2000 HSC Notes from the Examination Centre Engineering Science

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Engineering Science

Introduction

This report relates to the final examination of the 2 and 3 Unit Engineering Science courses. Students and teachers would be wise to note the often poor responses to discussion type questions and understand that the skills of describing, evaluating, discussing and explaining are all essential.

2/3 Unit (Common)

Section I

Question 1

This question involved a steel truss that had a 45° roller reaction at the right hand end. Candidates had great difficulty visualising this reaction perpendicular to the rollers and either tried using a vertical reaction or gave up on this part of the question and moved on.

When calculating forces in the truss members, most candidates were able to identify an appropriate section plane but were often unable to reach an answer due to the need to solve two equations if taking moments.

The difficulty of this first part did however discriminate between candidates and was offset by the relative ease of the remainder of the question that was answered reasonably well.

Most candidates were successful in using the stress formula to calculate the minimum diameter of a steel rod though some had difficulty in expressing the answer in millimetres.

Question 2

Candidates demonstrated a good understanding of the concept of conservation of momentum and were able to solve the early parts of this question.

The statements from the question ‘the impact was elastic’ and ‘combined block and projectile’ created some confusion for a significant number of candidates. Due to these statements, candidates used both conservation of energy and conservation of momentum in their calculations. Some candidates provided two solutions to this problem.

Many candidates could not determine the rebound from the wall and often failed to take frictional force into consideration, or did not connect the relationship between work and energy.

Candidates had difficulty calculating the velocity ratio of the bosun’s chair but were able to use the principles of mechanical advantage to calculate the effort required.

Question 3
The process of 'jiggering' for ceramics was not clearly understood and tended to be avoided by many candidates. As the question did not restrict usage of any term to once only, candidates could have correctly suggested that both the coffee mug and handbasin be mass-produced by slip casting.

The term 'opacity', as it applies to ceramics, caused difficulties for many candidates who were unable to give a clear answer to the question. Some candidates experienced confusion with 'temperature effect' rather than 'higher temperature' effect.

Sketching the grain structure of the cast steel hook caused difficulties for many candidates. Poor sketching techniques were common, with confusion in microstructures. In many instances fibrous grainflow was incorrectly shown. Some candidates showed typical 'ingot' as-cast structures rather than 'sand cast' structures.

In order to gain maximum marks for this question, candidates needed a sound understanding of forging, casting, mechanical testing and welding.

Question 4
Generally this question, relating to thermal equilibrium diagrams, was well answered. Many candidates had difficulty in determining how strength properties related to the microstructures of the different alloys.

Candidates had difficulty in naming the phases present in a 2.5% carbon in iron alloy at 1200°. More care must be taken when sketching microstructures. Labeling of each sketch, even if this is not required by the question, will often help to clarify the drawing.

Candidates had difficulty with the interpretation of the term 'structural change'. In the context of this question it should have been obvious that it referred to change in the iron's lattice structure

Question 5
In the first part of the question, the use of 50° for the cutting plane caused some candidates difficulty as they incorrectly assumed the section plane was inclined at 45°. Others read too much into the problem with inclination of the solid and triangulation being incorrectly used rather than a straight insertion of a horizontal cutting plane to find the points in the top view. Some candidates are still not adhering to AS1100 drawing standards with regard to the use of cross hatching lines when indicating the cut surface in the top view. It was also common to see hatching being erroneously used on the true shape of the cut surface.

Completing the line of intersection of two triangular prisms was generally well answered. The visibility of the hidden outline caused difficulty for many candidates and accurate projection also proved difficult.

Question 6
The addition of the slot to this rod end provided the opportunity to test the more able candidates in this question. The need to extend the profile edge (curve) in the front view to locate the lower points of the fillet curve was not generally well understood. Most candidates located section planes in the top view but many were unable to transfer these planes to the front view.

In the second part of the question, many candidates failed to recognize that the section of downpipe to be developed was simply part of a right cylinder. Location of generators by drawing an auxiliary circle on the sloping (elliptical) surface also resulted in incorrect solutions.

Section II

Question 7
Most candidates demonstrated an understanding of the stages in the evolution of braking systems and were able to display knowledge of improvements resulting from design changes made throughout that evolution. The majority of candidates were able to identify improvements and factors influencing changes in brake design but found it difficult to describe those improvements. Candidates were able to recognise some significance of the improvements in effectiveness of braking safety.

Generally candidates were able to arrange the historical diagrams of braking systems into order based on the era of development. A few candidates had difficulty determining the order of evolution and did not realise the significance of the time-line nature within the question. These candidates were able to arrange some of the stages in sequence but placed these stages incorrectly on the time line.

Many candidates were aware of the change in performance produced by the replacement of a 'trailing shoe' for a second leading shoe connected using a floating pin. Responses identified the servo assistance nature of this development but were unable to describe fully the significance of this improvement in relation to performance and maintenance. A small proportion of generally poor responses relied only on describing the information derived from the diagrams.

The majority of candidates had difficulty describing the reasons for the loss of effectiveness of braking systems due to heat. They were often unable to describe the link between excessive heat and the change in brake lining properties. Many candidates identified factors such as reduced friction and expansion as contributing factors but did not describe reasons for the loss of effectiveness. Many candidates demonstrated a sound understanding of the advantages that hydraulic braking systems have over mechanical braking systems.

Too many candidates described the operation of 'Anti-lock' Braking Systems while evading the intent of the question: that was, to describe how this system has improved the effectiveness of braking safety. Supplying a paraphrase of the question was often relied upon as the main part of the response.

In summary this question has highlighted the need for candidates to be more familiar with not only the historical developments that have occurred in many engineering systems, but also the influencing factors that have led to the evolution of those systems. Candidates would be well prepared if they can not only discuss the evolution of engineering systems but also critically analyse the historical evolution of engineering systems using skills developed throughout the Engineering Science course.

Question 8
A large proportion of the candidates scored full marks for reading a velocity/time graph in this part and found little difficulty in identifying changes in motion. They recognised that horizontal lines represent constant velocity, while sloping lines represent acceleration or deceleration. Many were able to successfully calculate the distance covered by the rider by recognising that distance equated to the area under the graph for that time. Some mistakes were made in misreading values or incorrectly calculating the area under the graph. Candidates should be made aware that they should always clearly show all working leading to the answer.

In this question, candidates had to identify the forces on an inclined plane that caused a bicycle and rider to move. It involved a gravitational component down the plane and a resisting force. Many candidates didn't even attempt this part, as they were unable to correctly identify and relate the forces involved. i.e. the total resisting force plus the component down the plane equal the driving force up the plane. The more difficult section of this part required the candidates to apply a power equation, P=Fv or P=fs/t. Most candidates were able to correctly substitute data into their equation. The most common errors were a failure to convert velocity, expressed in km/h, to m/s and neglecting to convert units in the answer to kilowatts.

Question 9
Many candidates failed to recognise the concept of double shear in the pin due to the design of the yoke and tang and therefore failed to double the area of the pin to find the total area in shear. A common error, where candidates recognised there was double shear, was to double the force. Simply calculating an area proved difficult, with many candidates either substituting wrong data or using the incorrect formula for area even though this formula is given on formula sheet. Candidates are again reminded to use the formula sheet. Candidates were of the belief that the pin would 'break', 'deform' or 'bend'. They often failed to relate their answer to the wearing of the yoke and tang or to simply suggest that the pin was easier to replace than the yoke and tang.

Not knowing the position on the graph of the proportional limit meant that quite often an incorrect value for extension was used. UTS or breaking point values for extension and 'load' were used. Load (kN) from graph was used in the formula for '*l*' rather than original gauge length. Difficulty in accurately reading the scales from the graph resulted in variations in the extension reading at proportional limit. Some candidates also had difficulty in describing the Elastic Limit.

Those candidates with a clear understanding of Young's Modulus of Elasticity knew that it was essential to use related data from within the straight-line section of the Load/Extension curve. Many candidates used incorrect data, often from the maximum load or breaking point, and others used incorrect units in the formula. When required to calculate the UTS, many candidates incorrectly read the maximum load from the graph and provided it as the answer. Other errors included wrong use of the formula and a failure to convert the cross-sectional area from square millimetres to square metres.

Question 10

Questions that asked the candidate to 'describe' or 'explain' were rarely fully answered. Once having named a correct process (injection moulding, rotational moulding etc.) the description of that process often excluded when the heating took place (prior to injection or after the polymer is placed into the mould) or that the article was cooled, ejected or joined.

Many candidates could not distinguish between service properties, mechanical properties or manufacturing properties and therefore gave an inappropriate response. Many also stated the obvious or re-worded the question in their answer. e.g. 'The service property of a fuel tank is to hold fuel.' or that it was 'water proof'. These are both incorrect responses. When a comparison between materials is required, candidates should endeavour to use the technical terms related to the material in question, not the basic terms such as 'easily destroyed' or 'broken easily'.

Many candidates were also unsure of the difference between a macrostructure and a microstructure. They showed individual grains, atoms, molecular chains or included metallurgical terms and descriptions instead of those appropriate to a glass filled polymer.

Question 11

The concept of grainflow in forged structures was generally well understood, however many candidates failed to show the correct detail of this grainflow. Interruption to the grainflow caused by machining the square was not well understood.

Most candidates were able to identify one factor that controlled the grain size of hot-worked metals but most had difficulty identifying a second factor. Candidates needed to qualify some responses to provide a clear answer. eg. 'Prior working' was a good response while simply 'working' didn't provide a clear answer. Some candidates failed to differentiate between the effects of cold working and hot working. Candidates should respond as requested by the question. When asked to 'state', long descriptions should be avoided and when asked to describe, simply naming the process is an inadequate response.

Candidates were often able to name industrial processes, such as thread rolling and upsetting, but were unable to describe the essential characteristics and features that distinguish each process. Some candidates named a forming process then went on to describe a totally different process. There was often confusion between metal casting processes and polymer forming techniques. Few candidates correctly differentiated between hot and cold forming processes and the need for mass-production was not well considered in many responses.

Candidates didn't appear to know or understand that a reverse thread is commonly used to prevent the loosening of a thread due to rotation. These mechanical concepts are often best understood by candidates who have 'hands-on' experience with a variety of engineered components.

Question 12

This question principally examined the reading and interpretation of the pictorial representation the assembly of a push rod. The question required the detail drawing of the assembly using AS1100 drawing standards.

The drawing of the size and shape of the components, the assembly of the parts and the interpretation of drawings has all showed improvement over recent years. This drawing examined fewer drawing standards compared to previous years and most candidates were able to gain creditable marks

Candidates should read questions carefully to determine what is being asked of them to complete in the drawing. Often clear directions are given about the positioning of the drawing along with details about the correct assembly of parts from the exploded isometric. Those candidates that did clearly read and interpret these instructions began the drawings on the centre lines indicated for both views and were able to assemble the
component parts in the correct way.

Many candidates misinterpreted the words 'through the yoke' and incorrectly assembled the push rod right through to the opposite side of the yoke. Candidates with a sound understanding of engineering paid attention to the detail of the threads and correctly placed the rod 5mm into the yoke as requested. These better responses also noted the correct position of the nuts and correctly interpreted the radius on the lug on the yoke due the bending process.

Knowledge of a number of drawing standards was essential for the correct completion of this drawing. Many candidates did not know how to represent the shaft break, the threads on the shaft in both the front and side views or the standards for either a standard or a lock nut. Candidates also needed to use an appropriate method of showing hidden features in the assembled parts. The use of hidden outline or an appropriate sectioning technique were both acceptable solutions.

3 Unit (Additional)

MECHANICS

Question 1

Many candidates were able to correctly calculate the reactions on a beam using moments equations, though care must be taken when analysing cantilever beams as in this case a downward reaction occurred at one support. Most candidates were able to correctly identify the shear force created by the reactions at the beam supports however many candidates failed to correctly apply the weight of the girder and the uniformly distributed load (UDL). A common error was to concentrate the UDL at the midpoint of the beam. The incorrect assumption being that the UDL acted over the length of the beam. This led to an incorrect shear force diagram.

When asked to determine the maximum bending moment, most candidates correctly identified that it occurred at the right-hand support. Having identified this point, many then failed to realise that calculations could be completed more easily by using the data from the right hand end of the beam rather than using the more complex data for the left hand end. When attempting to calculate bending stress, the most common mistake was to substitute incorrect values into the equations. Many candidates found difficulty in analysing the concepts involved in the rotational motion of the sphere as a conical pendulum and failed to solve the problem.

Question 3
Many candidates correctly calculated angular displacement however some were unable to convert the answer to revolutions. When dealing with angular velocity on a banked surface, candidates failed to analyse all the components involved. Incorrect answers resulted due to components not being included in calculations. Some candidates applied linear motion equations and converted their answer to rads/sec. Only a small number of candidates attempted this question.

Question 4
This difficult question involved a rigid bar suspended by wires of different lengths and different cross-sectional areas and candidates had difficulty analysing the concepts. The answer required that the elongation of the two wires be equated to ensure that the bar remained horizontal. Many candidates failed to then apply the shared forces to the problem in a moments equation to locate the point of application of the force on the beam.

MATERIALS

Question 2
Corrosion was generally well understood and the majority of candidates were able to identify anodic and cathodic areas, to give oxidation and reduction reactions, to calculate electrode potential and to explain the causes of corrosion. While most candidates demonstrated knowledge of chromium creating a passive oxide layer not many were able to explain that a smaller difference in electrode potential slowed the rate of corrosion.

Candidates appeared to have a poor understanding of crystallography and couldn't identify a slip plane or calculate the Miller Indices related to the plane.

Question 5
This question dealt with a temperature-time-transformation diagram for eutectoid steel and most candidates were able to identify the critical cooling rate for the formation of a fully martensitic structure. Many candidates were also able to identify

the cooling rate that produced a coarse pearlite and then correctly sketch and label this structure.

Fewer candidates understood the concept of a split transformation that formed both martensite and fine pearlite. While most candidates displayed a sound knowledge of the principles of Austempering, fewer could explain the value of Martempering in reducing the chance of quench cracking in larger components.

Question 6

Generally, candidates did not understand the SiO_2–Al_2O_3 phase diagram and this restricted their ability to answer the various parts of the question. Knowledge of the inverse lever rule was generally good but candidates had difficulty in sketching the microstructure and describing the allotropic transformation of crystobolite to tridymite.

While most candidates displayed a sound knowledge of the alloy formed between aluminium and 4% copper, not many were able to apply their theoretical understanding of age hardening to practical applications in the aircraft industry.

Section III

GRAPHICS

Many of the candidates displayed sound technical drawing skills in areas such as standards and linework but their ability in solving the drawing problems presented was disappointing. Each of the questions required some form of three-dimensional thought from the candidate and then the translation of this thought into a two-dimensional solution. Three-dimensional freehand sketches can sometimes help candidates to 'picture' the solution to a problem.

Most candidates were able to gain part marks for each question but many displayed difficulty in determining an apparent angle, locating all points on a line of intersection or in indicating the exact points of intersection between a sphere and a line. Candidate's responses to the transition piece were particularly disappointing as the concepts involved and the final solution should not have been difficult for a well-prepared candidate.