**1995 HIGHER SCHOOL CERTIFICATE EXAMINATION**

# ENGINEERING SCIENCE

## 2 UNIT AND 3 UNIT

In 1995 1777 candidates presented for the examination in Engineering Science. Of these 1458 presented for the 2 Unit Common paper and 319 for 3 Unit.

In the 2/3 Unit paper, all questions were compulsory. Candidates apportioned their time well, with most attempting all questions. Although the majority of students set their work out clearly, some still failed to show working or to sketch solutions accurately. Such students would be better advised to show clearly all substitutions in formulae and to use the time to draw lines accurately. They should also be acquainted with current drawing standards in graphics.

In the 3 Unit paper, students coped well with the new format.

## SECTION I

### Question 1

(a) Many students scored well. Some difficulty was, however, encountered not only in finding the direction of the reaction, but also in basic trigonometry. Graphical solutions were attempted by the minority who used the simplest method.

(b) This part was generally well done, particularly parts (i) and (ii). Common errors occurred in the conversion of $g$ to $kg$ and the use of *Change in KE* $= \frac{1}{2}mv^2$ rather than $\frac{1}{2}m(v^2 - u^2)$. Those who used work/energy relationships tended to be more successful than those using kinetics.

(c) This was poorly answered by the majority of candidates. Those who understood the concept of relative velocity solved the problem easily. The most common error was direct substitution into $v^2 = u^2 + 2as$ by using a variety of values. Other candidates attempted, with little success, to set up simultaneous equations.

**Question 2**

This was a good question which tested candidates at all levels.

(a) (i) This part was poorly answered, due mainly to the fact that the majority of candidates combined displacement and velocity on the one vector diagram.

(ii) Due to very poor concepts of $v = \frac{s}{t}$, very few achieved complete success.

(b) (i) Many candidates attempted to determine this by method of sections instead of by method of joints. A poor understanding of moments was apparent.

(ii) Method of sections was used and this part was generally well answered.

(iii) This was poorly answered since reactive force senses were poorly understood.

**Question 3**

This question covered a wide range of topics from the Materials section of the Syllabus. Unfortunately, although great depth of knowledge in each area did not seem to be required, attempts to answer the question were generally poor, indicating that the ceramics and polymers components of the Syllabus need to be treated in greater depth.

**Question 4**

(a) (i) Many candidates were unable to interpret the composition scale correctly, therefore reversing the composition of the microstructures. Quite a few candidates had difficulty in interpreting the solvus phase change, while microstructures were generally poorly drawn.

(ii) Clear arrestment points were not generally shown.

(b) (i) This part was, on the whole, well answered, although students often incorrectly used 2% carbon as the composition of $Fe_3C$. (6.67% C).

(ii) A number of candidates incorrectly assumed that pearlite was a single phase structure.

(iii) Many candidates found this section difficult, with very few giving *preferred recrystallisation with alignment of non-metallic inclusions* as the most acceptable answer. Microstructures were generally poorly drawn.

**Question 5**

(a) Failure to visualise the rod end resulted in a pre-conceived curve being drawn higher up on the rod. Some assumed that the rod end was at 45$^{o}$ to the P.V.P. Many candidates failed to understand the significance of points of intersection between the section planes and the completed Top View. While concentric cutting planes were shown by many, very few extended the radius curve in the front view. Linework and point plotting were poor.

(b) Many candidates failed to recognise the initial projection of the solid. Failure to join **a,e** and **d,e** in the Top View excluded the location of two cutting points and visibility of slant edges. Completed Top Views were good but, in many, students used hidden detail lines to indicate the sectional shape. Hatching of the sectional shape was either omitted or poorly drawn; when lettering was shown it was often incorrect.

**Question 6**

Both parts of Question 6 were generally well answered, with candidates displaying a good knowledge of related concepts and drawing standards.

(a) The majority of candidates were able to determine virtually all true lengths, but many failed to realise that **ae** was a curve. When only one intermediate point was used between **a** and **c**, inaccuracy resulted; this was compounded when straight lines were used to join the points rather than a smooth curve. A number of candidates failed to apply to the development the true lengths they found.

(b) Many misinterpreted the drawing as including a curved line of intersection. There was also obvious misconception about the visibility of the two points on long edge **b**. Some candidates attempted to locate points of intersection by complex methods which led to gross inaccuracies.

**<u>SECTION II</u>**

**Question 7**

(a) (i) On the whole this was well answered. Many candidates did not identify the slashing cutting action first used in the Victa 2-stroke mower but, instead, described the blade.

(ii) Most answers here generally described the push mower. Very few students identified the cutting action as being a shearing cut of the moving blades against a fixed blade.

(b) (i) Many students incorrectly suggested cast iron as being a suitable material. The majority, however, could describe a suitable manufacturing process that was appropriate, e.g. pressing, spinning, die-casting. Few used correct terminology.

(ii) Most students answered this correctly. The greatest source of difficulty lay in answering in terms of the *material* rather than the *shape*.

(c) (i) A significant number incorrectly answered by referring to a much longer timespan than the last 50 years, e.g. the development of rubber for pneumatic tyres; the rest, however, answered well.

(ii) *Reduction in weight* was a very common response. The majority of students understood the importance of relating part (ii) to part (i).

(iii) Many reasons given related to the frame materials rather than to manufacturing processes, and this part was poorly answered.

(iv) The majority of students explained developments in tubing, brazing and triangulated framing.

(v) The main social factors influencing the use of bicycles over the past fifty years included reliable transport, recreation and health. Responses were good.

**Question 8**

(a) (i) Most students indicated all three forces acting on the lawnmower.

(ii) The majority of candidates used moments to calculate the reaction.

(iii) Although the stress equation was used correctly, most students had difficulty with the units.

(iv) Students frequently read too much into this question, which was essentially a friction problem.

(b) (i) The maximum load was often incorrectly used instead of the elastic limit. Units created confusion, particularly in the conversion from $mm^2$ to $m^2$.

(ii) Many students failed to substitute the correct values for force and area and, consequently, failed to find the UTS.

(c) The correct value of 92.22N was easily calculated by using $P = Fv$. Many used $P = \frac{Fs}{t}$ and failed to see the relationship between $\frac{s}{t}$ and $v$.2

**Question 9**

(a) This part was generally well answered. Most students followed the progression through the problem; a number, however, had difficulty with velocity ratio in part (iv).

(b) (i) Conversion of *km/h* to *m/s* was poorly done. Some students confused *initial* with *final* velocity.

(ii) Responses here were good and the calculation to find the acceleration of $-1.39\ \text{m/s}^2$ was well done.

(iii) The change in kinetic energy was not always equated with work done. Some students used the concept of average velocity with $P = Fv$ to obtain the correct solution.

**Question 10**

(a) Many candidates confused the 1.0% normalised structure and the 0.1% annealed steel and, therefore, failed to answer the question. Phases and structures for all materials were not well understood.

(b) A number of students did not know that graphite flakes reduce the tensile strength of grey cast iron.

(c) Most students related the mechanical properties of the disc instead of the calliper. Many did not know the properties of spheroidal graphite cast iron.

(d) The question was often misread and, consequently, many students failed to describe recrystallisation. The drawing should have shown an equi-axed single-phase structure.

(e) Students were generally unaware of how a high tensile spring was manufactured. They did not understand the purpose of normalising or the resulting mechanical properties.

## Question 11

(a) (i) The majority of students named a suitable test but found it difficult to describe it.

(ii) Freehand sketches were poor. Grainflow was not well shown, especially in the exit of the flow lines from the upset region.

(b) (i) Many students wrote *light* which was not a mechanical property. Strength should be qualified, i.e. tensile, shear, etc.

(ii) This was generally well answered, although some students incorrectly stated *chemical resistance*.

(iii) Although students completed this question well, they would be advised to confine their description to distinct steps in the process.

(c) (i) The process of rotary tube piercing was poorly described. It was confused with extrusion and was frequently described as being continuous butt welded/electrical resistance welded tubemaking. Some students produced acceptable sketches instead of a description.

(ii) This part was well answered, although some candidates incorrectly referred to phases present in the structure rather than two mechanical properties.

(iii) In addition to the obvious answers of brazing and welding, students also stated *adhesives*. Most could name only one method successfully.

## Question 12

The majority of students attempted this question, providing a broad range of responses. The interpretation of the shape and size details in the front view was good, most students showing the correct relationship between the front view and the right side view. The scale that was given was correctly interpreted and used.

The projection required to produce the low limit point on the curves resulting from the hole in the head was not given by a large number of students.

Attention still needs to be given to knowledge and correct use of the AS1100 standards, particularly in regard to the following areas:

cylindrical breaks
thread details, especially when seen as circles
dimensioning techniques, and
the use of thin black and thick black lines.

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### 3 UNIT

### SECTION I

### Question 1

(a) (i) and (ii) A number of students failed to recognise the zero shear force and bending moment at the free end of the cantilever. Others did not realise that the reactions that were given determined the magnitude of the shear force and bending moment at the wall. Many attempted to make the part of the beam entering the wall part of the SF and BM diagrams. Cross-hatching SF and BM diagrams is not necessary; these diagrams should be plotted accurately to scale.

(iii) Many students failed to realise that the required bending moment was given earlier in the question. Some were confused by the requirement to calculate the bending stress on the inner surface of the pipe; a number, however, completed the required calculation successfully.

(b) (i) Most students failed to appreciate the connection between the torque provided by frictional resistance between the rollers and the acceleration/deceleration of the rollers. The majority of those who completed the question were able to change and manipulate the units correctly. It should have been understood that, as one roller increased rotation, the other slowed and the accelerations had opposite sense.

(ii) A number of students failed to recognise that this was a simple exercise in conservation of angular momentum, or else that time during slipping could be calculated and *w* determined from such time. Some students recognised this solution path but had difficulty in calculating a reliable time. By the equations used, some had little understanding of the difference between radial and rotational acceleration. Many candidates left parts (b)(i) and/or (ii) unanswered.

### Question 2

(a) (i) This was a well answered question, although some candidates answered in terms of the FCC unit cell rather than the BCC unit cell.

(ii) Candidates were able to find intercepts correctly but failed to take reciprocals and then convert to whole numbers. Confusion with identification of x, y and z axes also occurred.

(iii) Many students failed to understand the term *lattice parameter*. Candidates were able to determine diagonal distance but did not understand the application of Pythagoras' theorem or sine rule. Others used the atomic diameter instead of the atomic radius in their calculations.

(iv) Candidates had difficulty in answering this part. The majority had some understanding of substitutional and interstitial solid solutions but had difficulty in explaining them in terms of radius ratio.

(b) (i) Some candidates were able to position *ions* correctly on the top of the cube but became confused when positioning *ions* on the sides.

(ii) Many recognised that ionic bonding occurred but failed to explain the brittleness of NaCl in terms of a lack of slip planes due to the primitive cubic structure.

(c) (i) Those who were able to recognise age hardening scored well. Most indicated the basic steps of *heat* - *soak* - *quench*. Some failed to explain the process of solution treatment and ageing, while many gave answers associated with the heat treatment of steel, viz martempering, tempering.

(ii) The microstructure was poorly drawn. Failure to recognise $CuAl_2$ precipitation was common.

(d) (i) This part was generally well answered.

(ii) Most candidates showed sound understanding of the inverse lever rule.

(iii) Answers here were very poor and few candidates obtained full marks. Many could not represent a Widmanstatten structure.

(iv) Most candidates identified a martensitic structure in this well answered section.

## SECTION II

### Question 3

(a) Most answers here were poor since few students could analyse the forces involved.

(b) For each block the free-body diagram provided two equations, involving T, which needed to be solved to find the angular velocity.

(c) Most students were unable to answer this question. For no sliding to occur at any angular velocity the centripetal forces need to be equated to determine that the mass of block A would have to be 12 kg.

**Question 4**

(a) This part was generally well answered, with most candidates successfully selecting and using the correct equation.

(b) The majority of students showed little or no understanding of the relationship between Strain Energy, Kinetic Energy and Potential Energy and consequently this part was poorly answered.

**Question 5**

(a) (i) Answers here were poor since most students appeared to have little experience with half-cell reactions and did not understand the effects of increases in electrolyte concentration. Many who correctly answered *decrease* then restated *electrode potential will decrease* as a justification.

(ii) Answers to this part were poor. Candidates did not recognise that cadmium was the anode and failed to select the correct equation from the table.

(iii) This was well answered, although some simple calculation errors occurred.

(iv) Most candidates knew about the sacrificial anode and the question was well answered.

(v) Few candidates were aware of dezincification, i.e. the leaching of zinc from brass in salt water conditions (preferential corrosion of zinc leaving soft copper which gives a reddish colour).

(b) This was well answered, although some students confused the various case hardening processes and were unable to provide adequate descriptions.

**Question 6**

(a) Although many candidates seemed to have the fundamental knowledge about transformation and heat treatment, a number failed to grasp the significance of *austenite* in the process.

(b) (i) This part was well answered.

(ii) Some disappointing sketches of pearlite were submitted.

(iii) There was much confusion as to how to achieve tempered martensite in sample *B* or even what constitutes tempered martensite. Generally, sketches of the microstructure were poor but those who understood the tempering process produced good sketches. Responses, however, were generally disappointing.

(c) The concept of glass toughening was understood but candidates had difficulty in explaining how the compression in the surface affected bending strength.

(d) Many candidates confused the processes of tempering and annealing when discussing the heat treatment of both copper in electrical copper and glass in glass bottles.

## SECTION III

### Question 7

(a) The concept of finding true lengths by rotation was not well understood and many students were unable to project the top view of **ab**.

(b) Students failed to project the true length line **ab** as a *point of view* to obtain the true included angle. Many were able to draw the true shape because they found the individual true lengths by rotation.

### Question 8

This question was generally very well answered.

### Question 9

The majority of students successfully completed this question. Some incorrectly assumed that the faces of the rod end were 45° to the VP and failed to find the points of tangency accurately. Students should realise that, when a surface is tangential to a cylinder, the fillet curve produced has a pointed profile.

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### Question 10

This question was solved by most students who used horizontal section planes. The limit points were found successfully. Some found the true length **ab** but were unable to apply this to find the angle between **ab** and **ac**. They could have used an auxiliary view which would have made it easier to visualise the required angle.