A-LEVEL
PHYSICS

7408/3BC Engineering Physics
Report on the Examination

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General comments

There was evidence to show that some students were well-prepared for the examination and gave many answers with a good degree of confidence; some may not have been able to do this across the whole of the specification, however. On the other hand there were many students who had barely covered the specification and did not attempt some questions, or who made a stab in the dark at others.

Students did better on the rotational dynamics questions (Q1 and Q2) than the thermodynamics questions (Q3 and Q4). The concept of the reversed heat engine (Q4) is still not well understood. As in previous years, calculations were answered with more confidence than the questions which required qualitative answers. This is borne out by relatively high mean marks for questions 01.1 to 01.4, 02.1, and 03.2.

Questions targeted at Assessment Objective 3 require students to analyse or evaluate information or ideas and make judgements. Questions 02.2 and 4 were questions that only addressed this AO, and students found them difficult.

Examiners were frustrated by handwriting that was very difficult to read. Students were also let down by ideas that were badly expressed. Examiners mark exactly what they see – they cannot give credit for what they think the student *meant* to say.

Question 01.1

About two-thirds of students scored the first mark for an attempt to find the angular displacement of the rotor. Many of these were unable to do this accurately enough for the second mark. Some added the areas without taking the negative angular velocity into account. A very small number of students tried to answer by averaging ordinates from the graph or by counting squares, but were unsuccessful.

Question 01.2

This was answered well with about 80% of students gaining the mark.

Question 01.3

The question required a calculation of maximum angular acceleration from the graph in **Figure 2**, a determination of the torque to give this acceleration, and then a final addition of the friction torque. Common errors were using the 7 s to 12 s part of the graph, and omitting the friction torque altogether.

Question 01.4

About 60% achieved the one mark for this question. This is not surprising as the equation is in the Data and Formulae booklet. Two routes could be used:

- using *torque* × *time* but only with the correct torque i.e. before friction torque is added. A minority used the friction torque alone here.
- using $I \times \Delta\omega$. $\Delta\omega$ was invariably calculated correctly.

Question 01.5

Approximately 70% of students were able to select the graph showing the correct variation of torque with time for the rotor.

Question 02.1

Question 2 was a mini-comprehension exercise with the context of the question (a flywheel-powered tram) and numerical data given at the outset. Many were able to score the first mark for a valid attempt at mgh or Fs or both. To score the second mark, students needed to show the correct calculation for $mgh + Fs$.

Common errors were:

- missing 'g'
- missing the Fs component of the work done
- missing the mgh component of the work done
- missing the distance of $500\ \mathrm{m}$ altogether.

The third mark was awarded with error carried forward for using *their* work done (however calculated) and using $E_K = \frac{1}{2}I\omega^2$ to calculate the angular velocity of the flywheel. By this means it was not difficult to score two out of the three marks. Two-thirds of students were able to score one or more marks, with about one quarter scoring full marks.

Question 02.2

The two marks for this question were aimed at Assessment Objective 3 and required a good understanding of the context of the question i.e. the flywheel-powered tram travelling downhill.

There were some good answers which showed that students understood the principle of regenerative braking and the idea of saving energy with the flywheel connected for the downhill journey. A high proportion of answers, however, did not go far enough.

They

- simply stated that the flywheel gets charged up or stores energy, whereas the mark scheme required some mention of later use of this energy, or less energy needed at the next stop
- stated that the tram would slow down or not travel so fast, but without referring to energy changes or saving on braking.

Many answers referred to the flywheel smoothing the motion of the tram down the track. They remembered that flywheels smooth rotational motion, and thought it applied here. No credit was given.

Around 40% of students scored 1 mark, but only 10% scored both marks.

Question 02.3

This levels of response question had a six-mark allocation. About half the students scored 3 or more, but only a small minority were able to give the detail needed to reach the third response level. Students seem to have a good awareness of how moment of inertia depends on the distribution of mass about the axis, and suggested spokes or a thin inner disc (of low density material) and a heavy rim (of high density) to achieve this. Despite being told the mass of the tram should not increase, many suggested increasing the mass of the flywheel. Some enhanced their answers with explanatory sketches.

Many answers were strong on one or two of the three areas. It was pleasing to see references to centripetal force, breaking stress, means of reducing friction at the bearings, and means of reducing air resistance. Many students gave examples of suitable materials.

Misconceptions were that:

- reducing the moment of inertia of the flywheel would increase energy stored because it would accelerate more quickly to obtain a higher speed
- angular momentum is conserved, so reducing I would increase ω and hence energy stored.

Some students wrote "*inertia*" for "moment of inertia", and many used vague terms like “*heavier*”, ”*durable*”, “*robust*” or “*sturdy*” when referring to material properties. A command of appropriate terminology is expected at A-level.

Question 03.1

The question required a definition of an adiabatic change. The examiners required the question to discriminate between those who had a *sound* thermodynamic understanding and those who knew *something* about an adiabatic change. It required the three elements of

- heat or energy transfer
- to or from
- a gas, or substance or system

Common answers which failed to score were those that

- quoted the first law of thermodynamics applied to an adiabatic change, often without explaining the symbols
- only referred to energy transfer to, and not from, the system (or vice versa)
- referred only to the equation for an adiabatic change $pV^{\gamma} = c$

There were other answers that showed very little or no understanding, including those that confused an adiabatic change with an isothermal one.

Question 03.2

It was pleasing to see many confident answers, with students showing the steps in their calculations. In fact, more students were able to deal with the maths involved here than were able to calculate areas of triangles in question 01.1. About three-quarters of students showed a correct substitution of data into $p_1V_1{}^{\gamma} = p_2V_2{}^{\gamma}$. Some of these were then let down by not knowing either how to deal with the maths or how to use their calculator. A few used $(pV)^{\gamma} = c$ or $pV = c$.

Question 03.3

This required knowledge of how compression ratio influences the ignition of fuel in diesel and petrol engines. There were some very good answers but they were rare, with only about 10% of students scoring both marks. It was not enough to simply refer to a spark in the petrol engine, and high pressure in the diesel engine. The high compression ratio in a diesel engine results in a *temperature* that is high enough for the fuel to self-ignite. A high pressure was not enough to score the mark and neither were the terms high thermal energy or high heat. For the petrol engine, the spark needed to be related to a lower temperature, though we allowed lower pressure here instead.

Question 03.4

It is surprising that one in seven students made no attempt to draw any form of indicator diagram. Only about half of the students scored any marks at all. Judging from students' answers, many seemed unused to drawing indicator diagrams.
Errors seen were:

- drawing a loop that was larger than and/or outside the ideal cycle
- drawing induction/exhaust lines that were too far apart or of unequal length
- showing induction/exhaust line(s) that went right up to the pressure axis, or were too short
- missing out the induction/exhaust line(s) altogether
- taking the maximum pressure far above the ideal cycle.

Question 03.5

Students were asked to place an **X** on the indicator diagram at the point of fuel injection. Only about one student in eight was able to do this correctly. Many students placed their **X** at the start or end of the induction or exhaust stroke. Others placed it at the very end of the compression stroke. This would mean that the piston would be on its way down the cylinder by the time combustion had taken hold, leading to loss of power.

Question 03.6

The question involved a topic firmly on the specification, which asks for a comparison of indicator diagrams with theoretical cycles. Students did not find it difficult to describe two differences between a diesel-engine indicator diagram and the theoretical diesel cycle. Many, however, failed to give reasons. Some described the differences but gave the wrong reasons for the differences. A very common misunderstanding was to think that friction accounted for a difference in the area enclosed by the loops in the diagrams, not realising that an indicator diagram is taken *before* frictional losses are accounted for. A little over half the students scored no marks on this question.

Question 04.1

This question (and 04.2) was aimed at Assessment Objective 3, where students had to analyse and evaluate the application of a thermoelectric cooling element in a small refrigerator.
The majority of students struggled with the concepts required, especially as they were given both temperatures and powers. The COP_{ref} euqation is in the Data and Formulae booklet, but not the equation in terms of temperature.
Common errors were:

- thinking $Q_C = 65\ \text{W}$
- not converting temperatures to kelvin.

On the other hand, about 20% of students gave confident answers, with all steps in the calculations of the two COPs clearly stated. Those who were able to calculate the COPs correctly went on to score the last mark for their statement about the validity of the claim. In previous years, students often gave very terse concluding answers to questions where they had to make a deduction or a judgement about a claim, but that was not the case this year.

Question 04.2

Students scored one mark when they were able to give any advantage of the use of the thermoelectric cooling element for the refrigerator described. About half the students were successful in this. The second mark required an appreciation of the trade-off between the low COP (with its consequent increase of input power per Q_C) and the convenience or use of the solid state refrigerator. There were some good answers, but they were rare.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.