional Comments/Guidance	Mark
05.1	Tick against answer **B** ✓	Auto marked	1
05.2	COPref $= \frac{272}{343-272}$ (= 3.8 (3.83)) ✓ 3.8 = $Q_C/(100 - Q_C)$ giving Q_C = 79 (W) (79.3W) ✓ P_{IN} = 79/3.8 = 21 (W) (20.7 W) ✓ **OR** for 2nd and 3rd marks COPref = Q_C/W and $Q_C + W = Q_H$ = 100 ✓ 3.8 W + W =*100* So W = 21 (W) ✓ **OR** for 2nd and 3rd marks COPhp = COPref + 1 ✓ W = Q_H/4.8= 100/4.8 = 21 (W) ✓		3
Total			**4**