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 – POSTGRADUATE DIPLOMA 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								
POSTGRADUATE DIPLOMA								
9107-300	2	0	0	0	0	0	2	0.0
9107-301	1	0	0	0	1	0	0	100.0
9107-302	1	1	0	0	0	0	0	100.0
9107-303	0	0	0	0	0	0	0	0.0
9107-304	1	0	1	0	0	0	0	100.0
9107-305	1	0	0	1	0	0	0	100.0

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 9107-300 ADVANCED ENGINEERING ANALYSIS

Comments on Individual Questions:

Q1
No attempt to answer this question. All the answers expected are given in the question.

Q2
No attempt to answer this question.

The numerical answers are:
b) the solution is independent of θ, giving symmetrical normal modes with nodal lines which are concentric circles.

$$z_1 = A_1 J_0\left(2.405\frac{r}{R}\right)\cos\left(4.810t - \gamma\right)$$

$$z_2 = A_2 J_0\left(5.520\frac{r}{R}\right)\cos\left(11.040t - \gamma\right)$$

$$z_3 = A_3 J_0\left(8.654\frac{r}{R}\right)\cos\left(17.308t - \gamma\right)$$

c) for n = 1, z_1 = 0 on a diameter
z_2 = 0 on a diameter and at r = 0.546
z_3 = 0 on a diameter and at r = 0.377 and 0.690
for n = 2, z_1 = 0 on two perpendicular diameters
z_2 = 0 on two perpendicular diameters and at r = 0.610
z_3 = 0 on two perpendicular diameters and at r = 0.442 and 0.724

Q3
The candidates who attempted this question were able to use separation of variables to create ordinary differential equations for the independent variables x and y along with a separation constant. However, a form of constant was chosen which did not satisfy all of the boundary conditions.

Q4
The candidates who attempted this question provided largely correct linear-programming models in part (a). However, only one was able to generate a reasonable solution for the linear programming problem in part (b). In part (c) The candidates made no mention of the branch-and-bound method or the cutting plane method which are normally used to generate an optimal integer solution.

The numerical answers are:
b) 11.25 long-range and 18.75 short-range aircraft produce a profit of £56.62million.

Q5
No attempt to answer this question.

The numerical answers are:
a) 70.71, 86.60, 94.87 give f = 100.87
b)(i) 56.08, 68.68, 75.24 give f = 103.60
(ii) 53.94, 66.06, 80.00 give f = 103.75

Q6
No attempt to answer this question.

Q7
No attempt to answer this question.

Q8
No attempt to answer this question.

The answer for part (b) is:

$$S_y(\omega) = \frac{S_0}{\left(k - M\omega^2\right)^2 + \left(\xi\omega\right)^2}$$

Q9
No attempt to answer this question.

The answer for part (b) is:

$$X_0 = x_0 + x_1 + x_2 + x_3$$
$$X_1 = x_0 - x_2 - j\left(x_1 - x_3\right)$$
$$X_2 = x_0 + x_2 - \left(x_1 + x_3\right)$$
$$X_3 = x_0 - x_2 + j\left(x_1 - x_3\right)$$

SUBJECT 9107-301 GAS DYNAMICS

General Comments:

May 2005 was the first time that the examination paper 9107-301 Gas Dynamics was attempted by any candidates. The examination paper 9107-301 Gas Dynamics was produced in the previous three years, to be used by potential candidates as a guide to level of examination and breadth of syllabus.

Comments on Individual Questions:

Q1 Optical methods
Answer: the interferometer measures directly density changes, the Schlieren system makes density gradients visible in terms of intensity of illumination, the shadowgraph system uses the second derivative of density, that is, the shadowgraph is particularly suited to flows with rapid changes of density, for example, shock waves.

Q2 Super-sonic nozzle
Answer: pressure=0.592bar, Mach number=2.809, velocity=2866.8m/s.

Q3 Normal shock
Answer: Mach number=0.513, pressure=71.25bar, temperature=364^0C, stagnation temperature=397.5^0C.

Q4 Horizontal flow with friction
In order to carry out the analysis it is essential to appreciate that mass flow rate is constant and, where ever possible, to use the mass flow rate at entry to the control volume. If this is not done then the number of terms in the analysis increases and confusion can occur.
Answer: dM/dx=+0.000856m^{-1}.

Q5 Steady one-dimensional flow with heat transfer
In order to carry out the analysis it is essential to use the link between the velocity of sound in a perfect gas and the adiabatic constant, pressure and density, rather than the link to the adiabatic constant, the gas constant and temperature.
Answer: Mach number=1.224, pressure=3.192bar, temperature=707.6K, density=1.572kg/m^3, stagnation pressure=7.990bar, stagnation temperature=919.6K.

Q6 Oblique shocks
For supersonic flow over a wedge two shock angles are possible, one for a strong shock and the other for a weak shock. Generally the weak shock, with a smaller shock angle, is preferred. For small wedge angles the shock is attached to the leading edge of the wedge, but above a particular wedge angle, generally referred to as the maximum deflection angle, the oblique shock is detached.
Answer: pressure=0.5075bar, temperature=293K, velocity=697.6m/s.

Q7 Shock-boundary layer interactions
No comment

Q8 Supersonic flow with reflected shock
Answer: angle=29.86^0, pressure=5.860bar, temperature=516.8K, Mach number=1.462.

SUBJECT 9107-302 COMPUTATIONAL MECHANICS USING FINITE ELEMENT ANALYSIS

General Comments:

This was the third year of this examination. The paper follows a standard format of a theoretical Section A and Section B consisting of numerical problems.

Comments on Individual Questions:

Section A

Q1
Brief (two well-phrased sentences) descriptions of key terms. Patch test requires a more lengthy description with a well thought-out diagram.

Q2
An understanding of the way a commercial FE program outputs a contour map of stress is necessary. The reason for refining a mesh and the use of crack tip elements (such as those of Barsoum) are also necessary.

Q3
This is a standard derivation of a bar element angled to the horizontal in a 2D coordinate system. The coordinate transformation matrix is required at the end of the derivation.

Section B

Q4
This is a classic problem involving the ' $F = k \cdot d$ ' system of equations for the 6-dof simple beam element system. Once the element stiffness matrices have been evaluated, these must be then assembled to form the system stiffness matrix. The system reduces to a 3×3 system on application of boundary conditions, which then requires rigorous solution for the deflections, slopes, reaction forces and moments.

Q5
This problem requires an understanding of how FE deals with distributed and centrally-located concentrated loads acting over beam sections in order to obtain resultant equivalent nodal forces and moments.

Q6
This problem requires the assembly of the system stiffness matrix for the two bar element structure. This will be possible after the evaluation of the individual element stiffness matrices. On application of the boundary conditions, there will be a reduction in the size of the system equations.

SUBJECT 9107-303 TELECOMMUNICATIONS ENGINEERING

General Comments:

This was the third year of presentation of this examination. Unfortunately, once again, no candidates entered for, and therefore sat, the examination. So it is not possible to comment on their performance in individual questions. The following comments may be made on the individual questions.

Comments on Individual Questions:

Q1
This question is designed to test students' understanding of spectral efficiency in the design of waveforms for baseband transmission. Nine marks (45%) are allocated for the first, more general, part allowing a bare pass for answering just this part of the question. The remaining marks are allocated to the more specific issues concerned with the measurement of waveforms using eye diagrams and their recovery using matched filters.

Q2
The aim of this question is to test students' understanding of the concepts of symbol detection in the presence of errors. The first two parts of the question are descriptive. These account for 12 marks (60%). A bare pass (40%) may be obtained by the correct answers to the three calculations of probabilities in the third part.

Q3
This question tests the understanding of the principles of operation of digital trunk transmission. A bare pass may be obtained by gaining full marks for the first part of the question which asks for a description of the hierarchy of rates. Subsequent parts require a more detailed, deeper understanding for a good answer.

Q4
This question deals with traffic in packet transmission networks. It tests both knowledge and understanding by two descriptive parts and also by an arithmetically simple calculation which nonetheless requires a good grasp of the underlying principles.

Q5
This question tests candidates' understanding of local area networks (LANs) in general and access control protocols in particular. Half the available marks may be obtained from the two descriptive parts and the other half from the calculation of waiting time and transmission rate. Once again, the calculation is arithmetically simple but it requires a good grasp of the underlying principles

Q6
Following a small descriptive part (20% of the available marks) this question requires candidates to perform a series of design calculations of six parameters of the downlink of a satellite transmission system. As in previous questions the calculations are arithmetically simple, but require a good understanding of the underlying principles. Their development follows the logical sequence indicated in the question.

Q7
The purpose of this question is to test candidates' knowledge and understanding of some of the modulation schemes used in digital communication links. A bare pass may be obtained by the correct answer to the calculation in the last part of the question. Candidates must be able to provide the appropriate relationships and know how to use these.

Q8
This question is concerned with the design of the cell structure in cellular communication systems. The aim of the question is to test the understanding of candidates by asking

for an explanation, rather than the derivation or statement, of the relevant relationships. Accordingly marks are awarded for answers which demonstrate understanding rather than knowledge.

Q9
This is a very straight forward, descriptive question designed to test candidates' knowledge of the fundamentals of light propagation in optical fibres. Although the question is presented in a logical sequence of the development of the subject, it need not necessarily be answered in that order.

SUBJECT 9107-304 ADVANCED MANUFACTURING

General Comments:

This paper was set to cover the syllabus for the subject and the following comments may be made on the individual questions. Every question carried equal marks.

Comments on Individual Questions:

Q1
This question is designed to test students' understanding on the integrated nature of design and manufacture with all cost implications and the effect of various stages of manufacture on the others. The answer had to include the graphical representation of cost distribution in manufacturing, and the opportunity for and the difficulty of each stage. Marks were given to the graphs and the discussion.

Q2
The aim of this question is to test students' knowledge on the performance indicators of assembly systems, which is affected by the quality of component parts to be assembled. This question is of numerical type to establish performance indicators of an actual assembly system if the quality parameters of the component parts are known. The describing equations were provided.

Q3
This question tested the students' understanding on machining systems' limitations and process parameter optimisation. The constraints included the machined part's rigidity and power supply limit in an attempt to set the most productive cutting speed and utilise machine tool. In this numerical question some equations were provided to find the answers to Part (a) and Part (b), which carried differing marks.

Q4
This question tested the students' understanding on High-Speed-Machining (HSM). It specifically deals with the system approach followed in the development of HSM, which required the answer in the form of a block diagram. Also, the advantages of HSM had to be listed, explained and commented. Both development and advantages phase carried equal marks in the graphical/ reasoning question.

Q5
The aim of this question is to test students' knowledge on the most modern ways of machining cavities in the tool/ die industry with special respect to hard machining. In this context a comparison is required between the capabilities of laser cavity machining, electro-discharge machining and high-speed-milling in tool/ die making when using pre-hardened tool steels. A block diagram is required with full explanation for the comparison. Again, it is a graphical/ reasoning question.

Q6
This question requires a reverse engineering solution to be presented from data capture to physical object stage supported by a suitable block diagram and sufficient reasoning. This graphical/ reasoning question tests the students' knowledge on CAD/CAM strategies in reverse engineering.

Q7
This question is set to check the students' knowledge on Statistical Process Control (SPC) in manufacturing. This numerical question sets a real industrial problem to solve with measured dimensional values of a component part and also provides mathematical equations for the solution. The question has Part (a) and Part (b) of equal mark allocation.

Q8
This question targets the environmental/ tribology issues of advanced manufacturing. A suitable block diagram has to be presented and discussed for the minimum amount of cutting fluid application and its advantages must be analysed. This graphical/ reasoning question also covers the advantages of this technology over the traditional flood-type cutting fluid application.

SUBJECT 9107-305 HIGH PERFORMANCE COMPUTING

General Comments:

The questions should trigger critical discussion, and to this end, the following summary for each question is produced as a report.

Comments on Individual Questions:

Q1
Part (a). Assuming an n-element sequence, say a 20 integer sequence, the task graph should show a tree graph with recursive decomposition of the sequence, starting from partitioning of two arrays S and L with their own pivots. Given 5 processes and assuming that each process is mapped onto one processor in the MIMD architecture. If the S<L, then, it is sensible to allocate say a group of 2 processors to S and another group of 3 processors to L. The MIMD architecture provides a shared address space where unsorted and partially sorted arrays can be accessed by all processes.

The processing of sorting using the quicksort algorithm takes the following critical steps. i) rearrange the subsequence in their own group ii) determine the locations in an rearranged array where the local elements will go to iii) perform the global

rearrangement. There are obviously repetitions of the above steps performed by processes.

Part (b). The arrays are stored in the shared address space, and the obvious advantage is that the processors have to perform only memory accesses. The arrays need not be distributed to processors' own address space. The sorted array is available in the shared address space. The disadvantages are the communication overhead, controlling accesses to the shared address space etc. which are architectural problems.

Q2

Part (a) The two major factors that limit the speedup achievable in a parallel architecture are i) the application itself- the programs that form the application may not have enough degree of parallelism exploitable for speedup ii) the communication overhead which may restrict the speedup benefits. From the Amdhal's Law, page 644 Computer `Architecture - A Quantitative Approach by Patterson and Hennessey (second edition):

$0.7 * \text{fraction}_{parallel/} + 70*(1- \text{fraction}_{parallel}) = 1$

i.e. $\text{fraction}_{parallel} = 0.9956$ which shows restricts the sequential characteristics of the application under 50%.

Part (b) The question expects critical comment on usage of performance metrics. The common metrics are MIPS, Mflops, Dhrystone and Whetstone MIPS and Mflops describe instruction execution rate and floating point capability. These vary between programs executed on the same system, and are subjective. The Dhrystone and Whetstone are benchmarks and not real programs and do not reflect the optimisation that occur in real programs. Hence metrics defined as performance measures need careful consideration.

Q3

Part (a) A typical code fragment could two register loads, three adds and a store.The execution schedule should show for example, that the two load instructions are issued concurrently at t=0. The add instructions are issued at t=1 and can be issued concurrently as the processor is pipelined and can terminate at t=5. The schedule could assume that each memory access takes place in a single cycle.

Part (b) The example is from Computer `Architecture - A Quantitative Approach by Patterson and Hennessey (second edition), page 289. and involves comments on loop unrolling to eliminate\dependencies, checking the memory references etc. to improve instruction level parallelism. Complier use of detecting dependencies and circular dependencies are often very effective.

Q4

Part (a) Snoopy protocols achieves data consistency through a bus watching mechanism. Consider three processors, p1, p2 and p3 maintaining consistent copies of X in their local caches. Assume p1 operation. Use two-state transition graphs to show the write invalidate protocol. The first transition graph should show a write through cache operation with two states valid and invalid and the second transition graph should show read, read only and invalidated states in a write-back operation.

Part (b) Average memory access times for 16and 32 KB cache sizes. Use the formulae on page 387 of Computer `Architecture - A Quantitative Approach by Patterson and Hennessey (second edition).

Q5

Part (a) The algorithm should partition the image equally across processors. Each Processor should apply the template to its own subimage. Assuming an MIMD system with loosely connected processors, the operation cab be as follows:

```
begin
  exchange n pixels with two adjoining processors
  apply template to local sub image .
end
```

The first operation involves two n-word messages . There will be nine multiply- add operations for each pixel as the process of applying the template involves multiplying pixel values with corresponding template values and performing a convolution (summing)operation.

Part (b) The features should include constructs for control of parallelism-explicit and implicit constructs, shared task queue, shared abstract data types, global parallelism etc.., synchronisation and communication constructs like shared variables, send/receive, semaphores, barriers etc..

The phases of compilation are flow analysis, program optimisation and parallel code generation.

Q6

Part (a) For DSP and MIMD processing, the ARMv6 'lightweight' SIMD approach with 8-bit instructions like SSDDB, signed 8-bit add, .UADDB, unsigned 8-bit add which operates on the sliced four 8-bits or two 16-bit data path slices .
Exception processing such as SRS and RFE help to save return state and return from exception in cases of interrupts and exceptions on stack.
Semaphores as synchronising primitives are implemented using the SWP Instruction as well as LDREX and STREX for implementing mutual exclusion primitives.

Part (b) Trust zone is an architectural support that adds new operating states where only a small verifiable kernel will run and operate peripherals in a secure state.
Useful for carrying out downloads in cell phones or iPODs. The trust zone operation is through a trust code base of the software kernel.

Part (c) Run, Sleep and Idle states. The Sleep modes shutting all the on-chip activities and the Idle mode stopping the processor clock.

Q7

Part (a) Java carries abstraction to a new height. It is language and also a platform. The JVM interprets byte codes. The multithreading imposes overhead. Java's dynamic lading and security measures all contribute to slower execution times. Java hardware solution – Java chips, faster JVMs, byte code optimisers, JIT compliers etc. improve the execution time.

Part (b) The J2EE architecture with Application Client Container, Web Container and EJB Container. The J2EE standard is widely reported.

Q8

Part (a) A generic virtual reality system typically contains a 3D tracker, voice recognition, 3D sound processor, a virtual environment data base and a host computer all interfaced to powerful head mounted and glove control systems. The VR system is a collection of objects with static and dynamic features and a collection of objects can form functional blocks. An MIMD architecture is an appropriate choice for the generation of the 3D VE environment.

Part (b) The data management problem arises from handling of a large data set. One strategy of addressing a large data set problem is to use compression algorithms. Another strategy is to put as much of the data set as possible in a fast accessible memory. Computational requirements are addressed by appropriate MIMD model. An MIMD parallel processor architecture would meet the computational capabilities for carrying out graphics processing, data management, peripheral control, synchronisation etc.

Q9

Part (a) Real-time features: system calls, time services and scheduling mechanisms, communication and synchronisation, event notification and software interrupt, memory management and i/o and networking all implemented in commercial kernels like ARM RTOS, QNX Neutrino, Windriver Tornado etc..

Part (b) Fist creating a watch dog timer and consists of system initialisation, sporadic thread, interrupt handling and timing monitoring functions.

The timer_settim () can be called from a timer_create routine:

```
timer_create(clock_realtime, timer_id)
  block sigalrm ;
  instances=200
timer_set time( timer-id, relative, 10,200);
while (instances>0);
  sigwaitinfo(signalrm);
  --periodic task code—
 instances=instances-1;
endwhile;
timer_delete(timer-id):
…
```

Q10

Part (a) A system is reliable if it conforms to some specification of its behaviour. A system is fault tolerant if it continues to operate in the presence of faults with a limited period without significant loss of its performance or functionality.

Three levels: Full fault tolerance, graceful degradation and fail safe.

Part (b) Fault tolerance can be achieved by redundancy where a redundant module is not required for system's normal mode of operation. For example in a triple modular redundancy operation, outputs of the three modules are compared and a majority voting scheme is used. In recovery block approach, the recovery point established is tested for alternatives and an acceptance test is used to test the system. Establishing recovery points can be expensive and hardware support may be essential. Discussion of appropriateness of each technique through examples.