INTRODUCTION

The reports contained in this booklet are designed to be informative and helpful both to candidates and those responsible for preparing them. The Examinations Committee will be pleased to receive any comments or constructive criticism on the content of the reports, either of a general nature or relating to a particular subject.

The Committee emphasises that the individual subject reports should be read in conjunction with the appropriate question papers. These are available from the Engineering Council Examinations department at City & Guilds in sets/individually for Certificate examinations and individually for Graduate Diploma and Postgraduate Diploma examinations.

MAY 2005 – CERTIFICATE EXAMINATION

ANALYSIS OF RESULTS BY SUBJECT

Subject	Number of Cands	Grade A	Grade B	Grade C	Grade D	Grade E	Grade F	pass rate %
UK & Overseas								
CERTIFICATE								
9107-101	377	0	1	17	76	33	250	24.9
9107-102	226	4	28	63	58	6	67	67.7
9107-103	308	1	5	30	113	42	117	48.4
9107-104	227	3	16	53	90	23	42	71.4
9107-105	173	8	8	26	61	8	62	59.5
9107-106	158	0	0	2	11	9	136	8.2
9107-107	156	0	0	11	36	21	88	30.1
9107-108	12	0	0	1	3	1	7	33.3

Engineering Council Examinations

Advice Note on Self-Assessment and Time Management

The following notes are aimed at providing prospective Examination candidates with some advice and guidance on their preparation for and performance in any forthcoming timed written EC Examination.

Candidates are reminded that the purpose of an examination is to demonstrate to the Examiner an understanding of the subject matter.

In an examination context, **good time management implies the best use of the time available in which to attain the highest possible amount of marks**. More specifically, that means making the best use of the 3 hours available in which to score at least 40 marks (the 'pass' threshold) from the 100 marks total that is allotted to the paper.

Read the rubric - Read the rubric ('rubric' means the instructions) on the front cover of the question paper. This will tell you how many questions you have to answer, and whether you are only allowed to answer a specific amount from any section. It is very important that you understand and comply with the rubric: if you do not, the marks gained for some of your questions will not be counted.

Read the whole question paper first - The Examiners have built into the question paper what they consider to be adequate time for you to read and think about the questions *before* you start to answer them. Please use this time well. Read the whole paper and then choose the questions that you wish to answer wisely.

Make outlines and notes for answers - Plan your answer before you begin to write by making notes of points as you read through the question again. You must write these notes in your answer book and then cross through them (with a single diagonal line). The Examiner will not mark them but could still refer to them if he or she is not clear on something in your answer.

Write legibly - Your answers must be capable of being read by the Examiner. This does not mean simply that they should be written in clear and concise English, but also that the handwriting should be clear. If your answer cannot be read and understood, the Examiner cannot award marks to it. Where diagrams are included in your answer, these should be clearly drawn and labelled.

Candidates should be prepared to work on the task of answering the questions that the examiner has asked. Ideally, that means

- being prepared for the correct subject (candidates have been known to get their examination dates mixed up)

- ensuring that you actually understand the question that is being asked **Answer the question set -** Ensure that you read the questions carefully so that you understand what it is the Examiner is asking you to do. Candidates often fail to answer the question set but instead give a pre-prepared answer to a question that they had hoped would be set. Examiners will not reward material which is not relevant and candidates must not think that simply writing down everything they know will result in a pass. (strange as it may seem, some candidates provide an 'answer' that has nothing to do with what was asked)
- have all the appropriate 'tools' you require, and are permitted
- being fit, free from colds etc, not tired, and generally in a reasonably good state
- of health.

Do not go into an examination and attempt a question on a topic that you have never previously done any worked examples on. This is not the time to be breaking new ground and it never works out in your favour. OK, if you have exhausted all your efforts and are scratching around trying to pick up the odd mark here and there, you might attempt this. But you do not do it as a planned strategy.

Have a planned strategy for each examination. You must know what topics you understand and which ones you are weak on. If you don't, you haven't achieved a rigorous enough level of self-assessment and you probably shouldn't be there! If you are strong on them all, then you will assuredly pass. You will try to avoid those you are weak on and concentrate on those that you know you can do something with. Start with a question you are confident about – it doesn't have to be Q1.

What do we mean by self-assessment? It is a means whereby you can establish how good your knowledge of the syllabus is, and is best achieved by doing as many and varied worked examples as possible, either from the recommended text books or, better still, by going over old exam papers. And what you are really trying to establish in doing this, is an understanding of the principles and concepts that are embraced within the topics of the syllabus. Statistically, of course, the more examples you do in your preparation, then the greater is the probability that you will recognise something very similar to what you have already done when you meet the exam questions. There is really no other better substitute to this policy – not because it always guarantees that you will understand everything you do, but it should tell you what you don't understand, and that is the real key to self-assessment. As an example of self-assessment or rather the lack of it, in a recent EC Examination 20% of the candidates scored less than 15% of the possible marks. It was abundantly clear to the examiner that not only were those candidates so poorly prepared that they should never have sat the examination, but also that they should have been aware of that long before they arrived at the examination centre.

Luck should not be a factor in passing an exam – particularly the good luck in only having to do those topics that you know about (or the bad luck if the reverse occurs).The strategy behind exam papers in which all questions require to be answered is partly to eliminate the so-called 'luck factor' which may occur when only a number of the questions making up the paper require to be answered. Of course, whether all or only a certain number of questions require to be attempted will not stop the candidate from simply doing what he or she is able to do.

Time your answers - This is very important. Candidates often penalise themselves by answering too few questions because they have not apportioned their time wisely. Make sure you know how many questions you will be expected to answer so that you can work out your time allocation per question in advance. Then you must pay close attention to the number of marks awarded to individual parts of questions. Spending too much time on a question worth two marks is a waste: you will not be awarded more than two marks however much you write. **Do not waste time writing on your script data that has already been provided** – a commonly bad habit when numerical analysis is required

Calculations - If a question requires a calculation, candidates should show all the intermediate steps taken to arrive at an answer so that it is clear to the Examiner how the answer has been reached. This way, there is a greater chance that the Examiner can award marks for the process, even if the result of the calculation is incorrect. If candidates realise that their answer is quite clearly wrong but lack the time to re-calculate it, then they should explain this to the Examiner and say how they know it is wrong. Candidates that show this kind of awareness are far more likely to be rewarded than those that simply write down a blatantly wrong result.

Prepare yourself well - You can improve your examination technique by obtaining past question papers and working through them under timed conditions.

SUBJECT 9107-101 MATHEMATICS

General Comments:

The structure of the paper was the same as that of the previous year. The candidates found this a very hard paper. Only a handful of candidates achieved a mark in excess of 50%. Several of the questions appeared beyond the reach of most candidates with certain parts being attempted by virtually no one. Even routine mathematical operations were not done well by a significant proportion of the candidature.

Given the breadth of the syllabus some areas will inevitably not be tested in any one year; candidates would be well advised not to assume that a particular topic will appear in the year that they sit the examination, but rather prepare by covering as much of the syllabus as is practicable. Within a topic there are certain basic skills which should be mastered: there were many examples where the wrong method of attack was employed, even in standard situations.

Comments on Individual Questions:

Q1
Most candidates found Q1(a) to be difficult; very few of the graphs that were drawn contained even a broadly correct picture of the function. A handful of candidates did find the symmetry about the *y*-axis. The need to take two square roots in order to find the intersection of the graph with the *x*-axis meant that most candidates missed at least one pair of values. The asymptotes at $x=1$ and $x=-1$ were a source of major confusion with many candidates stating that the graph intersected the *x*-axis here. Only one candidate in the batch of scripts marked noted the asymptote $y=-2$ as $x \to \pm\infty$. When it came to finding stationary points the majority of candidates ignored the fact that the power of $(1-x^2)$ in the derivative is negative and stated that there were stationary points at $x=1$ and $x=-1$. Few candidates attempted the part about points of inflection. Curve sketching is a skill which draws together many threads and is a good test of the understanding of fundamental features of graphs of functions.

Q1(b) proved more tractable with many correct answers. Leaving aside sign errors in $\frac{dx}{d\theta}$ and $\frac{dy}{d\theta}$, the most common error was in finding $\frac{d^2y}{dx^2}$ – many candidates simply differentiated $\frac{dy}{dx}$ with respect to θ and some stated that $\frac{d^2y}{dx^2} = \frac{d^2y}{d\theta^2} \div \frac{d^2x}{d\theta^2}$.

Q2
Q2 vied with Q9 as the question answered least well. In part (a), candidates may have misunderstood what they were allowed to do, but only a handful quoted and used the standard series for $\ln(1+y)$. The majority of attempts at this question tried to work from first principles for η and differentiate it with respect to *x*: invariably this led to errors. There were no reasonable attempts at part (b).

Q3
Many candidates made fairly good attempts at Q3(a) (although there were several who wrote down an incorrect form of the partial fraction decomposition). There were inevitable numerical errors in determining the coefficients in the partial fractions but the

integration was usually reasonable. There were, however, several errors when it came to actually evaluating the integral, the worst of which was to use degrees rather than radians when evaluating the *arctan* term.

In 3(b), only a few candidates made a sensible attempt at limiting the range of integration (in view of the periodic nature of the function). Several opted for 0 to 2π without explanation. However, the use of the appropriate trigonometric identity for $\sin^2 x$ was widespread.

Q4
Q4 was generally well done (although, of course, there were arithmetic mistakes, particularly in finding the particular integral). Calculating the coefficients for the general solution to ensure that the initial conditions are satisfied was prone to error and many candidates did not attempt to identify the transient and steady state parts.

Q5
Many candidates did not even attempt Q5. Of those that did very few answered part (a) correctly. Rather than show that the point $(\bar{x},\bar{y})$ always lies on the regression line most attempts at part 9(b) were carried out for the specific data of this question. Determining the regression line was done reasonably well; however, when it came to plotting this line, most candidates failed – there seemed to be a desire to make the regression line go through the end two data points even though its equation does not take it through either of these points. Calculation of the correlation coefficient was generally satisfactory (there were the expected arithmetic errors) but no one tried to draw any conclusions from the value they calculated for ^{2}.

Q6
There were many correct attempts at Q6, although there were also several small errors (usually missing minus signs), which led to creative (or perhaps one should just say incorrect) attempts to prove the required result. Provided that candidates realised that they needed to use the product rule for the *t* differentiation they usually made a reasonable attempt at the question.

There was a typographical error in this question: $\frac{\partial \phi}{\partial t^2}$ should have been $\frac{\partial^2 \phi}{\partial t^2}$.
However, only a very few candidates were misled by it, and their marks were adjusted in compensation.

Q7
Many candidates thought that the way to solve Q7(a) was by dividing one matrix by another. Others though that $(\mathbf{AB})^{-1}$ is the same as $\mathbf{A}^{-1}\mathbf{B}^{-1}$ but those who managed to avoid these two mistakes generally made a good attempt. The first part of Q7(b) was probably the most consistently correctly answered question on the paper. Even candidates who were otherwise weak were able to find $\mathbf{A}^{-1}$ after correctly calculating the determinant and all the cofactors. However, the determination of the conditions for the requirement $\mathbf{A}^{-1} = \mathbf{A}$ defeated the majority of candidates. The first condition coming from $a^2 = 1$ was fairly straightforward but the subsequent condition $ab = -\frac{b}{a}$, which should have led to $b = 0$, confused many.

Q8
In Q8 part (i) was answered correctly by the majority of candidates. However, little else was. As expected, the argument of *z* was often calculated incorrectly (an angle in the first quadrant was the standard answer). Applying de Moivre's theorem to get two square roots was beyond the capability of many and even those who did manage to cope often did not convert their answer back into $a + bi$ form. Parts (iii) and (iv) defeated virtually everyone.

Q9
Q9 just about beat Q2 to be the question that was answered least well overall. Very few candidates even made an attempt at either part of this question, and even fewer scored any marks. In part (a) a model answer would start with a statement of the conditions for an equivalence relation – yet this was hardly ever seen, so it is not surprising that candidates did not then demonstrate that the given relation has the required properties. Q9(b) was equally perplexing to candidates, with almost no one having any ideas about how to approach the solution.

Q10
The majority of candidates attempting Q10(a) did not realise that they needed to introduce a new random variable: the difference between the diameter of the cylinder and the piston. Instead they tried to carry out calculations with the two separate random variables, which leads nowhere. Amongst those who did introduce a new random variable there seemed to be a considerable amount of confusion about how to calculate the mean and, more particularly, the standard deviation of the new random variable. Finally, once the mean and standard deviation had been calculated some candidates only considered the case where the difference was more than 1.5mm; they overlooked the case that the difference is not allowed to be negative.

Q10(b) produced a range of answers with some candidates trying to use a Poisson distribution for the number of unsatisfactory fits; others tried to persevere with a Normal distribution. Several candidates did correctly identify that a binomial distribution should be used but just assumed a *p* value of 0.5 (irrespective of their answer to part (a)). There were then problems with determining precisely which probabilities should be calculated using the binomial formula and whether or not they should be subtracted from 1.

SUBJECT 9107-102 ENGINEERING MATERIALS

General Comments:

The style of the paper was slightly different this year, with some parts of questions exploring different aspects of the standard subject matter or with questions set in slightly different format to those of previous years. This was reflected in the quality of the answers received. Candidates preparing for the examination are reminded that the paper is set on the syllabus and that previous examination papers are only a guide to the type of questions set.

Comments on Individual Questions:

Q1 Polymer structures
First part was done well, with most candidates identifying the differences between thermosetting and thermoplastic materials. The descriptions of the inter- and intra-chain bonding were well understood by the majority of candidates. The remainder of the question was done rather poorly. Very few candidates were able to draw appropriate stress-strain curves and the explanation of the form of the curve was virtually non-existent. Candidates did not appreciate the significance of the temperature (above Tg to allow a change in chain conformation, but below Tm, so no melting.) Viscoelasticity was also poorly understood, with only a small fraction of candidates drawing a curve showing a much stiffer material at high strain rates.

Q2 Mechanical testing & Stress/strain curves
A similar question to last year, but the emphasis reversed – candidates were given mechanical data and asked to draw the stress vs strain curve. The first part on mechanical testing was satisfactory. When asked to draw the stress strain curve, the majority of candidates ignored the instruction to assume a linear work hardening rate, and sacrificed marks accordingly. Candidates were not able to calculate the yield stress from the data given. This required candidates to find the intersection of two straight lines, requiring solving two simultaneous equations using the data supplied. Answers to remaining numerical questions were generally satisfactory, but it was disappointing to see so many simple numerical errors (particularly with powers of 10) and that many candidates quoted strain with units of mm instead of the correct answer, which is dimensionless.

Q3 Materials Selection – Biomedical Materials
Answers given to this question highlighted many misconceptions about the general properties of various classes of materials. Many candidates thought that there were no corrosion issues with steel, that polymers were strong (in comparison to metals) and that ceramics were tough. Most candidates showed an understanding of the mechanical aspects of material selection for implant application, but failed to reason that the body provides a very aggressive environment with biological implications for the recipient. There were numerous inconsistencies in solutions provided. For example, candidates would justify composites as the best material in part (b) on the grounds of low cost, when one paragraph earlier in part (a) they had correctly identified the high cost of CFRP as a disadvantage of the material.

Q4 Phase diagrams
Many candidates scored well on this straightforward question. However, there were a number of issues that should be highlighted. These include a misunderstanding of the composition labelling e.g. Cu-20%Zn was plotted as 20%Cu i.e. closer to Zn, and that a number of candidates tried to draw eutectic systems. Diagrams that were not drawn to scale were a problem for candidates as the compositions chosen for part (b) required a reasonably accurate diagram in part (a). The concept of a *solid solution* was also misunderstood by many, with microstructure diagrams presented showing a two-phase mixture of Zn-rich and Cu-rich regions.

Q5 Semiconductors
Candidates were generally well acquainted with this section of the syllabus and provided many good solutions. Descriptions of n-type and p-type semiconductors were good, but the detailed operation of an npn transistor was not always complete. Some candidates correctly asserted that the emitter-base junction should be forward biased, but then drew a reverse biased configuration in their diagram. Most candidates lost marks by not clearly stating that the base was lightly doped and therefore recombination with electrons from the emitter rapidly used up all the holes in the base, leaving the majority of electrons to flow to the collector. The calculation of current was done well in most cases, although there were a few errors with logarithms and exponential terms.

Q6 Microstructural effects on properties
Very few candidates showed an appreciation of the role that microstructure plays in the mechanical properties of metallic materials. This is disappointing, since the interaction of structure and properties is essential to an understanding of the whole of Materials Engineering studies. Some candidates correctly appreciated that a reduction in grain size, increase in dislocation density and increase in solute content would all increase yield strength but explanations of why were very poor. In part (b), the ranking and reasons were argued weakly, but this can be understood given the difficulties with part (a). In the last part, virtually every candidate who attempted the question proposed incorrectly that modulus would vary in exactly the same way as yield strength, on the grounds that modulus equals stress divided by strain, therefore if strength goes up, so does modulus. It was not understood that modulus depends on interatomic bonding and not the microstructure. So all four materials in this question would have almost identical values of modulus.

SUBJECT 9107-103 ENGINEERING SCIENCE

Comments on Individual Questions:

Q1
Many candidates were unable to draw a correct force diagram for the arrangement of three blocks in this question. Some candidates assumed incorrectly that the reaction forces at the points of contact of the two lower blocks with the ground were equal. Other candidates failed to include one or more of the reactions or block weights. Fully correct solutions for the force F required in part a) of the question were therefore rare. Candidates who did have a correct force diagram were unable to determine the correct geometrical distances between various points on the diagram. The simplest approach to obtaining the correct expression was to obtain two equations by taking moments about each of the lower contact points for the whole structure and to combine these with a third equation obtained by resolving forces for the whole structure in the vertical direction. The correct expression was $F = 2W\dfrac{t\sin\theta - L\cos\theta}{L\sin\theta + t\cos\theta}$

In part b), the structure will collapse at the angle where the force F drops to zero. Although many candidates had the incorrect expression for F from part a), they frequently had the correct numerator in the expression and hence were able to determine that at the point of collapse $\theta = \tan^{-1}\left(\frac{L}{t}\right)$

Q2

The majority of candidates were able to write down the correct relationship between torque and shear stress required for part a). Some candidates were unable however to deduce that the maximum shear stress occurs on the outer surface of the shaft. Usually these candidates computed the shear stress at the mean radius. Some candidates made errors in the calculation, usually in determining *J* often through incorrect conversion from millimetres to metres. The correct value for the maximum shear stress was 39.96 MN/m^2. The majority of candidates were also able to write down the expression for the angle of twist and to compute its value as 0.213 radians or 12.2 degrees. Some candidates were unsure as to whether their answer was in radians or degrees. Answers that were incorrect by factors of 10 were also quite common.

Q3

The majority of candidates tackled this question by using Newton's second law to equate the net force on either the complete system or one of its components to the rate of change of momentum. Very few candidates recognised that the acceleration of the centre of gravity of the rollers is only a half of that of the block but rather assumed that these accelerations were equal and hence that the rollers were replaced by wheels mounted on the block. Few candidates obtained the correct acceleration of $\frac{(M+m)g\sin\theta}{M+\frac{m}{2}+\frac{I}{2\ {}^{2}}}$. Some candidates made errors in their algebra, resulting in one or more of the positive signs in this expression being replaced by negative signs. Candidates are advised to consider whether their answers are feasible as in this case negative signs would suggest that zero or infinite accelerations are possible for certain *M*, *m* and *I* combinations. This problem could also be solved by equating the reduction in potential energy to the increase in kinetic energy. This approach is generally more straightforward for constant acceleration problems than an approach using Newton's second law, but was hardly ever used by candidates.

Q4

The majority of candidates were familiar with this type of problem and were able to write down the conservation of momentum equation and the definition of coefficient of restitution required for the solution. Some candidates did however incorrectly assume that the kinetic energy of the particles is the same before and after the collision. The majority of candidates were able to do the algebraic manipulation to obtain the expressions for the velocities of the particles following the collision $\frac{(m_1 - em_2)u}{m_1 + m_2}$ and $\frac{(1+e)m_1 u}{m_1 + m_2}$. Some candidates failed to simplify their final expressions sufficiently to gain full marks though.

Q5

Most candidates were able to write down the expression for the hydrostatic pressure at a depth beneath the water's surface. Many were also able to determine the expression for the resultant force on a plate, but some were unsure as to whether to use the full area of the plate or just the wetted area. The correct force on the plate required in part a) of the question was 313.9 N. Many candidates found part b) more challenging. Some candidates chose to simply divide the force equally between the four bolts. Others worked out the hydrostatic force acting on the head of each bolt. Around a third of candidates realised that they needed to take moments about a line running through either the centres of the lower or upper bolts. Many of these candidates made algebraic errors during the subsequent analysis and hence many did not obtain the correct answers of 75.8 N and 81.2 N for the upper and lower bolts respectively. In some cases the final answers submitted were clearly orders of magnitude larger or smaller than the total force on the plate and were therefore clearly wrong. Candidates are therefore advised to check whether their answers are feasible.

Q6
The majority of candidates recognised that this question required the use of the Steady Flow Energy Equation and were able to quote it correctly. Most candidates were then able to correctly enter the values for the majority of the terms. The exception was generally the specific enthalpy of the air entering the turbine, which required candidates to work out the temperature of this air from the equation of state. Other common errors resulted from failing to convert all the terms into either W or kW or inconsistent use of the candidates chosen sign convention. The turbine power output was 59.6 kW.

Q7
Many candidates' attempts to this question were far more complex than necessary, because they failed to utilise symmetry. The circuit shown is symmetric in both part a) and part b). Therefore, in part (a) the voltage across OA, OD and OG must be 3v and the voltages across OC and EB and the voltages across OF and HB must be equal. This greatly simplifies the nodal analysis. The remaining voltages are OC 1.8v, OF 2.4v, OE 4.2v and OH 3.6v. Some candidates who had failed to utilise symmetry in part a) did so in part b). In this case the voltage across OB, OD and OF is 3v and the voltages across OA, OC, EH and GH are all equal. Simple nodal analysis leads to the voltages OA and OC of 2v and OE and OG of 4v. Candidates are advised to look carefully at circuits to determine whether they can use symmetry. Generally problems of this type should not involve the solution of a maximum of 3 or 4 simultaneous equations.

Q8
The majority of candidates were able to sketch the waveform required in part (a) resulting from the half wave rectification circuit shown in the question. In some cases marks had to be deducted though because the sketched waveform was insufficiently detailed. A few candidates incorrectly showed the output voltage rising during the periods when the power is being drawn from the capacitor. In parts (b) and (c) only a few candidates realised that changing the resistance values would effect both the DC and AC components of the voltage across the load resistor with roughly equal numbers of candidates commenting on the change to either just the DC or just the AC component. In part (d) most candidates recognised the role of the capacitor and that increasing its value would result in reduction of the AC ripple voltage. In many cases the signals were sketched with no reference scale and hence it was impossible for the examiner to distinguish the effect on the waveform asked for in the question.

SUBJECT 9107-104 ENGINEERING PERSPECTIVES AND SKILLS

General Comments:

This syllabus covers a wide area of engineering, and consequently the variety of questions on this paper was specifically designed to reflect this. This year there seems to have been a better attempt at most of the questions on the paper.

Comments on Individual Questions:

Q1
A list of the main rules or laws of good report writing is published by the IEE as follows.

A good report is easy to recognise. Its title is precise and informative, its layout and format are well organised, and the binding is easy to handle and opens flat to reveal both text and diagrams. A typical summary of the report writing laws is as follows.

1. The reader is the most important person.
2. Keep the report as short as possible
3. Organise for the convenience of the report user.
4. All references should be correct in all details.
5. The writing should be accurate, concise and unobtrusive.
6. The right diagram with the right labels should be in the right place for the reader.
7. Summaries give the whole picture, in miniature.
8. Reports should be checked for technical errors, typing errors and inconsistency.
9. The report should look as good as it is.
10. The reader is the most important person.

The first law is repeated because it is the only law, which should never be broken. Flexibility and adaptation may be useful, but only to make the report more accessible to the reader.

All other considerations, even saving time and money, are in the end counter-productive if readers find reading the report a burden they would prefer not to undertake.

A significant number of candidates had clearly studied the IEE publication, although many ignored the instruction to “list” the main rules in a form similar to the above. Often candidates gave repetitive accounts of one of these points. More attention should be given to planning the points to be made in the answer, <u>before</u> writing the final text as concisely as possible.

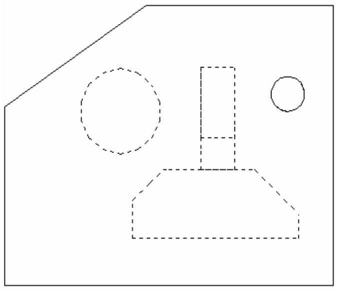
Q2

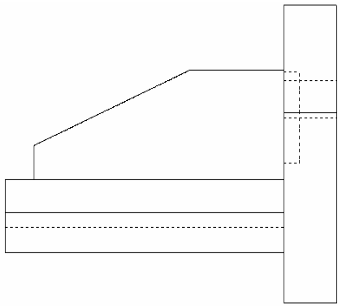
1. optimistic	6. structure chart
2. ALU	7. morphological analysis
3. auxiliary	8. applets
4. comparability	9. seed value
5. ASCII	10. JPEG

This question was poorly attempted.

Q3

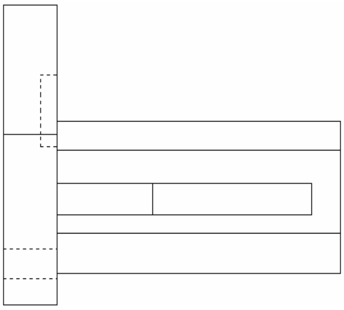
View in the + x direction





View in the -y direction

View in the -z direction



Incomplete views and missing hidden details were common problems, particularly in the case of the large “blind” hole.
Sometimes candidates produced views other than those requested.
The best responses used the standard graph paper in the centre of the answer booklet to produce good, scale drawings, but often the views were drawn directly into the answer book, with consequent distortions of scale.

Q4
This is a straightforward network problem, which is very similar to that given in the list of specimen questions published previously, although some candidates did not use the three time estimates correctly, which requires the following: -

t = (a + 4m + b)/6 **variance v = ((b - a)/6)^2**

Item	Activity	a	m	b	t	v	ES	EF	LS	LF	Slack	CPath
1	1 - 2	10	35	80	38.33	136.11	0	38.3	90.03	128.33	90.03	
2	1 - 3	20	40	55	39.17	34.03	0	39.17	71.66	110.83	71.66	
3	1 - 4	30	50	75	50.83	56.25	0	50.83	0	50.83	0	*
4	2 - 5	15	30	45	30	25	99.16	129.16	128.33	158.33	29.17	
5	3 - 5	25	45	80	47.5	84.03	39.17	86.67	110.83	158.33	71.66	
6	3 - 7	20	60	80	56.66	100	39.17	95.83	145	201.66	105.83	
7	4 - 2	15	50	75	48.33	100	50.83	99.16	80	128.33	29.17	
8	4 - 6	35	45	100	52.5	117.36	50.83	103.33	50.83	103.33	0	*
9	4 - 5	20	60	75	55.83	84.03	50.83	106.66	102.5	158.33	51.67	
10	5 - 7	10	45	70	43.33	100	129.16	172.49	158.33	201.66	29.17	
11	6 - 7	15	100	175	98.33	711.11	103.33	201.66	103.33	201.66	0	*

Critical path = 1 - 4- 6 - 7 expected project completion time μ = 50.8 + 52.5 + 98.3 = **201.66 days**
Project variance = 56.25 + 117.36 + 711.11 = **884.72 days**, the project SD σ = √ 884.72 **= 29.74 days**

Probability that project is completed in less than 245 days
Z = (x - μ) / σ = (245 – 201.66) / 29.74 = 1.4573 and from standard normal table,
Prob. = 0.4275 so % probability = (0.5 + 0.4275) 100% **= 92.75 %**

Q5
By its nature the answer to this question is specific to each individual examination candidate.
Ideally, a flowchart, pseudocode, or other planning device should be clearly stated and then used, before completing the coding task required by this specific problem.

When attempted, the answers to this question were often satisfactory. Some candidates did not identify clearly the method or language adopted. Often the main observation was not made, i.e. that the differentiation of the result R with respect to the particular variable was required before the more detailed coding took place

Q6

Items in the Profit and Loss Account Ace Engineering Company 1, 2, 3, 4, 5, 6, 11, 12, 13, 14

	Current Liabilities			
19	Trade Creditors	88800		
20	Interest payable	247200		
21	Salaries payable	60000		
24	Rates accrual	98400		
23	other accruals	16000		
25	Deferred revenue	62400	**572800**	
	Fixed assets			
16	Land		1044000	
17	Buildings	3168000		
18	Accumulated depreciation	614400	2553600	**3597600**

Many candidates answered this question fully, though some wasted time by attempting to produce a full balance sheet, which was not required.

Q7

(a) The simple cash flow diagram was usually answered correctly.

The general equation for the NPV (£K) is given by

Y = NPV = -25 -12x^1.5 + 14x^3.2 + 20x^4 + 12x^4.5 + 10x^7.5 + 6x^8 + 4x^10

where x = 1/(1+i/100) = 1/1.07 = 0.934579, and the values of the various coefficients are as follows

So the NPV for the whole project, for x = 1/1.07 then the **NPV** = + **£11.087K**

The cash flow diagrams were usually drawn correctly and in general this section was well answered.

Some candidates ignored the time value of money and simply used the nominal values

(b) Using the secant method with an interval such that b/a = 1.0001, then starting with i = 0%, ie x = 1, and the equation given in part (a). After 3 iterations the solution is sufficiently accurate, as follows

	a=Xa= 1	**=first guess**
b=Xb=	1.0001	
Ya=	29000	
Yb=	28967.63174	
R1=	1.089593955	=new a
b=Xb=	1.089702914	
Ya=	7404.060279	
Yb=	7384.84622	
R1=	1.131581019	=new a
b=Xb=	1.131694177	
Ya=	885.9670287	
Yb=	870.5608299	
R1=	1.138088422	=new a
b=Xb=	1.138202231	
Ya=	16.69799605	
Yb=	1.792899268	
R1=	1.138215921	=ROOT1=solution

ie=**13.82%=IRR**

This section was very poorly attempted. Even though the question clearly requested a systematic and numerical approach (as indicated by the appropriate method to be used), a few candidates ignored this, and wasted time trying to find an analytical solution. Very few candidates obtained the correct numerical values.

SUBJECT 9107-105 MECHANICAL AND STRUCTURAL ENGINEERING

General Comments:

This year's Paper was very similar in format and structure to last year's and contained seven questions that fully covered the syllabus.

Candidate numbers, pass rate and average mark were slightly down on the corresponding figures for 2004. Disappointingly, however, the proportion of candidates who were quite unprepared for the examination had increased and was approaching the unacceptably high levels of two or three years ago.

I believe that the exam paper fairly tested knowledge and understanding of the syllabus. This year, candidates tended to favour the questions on dynamics with the question on velocity and acceleration of a linkage being particularly well done. The statics questions on shear force and bending moments and stress at a point, were particularly poorly done indicating clear evidence of lack of understanding of basic principles.

Candidates need to pay yet more attention to self-assessment and preparation for the examination. There were many examples of candidates showing poor exam strategy and time management, and tutors should note that candidates will continue to require advice and guidance on these aspects.

Comments on Individual Questions:

Candidates are reminded that the purpose of the Exam is for them to demonstrate an acceptable level of knowledge and understanding of the subject matter.

The procedure to solve a problem is not necessarily the same as the procedure to demonstrate an understanding of the problem. For example, the evaluation of the principal stresses at a point does not *have* to involve the drawing of a Mohr circle, particularly if the only requirement is to determine the magnitude of the maximum direct (principal) or shear stress at the point. However, in demonstrating a clear understanding of the state of stress at a point and how that state of stress will vary with orientation, the Mohr circle gives an immediate visual interpretation of the various states of stress that may exist at the point. Similarly, shear force and bending moment diagrams clearly demonstrate the variations of shear and bending irrespective of what the individual load conditions on the beam may be. This is also so with the illustration of velocity and acceleration of linkages. While the solution of an actual problem will now be done by fast, computer-based processes simply to obtain a speedy and numerically-correct output, the ability to take a 'snapshot' of the system by vector analysis is paramount. Candidates - and tutors - should understand why these procedures require to be grasped. *There is evidence that candidates try to memorise a range of problems in the hope that an examination question will remind them of one of these in their attempt to provide a solution. If the principles and concepts are truly understood, then the solution will assuredly be achieved irrespective of the given shape of the problem.*

The following comments relate to the particular features and concepts that each question attempts to highlight. In many instances, the numerical answers are of little consequence and credit is given when there is a clear indication that the fundamental principles are understood. Tutors and prospective candidates should take particular note of these comments as they indicate the level of knowledge and understanding expected of each topic at this stage.

Q1

Assesses the fundamental concepts of **stress at a point** in a shaft subject to torsional, and other unspecified, loading. In this instance, the given stresses were principal stresses which appeared to throw candidates into total confusion presumably because they had always done such questions on the basis that the given stresses were *not* the principal stresses (reference to the introductory point above). So the discipline of applying the same fundamental concepts were discarded in a panic attempt to fit previous solution procedures to the problem without any success whatsoever! Since, by definition, the shear stresses on the principal planes are zero, the coordinates of the two points on the Mohr circle which permit its construction are therefore (210, 0) and (-70, 0) MN/m² ie the points on the x-axis. So the centre of the circle is 70MN/m² and its radius is 140MN/m². The planes at 45° to the principal planes correspond to angles of 90° on the Mohr circle ie the vertical diameter of the circle, giving the coords of (70, 140). That is, the stresses on planes at 45° to the principal planes are 70 MN/m² tension and 140 MN/m² shear. If the shear stresses on the 45° planes are *assumed* to be due to axial torque then, from the simple torsion formula, the torque equals 92.8 kNm.
Part (c) is obtained by noting the two points on the circle which cut the vertical axis ie where the direct stress is zero. The angle that these radial lines make to the x-axis is + 60° ie the required planes are + 30° either side of the minimum principal plane. *Note that they are not mutually perpendicular.* This part of the Question was very badly done

because candidates have not fully grasped the concepts of the Mohr circle. It should be further noted that the assumption that the maximum shear stress of 140 MN/m² is due to an axial torque, implies that the principal planes are at 45º to the shaft axis.

Q2

Assesses understanding of **shear force and bending moment distributions** in beams and the **identification of static determinacy/indeterminacy**. The given beam containing a hinge requires the bending moment at the hinge to be zero otherwise part AC of the beam would rotate about C. This means that the clockwise moment of the vertical reaction at B about C must equal the counterclockwise moment of the udl about C and the beam is consequently statically determinate. Even although all of these points were more or less stated in the question, very few candidates drew the correct conclusions and became hopelessly bogged down trying to evaluate the support reactions. By taking moments about C, the reaction at B is found to be18 kN. Hence the vertical reaction at E is 9 kN and the fixing moment at E is 3 kNm. Candidates who sketched correctly the general shapes of the shear force and bending moment diagrams were given credit even if the individual values at change-of-section points were incorrect. Most candidates were able to identify the procedure of double integration for determining the solution of the statically indeterminate case which the beam became when the hinge was removed, although some were clearly confused about their reference point when it came to stating boundary conditions.

Q3

Assesses understanding of **equilibrium and free-body diagrams** for a simple pinned frame and was universally well done. Only a few candidates noted that the given value of the load on member BD was theoretically in error and should have been 10kN. This did not in any way influence the evaluation of H = 5 kN (acting to the left) and V = 10 kN (vertically downwards). Resolution of the forces at B and D gives a horizontal reaction at B of 15 kN (to the right) and a vertical upward reaction of 10 kN, along with a horizontal reaction at D of 10 kN (to the left). Because of the roller, there should be no vertical reaction at D, but the given load value for member BD implies a frictional effect of 0.61 kN there. No marks were deducted if the given value of 10.61 kN was correctly used in the analysis.

Q4

Features **static indeterminacy in torsion**. In this case, the torque in AB + the torque in BC = the applied torque of 8 kNm, and the angle of twist in AB = the angle of twist in BC. So, from the simple torsion formula the torque in AB is found to be equal to (0.723 x torque in BC) ie 3.36 kNm and 4.64 kNm respectively. The maximum shear stresses in AB and BC are then found to be 137 MN/m² and 109 MN/m² respectively. Most candidates understood that the shaft was statically indeterminate, but some made the fundamental error of assuming equal torques on the two sections of shaft instead of equal angles of twist.

Q5

Assesses the concept of **work, energy, momentum and impact** (as well as **uniform motion** as some candidates demonstrated). The best method is to determine the velocities of separation immediately after impact using the work-energy approach, and the rebound skid distances, viz

$$\mu(mg) \text{ skid distance} = \tfrac{1}{2} m v^2$$

These are found to be 13.13 m/s for A and 9.7 m/s for B. The velocities at impact can then be obtained using the conservation of momentum and the coefficient of restitution expressions, being careful to take accurate account of the sign convention (ie directions of travel). The impact velocity of A is then found to be 34.1 m/s and that of B, 23 m/s. The second part of the question can be determined by again using the work-energy expressions and the initial skid distances to give an initial velocity for A of 42.9 m/s and for B of 33.3 m/s. Since the legal speed limit of 120 km/hour corresponds to 33.3 m/s, this means that vehicle A was exceeding the speed limit while B was just on the legal limit.

Q6

Assesses fundamental understanding of the **SHM of a spring-mass system** and was generally well done. Most were able to establish the dynamic equations of equilibrium for the mass ($mg - T = m. d^2x/dt^2$), the pulley ($T.r - P.r = I.\alpha$), and the spring force ($P = k.x$) in terms of either the mass displacement or angular displacement of the pulley. These combined to indicate that the motion of the system was simple harmonic and reduced the coefficient ω to $\sqrt{}k/(m + I/r^2)$ in general terms. Inserting the appropriate values, ω was found to be 33 rad/s.
Hence, the natural frequency of vibration of the system, from $\omega/2\pi$, is established as 5.3 Hz.

Q7

Assesses fundamental understanding of **velocity and acceleration characteristics of a simple mechanism** and was generally well done. Candidates had clearly taken on board the advice in last year's Report regarding this topic and demonstrated a marked improvement in understanding. The tangential velocity of A is quickly established as 0.6 m/s. Most correctly identified the points on the velocity diagram and consequently evaluated the vertical (upward) velocity of the slider B as1.16 m/s and the linear velocity of A relative to B as 0.85 m/s, which resulted in an angular velocity of AB of 1.4 rad/s. From these velocity values, the centripetal accelerations of A, and B relative to A, are calculated as 2.4 and 1.2 m/s² respectively. These can now be drawn in the appropriate directions on the Worksheet. Since the direction of the tangential acceleration of B relative to A is known, and the acceleration of the slider B has to be in the vertical direction, these two vectors can be drawn in and where they intersect gives the location of the point b' on the diagram. From the diagram, the vector for the acceleration of the slider B can be measured, and is found to be 1.24 m/s² acting in the opposite direction to the direction of the velocity vector for B. Hence, the slider is decelerating ie it has negative rate of change of velocity. Too many candidates sketched the acceleration diagram in their Answer book instead of on the Worksheet as requested. No marks were deducted for this but it really makes no sense not to use the sheet provided especially when the transference of data is likely to be less accurate if it is not used.

SUBJECT 9107-106 THERMODYNAMIC, FLUID AND PROCESS ENGINEERING

General Comments:

The results this year are significantly poorer than in 2004, with a lower average mark and a considerably lower pass rate.

The topics considered in the paper were spread across the syllabus and the questions were broadly similar in scope to those in 2004. The weaker candidates tended to offer answers only to the more elementary parts of questions. The solutions from many candidates contained careless arithmetic and algebraic errors which often produced quite unrealistic answers. Perhaps the most common of these involved errors and inconsistencies in the use of units. Similar problems were also noted in 2004. The best candidates demonstrated a good understanding of some of the question topics, often gaining maximum marks. However, this was offset by mediocre answers to other topics.

Many candidates stated the sign convention used in the first law of thermodynamics in their solutions which was helpful. Some candidates use temperatures in °C rather than K in thermodynamics calculations, producing large errors when temperature ratios are involved. A large number of candidates continue to assume wrongly that all adiabatic processes are isentropic processes and sometimes that they are also isothermal processes. Some candidates appear to have had little experience of using the steam property tables while many candidates happily mix steam properties from tables with properties derived from perfect gas equations, often using the perfect gas properties for air in steam calculations. There were many instances of careless errors when extracting data from property tables. These included reading values from the wrong rows or columns and ignoring the multiplier term in the rows for specific volume in the superheat region. Another frequent source of error was the incorrect or incomplete use of the isentropic efficiencies given in some questions.

Comments on individual questions:

Q1

This question required candidates to use the hydrostatic pressure equation for the water and oil columns in the manometer and also determine the changes in head in each of the tubes due to the displacement of a volume of water when a pressure difference of 250 N/m^2 is introduced. Most candidates were able to choose a suitable level datum and generate a hydrostatic pressure equation. Also, many correctly understood the need to account for the volume displacement of fluid although not all were able to account for it correctly. However, a frequently occurring error was made by candidates assuming that the levels of the fluid in tubes A and B are equal when the same gas pressure is applied to each tube. This of course would only be so if the density of each liquid was the same. That initial level error leads to an unknown variable in the hydrostatic equation when the pressure difference is applied to tubes A and B. Several candidates unsuccessfully attempted to use the Bernoulli equation for the problem which showed a poor understanding of the basis for that equation.

Q2

This question was correctly answered by several candidates although the majority of candidates exposed a variety of misunderstandings about air-standard cycle processes. The question requires the candidate to start from definitions for thermal efficiency and mean effective pressure and then perform simple algebraic manipulation of ideal gas relations. Most candidates were able to correctly sketch the cycle on p-V and T-s diagrams although a number of diagrams suggested no understanding of the processes involved. The majority of errors in answers to part (b) were caused by candidates either assuming that an isentropic process is also isothermal or that a constant pressure expansion process does no external work. A number of candidates tried to fabricate the result required by dissecting the expression given but usually introduced algebraic errors in the process. Others got lost in their derivation and concluded, incorrectly, that the remaining steps were obvious and did not need to be completed. In part (c), although most candidates understood the concept of mean effective pressure, many incorrectly based the swept volume either on V_1 alone or on $(V_2 - V_1)$ rather than $(V_1 - V_2)$. Here again, although there were several correct solutions, most candidates introduced one or more algebraic errors during the derivation.

Q3

Several candidates produced completely correct solutions for this question but most introduced careless errors or showed incomplete understanding about Rankine cycle calculations and in particular about isentropic efficiency. In addition, many candidates incorrectly used expressions for a perfect gas, usually based on the properties of air, to determine steam properties instead of using the steam tables. Candidates who used the steam tables frequently made careless errors when reading the tables for property values. These included reading entries from the wrong pressure level or the wrong temperature level, using saturated vapour values for wet steam or assuming the turbine entry state was saturated vapour instead of superheated vapour. A significant number of candidates gave the impression of having little or no experience of using the steam tables to obtain property values. Many candidates used the turbine isentropic efficiency correctly to determine the actual turbine work output from the calculated isentropic work but failed to realise that the exit state of the steam from the turbine is also affected by non-isentropic operation. As a result, the turbine isentropic exit state was used in (c) producing an incorrect heat rejection rate in the condenser. A significant group of candidates showed no understanding of the Rankine cycle and the associated calculations.

Q4

This question is concerned with the free expansion of carbon dioxide between compartments in a closed vessel. Its solution requires use of the equation of state for a perfect gas, the first law of thermodynamics for a closed system and the entropy change equation for a perfect gas given in the list of equations. It also requires the candidate to determine the gas constant and the specific heat at constant volume for carbon dioxide using the universal gas constant and the constant pressure specific heat given in the question. A surprising number of candidates were unable to correctly obtain the gas constant. In some cases they simply used the universal constant as given, but in most cases errors in units caused the calculation of masses in part (a) to be a thousand times too big. Candidates should be encouraged to clearly determine the units of any quantity calculated so that, for example, they do not inadvertently use kilojoules and joules or kilogrammes and kilomoles as equivalents in the same calculation. Unfortunately, most candidates write down a result as a number only rather than include a display of its units. Almost no candidate correctly stated the first law for the given situation which shows that the internal energy of the gas remains constant. This allows calculation of the temperature after mixing. In many cases, candidates incorrectly used the open, steady-flow form of the energy equation, often with an external work term. No candidate was able to calculate the change in entropy for the process. Many used the equation in the list given, though often replacing the unknown C_V term with C_p. However, none realised that the equation needs to be used twice, from each initial state of the gas to the final common state.

Q5

Many candidates appeared to have little understanding of the cycle used in a gas turbine engine and often had great difficulty utilising the compressor and turbine isentropic efficiencies in the calculations. A surprising number of candidates used the first law for a closed system in their calculations. Candidates frequently showed the T-s diagram for the cycle in part (a) embedded in the liquid/wet vapour region of a pure substance, suggesting a very poor understanding of the gas states of a substance. This was compounded by several candidates obtaining some state properties from steam tables. The pressure drop in the combustion chamber also caused problems. This practical pressure loss results from fluid friction effects in the combustion chamber and it simply leads to a smaller pressure ratio available across the turbine compared with the compressor, reducing the work from the turbine. A number of candidates tried to generate a work term in the combustion chamber to account for this loss. Many candidates used the correct definitions for the compressor and turbine isentropic efficiencies to determine the actual work required in the compressor and actual work output from the turbine. However, in part (b), only some candidates also used the efficiencies to calculate the outlet temperatures. Temperatures in °C rather than K were used in some cases, causing errors in calculations involving temperature ratios. In part (c), no candidate correctly calculated the percentage of the turbine power used to drive the compressor.

Q6

Most candidates were able to generate an accurate stoichiometric equation for complete combustion and use this to calculate the air fuel ratio in part (a). However, almost none of the candidates correctly calculated the actual air fuel ratio in part (b) using the volumetric dry gas analysis given. The main reason for this was candidates failed to recognise that the given exhaust gas percentages imply a quantity of dry gas, for example 1 kmol or 100 kmols. This in turn requires a calculation of the amount of fuel needed to produce this dry exhaust gas, using a carbon balance while a nitrogen balance also yields the oxygen required for the given combustion conditions. Only a small number of candidates attempted to balance the constituents between reactants and products while all of these incorrectly assumed one mole of fuel in the calculations in conjunction with the dry gas analysis results as given. In part (c), most candidates simply stated there was an insufficient air supply and ignored the presence of excess oxygen in the exhaust. In fact, a more likely reason is inadequate mixing of the fuel and air or poor movement or quenching of the flame front.

Q7

This question requires use of steam properties from the steam tables, the steady-state, steady-flow energy equation and the mass continuity equation to calculate the conditions at exit from the pipe. In part (a), only a few were able to correctly sketch the process in the h-s and T-s diagrams. The majority of candidates were unable to correctly place a saturation curve in the h-s diagram and many simply omitted it. A disturbingly large number of candidates had entropy increasing in one diagram and decreasing in the other diagram between the same end states. In part (b), calculation of the inlet steam velocity required a value for the specific volume of the initially superheated steam. While many used interpolation of the steam table entries to get this, a significant number incorrectly assumed a density of 1000 kg/m^3, the density of liquid water to obtain the specific volume. Many of those using the steam tables overlooked the multiplying factor of 100 in the superheat table entries and produced unrealistic values. The energy equation with adiabatic conditions and no external work done leads to no change in the stagnation enthalpy (h + 0.5c^2) between entry and exit. Since the velocity terms are very small compared with the enthalpy terms, it is reasonable to make the assumption $h_{in} = h_{out}$ to calculate the exit steam state. While some did use this, a large number wrongly assumed an isentropic process to calculate the end state. Others equally wrongly used the equation of state for a perfect gas with R for air to obtain the exit conditions. Still others wrongly applied the Bernoulli equation instead of the energy equation. Most of those who attempted part (c) treated the steam as a perfect gas and used the equation given in the equation list to obtain the entropy change. These included candidates who had already assumed that the process was isentropic.

Q8

Many candidates did not offer an answer for part (a) apart from writing the Bernoulli equation given in the equation list which is the pressure form of the equation. Only a few gave the specific energy form and many wrongly added a 'loss' term. Although many candidates stated the correct conditions of incompressible fluid and steady flow, only a few added the essential condition of an inviscid fluid. The problem in part (b) requires application of the Bernoulli equation and the continuity equation. Most candidates used the Bernoulli equation but many overlooked the continuity equation, particularly when calculating part (b)(ii). There it was quite common for candidates to wrongly assume that the velocity at the bend in the tube was zero. Quite a large number of candidates applied atmospheric pressure to one side of the Bernoulli equation but not the other, or assumed an atmospheric pressure difference between the tube inlet and outlet corresponding to the hydrostatic pressure of a head of 5 m of water. Many candidates introduced other careless errors into their calculations or made careless application of the given conditions. The most frequent of these included having a ρ term on one side of the equation but not the other, choosing a level datum for one state and a different datum for the other state and defining the circular area as $\pi D^4/4$.

SUBJECT 9107-107 ELECTRICAL AND ELECTRONIC ENGINEERING

General comments:

It is of course realised that English is not the first language of most candidates and every attempt is made to allow for this in spite of the occasional difficulty in interpreting the intended meaning. However there is no excuse for poor penmanship and all candidates should be encouraged to write as clearly as possible.

A useful exam technique in the case where a result is given and its derivation asked for, is to use the given result and then work backwards. For example this could be used to advantage in questions 1 and 6.

Comments on individual questions:

Q1
Many candidates did not understand that if the voltage changes instantaneously this means that dv/dt is infinite. From the equation this means infinite current is required which is clearly impossible. Understanding that the capacitor voltage cannot change instantaneously is the key to solving transient problems such as that in part (c).

Part (b) was mostly well done although many sketches did not include a time scale. This is best done by marking off the time-constant and showing the initial tangent of the decaying waveform.

Part (c) was poorly done. Using part (a) the waveform must have jumps of ± E. Also in the steady state the mean value of the capacitor current must be zero otherwise the voltage would be continually increasing. Therefore the area under one complete cycle must be zero. This means the waveform must have identical positive and negative parts. The sketch of the repetitive waveform can be produced to sufficient accuracy by using this information and by sketching in the time-constant and tangents.

Q2
This question was generally well done. In Part (b) truth tables or a statement of function were generally given correctly but answers just based on undefined Boolean symbols were not acceptable. Some candidates quoted multiplication and addition operations and were clearly confused by the same symbols being used for logic AND/OR and multiplication/addition.

Q3
This question was generally well done. In part (b) some candidates used sine functions rather than the required cosine functions.

Solution: depth of modulation 33.3%, 1.5 V, mean powers in a 1 Ω resistor = 1.1875 W, 62.5 mW, side-band frequencies 790 and 810 kHz.

Q4
Only a few candidates could explain that phasor is a snapshot of a rotating vector showing the magnitude and phase relationships at an instant in time.

In part (b) many candidates correctly identified the components and obtained the scaling factors by calculation (e.g. using Pythagorus). Some obtained the results by crude measurement of the diagram. This resulted in appreciable errors.

This years answers showed a better grasp of the use of phasor diagrams compared to previous years.

Solution: scaling factors: 70.7 V/square, 1.125 A/square. $R_1 = R_2 = 62.8\ \Omega$, $C = 50.7\ \mu F$.

Q5
A good percentage of candidates were able to draw an equivalent circuit although many did not refer all components to the primary side which is needed for the calculations. Few were able to calculate the values of the magnetizing and leakage reactances.

In the last part many candidates failed to realise that the input power is given by the power-rating multiplied by the power-factor plus the sum of the given resistive losses.

Solution: core loss 2.3 kΩ, magnetizing reactance 0.89 kΩ, copper loss 0.25 Ω, leakage reactance 0.55 Ω, efficiency 96.3%.

Q6
Although many candidates could write down the expressions for series and parallel RC circuits they failed to use them correctly. This was often due to untidy layout of the algebra. The question gives the result and asks for it to be verified. Very few candidates made use of this – for example by replacing ωCR by 1 in the expressions the calculations are then greatly simplified.

Nearly all candidates who attempted this question knew what the Thevenin equivalent called for but many failed to manipulate the necessary expressions for the voltage and particularly impedance. Again the previous comment is relevant.

Solution: $V_{TH} = -v/6$, $Z_{TH} = R(5-2j)/6$, $\angle I_{ab} = -162°$.

Q7
Many candidates appear to have been put off by the apparent complexity of the circuit. They are however only required to consider the static conditions. This means stating that collector and emitter currents are equal because the base currents are negligible, inserting 0.7 V base-emitter volt drops and then applying Ohm's Law.

Solution: $V_L = 10$ V, $P_{DT1} = 6.7$ W, $P_{DT2} = 8.3$ mW, $P_{DZ} = 161.5$ mW.
The 1 kΩ resistor needs a rating of at least 600 mW

Q8
Very few candidates attempted this question. This may have been the result of lack of time. It is a few years since a question was set on this topic but it is of practical significance and merits more attention in the future. There were two equally valid solutions: series/shunt or shunt/series connection of the two resistors.

Solution: $R_1 = 50$ Ω, $R_2 = 100$ Ω, insertion loss = 1.5, or $R_1 = 141$ Ω, $R_2 = 41$ Ω, insertion loss = 1.65. Use three of the attenuators to obtain 18 dB insertion loss.

SUBJECT 9107-108 SOFTWARE AND INFORMATION SYSTEMS ENGINEERING

Comments on Individual Questions:

Q1 Systems Analysis
This question contributed to the assessment of learning outcomes (i) and, indirectly, (iii). The question related mainly to the part of the syllabus on "analysis" and "system models."

The first part of the question simply asked for an explanation of the purpose of systems analysis. This was quite reasonably answered. All students attempted the question and most were able to state that the process is intended to develop a detailed understanding of the system requirements, typically expressed as a set of models (the recommended textbook by Pressman calls this set, “The Analysis Model”).

The more heavily weighted second part of the question asked for a discussion of two models used in the analysis process. Students could choose models employed in either an object-oriented or a structured approach to systems analysis. Given the importance of analysis in software engineering it was expected that any student studying this subject would be able to name two such models and say a little about them, so it was disappointing that the majority of students did not attempt this part of the question at all, and a number of those who did gave answers unrelated to the question (talking instead about design approaches, or whole life-cycle development models such as the waterfall model). The few good answers were on structured models, correctly emphasising the use of Entity-Relationship Diagrams (ERD), Data-Flow Diagrams (DFD) and/or state-transition diagrams. Students might have been expected to note the importance of having several independent perspectives in order to obtain a sufficiently comprehensive understanding of the system, but almost no answers noted this.

Q2 Systems Design
Like Q1, this question contributed to the assessment of learning outcomes (i) and (iii). The question related mainly to the part of the syllabus on “design” and on “system models.”

Surprisingly, a quarter of those taking the examination did not attempt this question at all, and although the average performance was better than in question 1 there were no students who obtained more than half marks for the question.

This question was similar to Q1 in that it was in two parts, one on the purpose of system design, the second asking for a description of two models used in the design process. Again students could choose models employed in either structured or object-oriented design.

Most of those who answered were able to say that the purpose of system design is to produce a set of models of the software system to be constructed. Design is concerned with how the system does what it should do and how the functionality of the system can be provided by its components.

The second part of the question was generally not well answered – a number of students described top-down and bottom-up design, for example, as approaches to design rather than discussing the kinds of model that might be used to describe the system. A few discussed architectural design with an implication that a model of the architecture is produced, though the kinds of model, such as the control hierarchy discussed by Pressman in the context of architecture, were not described.

Q3 Software Testing
This question contributed to the assessment of learning outcomes (i), (ii) and (iv). It relates mainly to the part of the syllabus on “testing.”

Some students produced very good answers to this question, and practically everyone who sat the examination attempted it. It was anticipated that most students would assume the whole question related to defect testing (particularly given the focus in the second part of the question), and full marks could be obtained on that basis. The majority of students correctly stated that the purpose of testing is to uncover errors in the software. A number directly quoted Myers, indicating that the intent in executing the software in testing is to find errors, and a successful test is one that uncovers an as-yet-undiscovered error. There were also some good explanations of the difference between black-box testing (test cases ignore the internal logic of a module and are generated around possible inputs and their corresponding expected outputs), and white box testing which involves looking at the internal logic of the unit being tested and generating test cases which ensure that every independent path through the unit is exercised.

Q4 Programming example
This question was intended to contribute to the assessment of learning outcome (iii). It relates mainly to the parts of the syllabus on “implementation,” “testing,” and to some extent “ … design.”

This was by far the least popular and most poorly done question in the examination, with more than half the students sitting the examination not attempting it all. This suggests that many students taking the unit have difficulties in some of the areas assumed in the stated prerequisites for the unit.

Students are expected to be able to write simple software components and it is suggested that those preparing for this examination spend some time developing their basic programming skills in a programming language they feel comfortable with.

Q5 Formal methods and verification
This question contributed to the assessment of outcomes (i), (ii) and (iv). It related mainly to the parts of the syllabus on “formal description techniques,” “verification,” and “requirements elicitation/specification,” but was also relevant to “assessment and evaluation,” and “software dependability.”

Only a few students were able to state what formal methods are or identify the kinds of systems for which they might be appropriate. The second part of the question, on validation and verification, was better done and most students could distinguish between them. From some answers it appeared that students were guessing what might be meant by “validation criteria” in a software requirements specification but where students understood the purpose of validation many of these answers were reasonable.

Q6 Project Management
This question mainly contributed to the assessment of outcome (iv). It related primarily to the part of the syllabus on “project management.”

This question was generally well answered, and it is clear that students are familiar with a range of project management approaches.

Q7 Software Metrics
This question contributed to the assessment of outcomes (ii) and (iv). It related mainly to the parts of the syllabus on “project management,” “quality assurance and management,” and “software measurement and metrics.”

Again, a quarter of the students did not attempt this question, some of those that did, produced quite reasonable answers showing an understanding of what software metrics are and some familiarity with metrics that can be used to assess the quality of a software system.

Q8 Design Patterns and CASE Tools
This question contributed to the assessment of outcomes (i), (ii) and (iv) It related to the parts of the syllabus on “design (including architectural design and design patterns),” “software reuse,” “tools (including CASE),” and “documentation.”

Not many students were able to state what design patterns are or how they are documented. The second part of the question, on Computer Aided Software Engineering, however, was well answered by many candidates and it was clear in these cases that students understood the importance of tool support through the software process.