UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 1996

BEng Honours Degree in Computing Part III
BEng Honours Degree in Information Systems Engineering Part III
MEng Honours Degree in Information Systems Engineering Part III
BSc Honours Degree in Mathematics and Computer Science Part III
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute Associateship of the Royal College of Science

PAPER 3.02 / I3.8

SOFTWARE ENGINEERING—METHODS
Wednesday, May 1st 1996, 10.00 - 12.00

Answer THREE questions

For admin. only: paper contains
5 questions
5 pages (excluding cover page)

1 a Figure 1 illustrates key concerns during the preliminary "start-up" period of a systems development project. Provide a brief commentary on this figure, explaining all the elements shown.

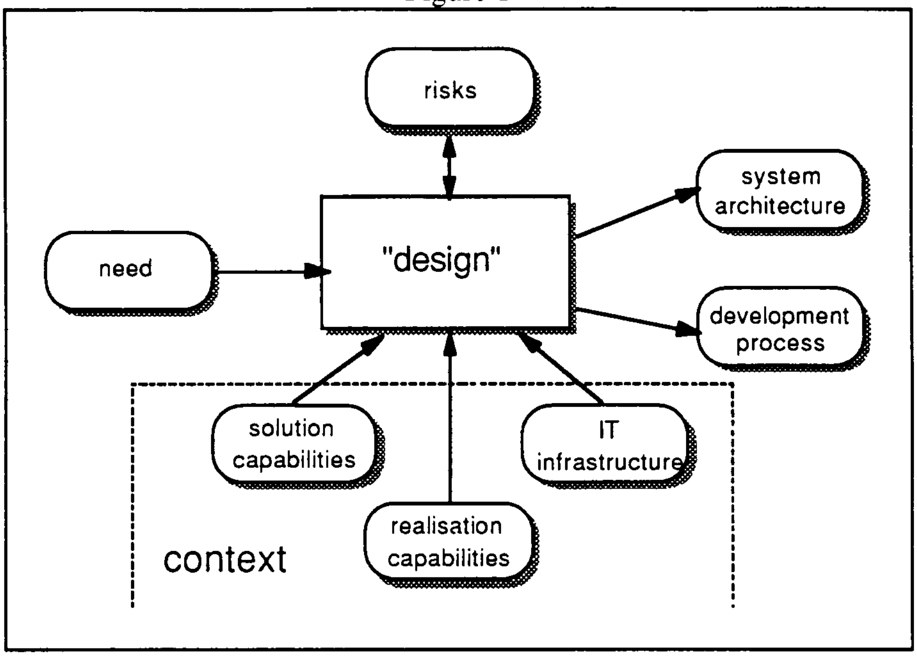
b Provide a companion figure for figure 1, illustrating key concerns during the main part of the project once the preliminary start-up period has been completed.

c Provide a brief commentary on your own figure, explaining all its elements.

Note. Lengthy, essay-style answers are not necessary; simple statements of key points will be quite sufficient.

The three parts carry, respectively, 45%, 15%, 40% of the marks.

Figure 1



2 a Consider the following examples of meaningful and meaningless statements about measurement (in the context of measurement scales, admissible transformations between scales and assuming 'normal intuitive relation systems'). For each statement, indicate whether it is or is not meaningful and justify your answer. If the statement is meaningless, indicate if there is a 'quick fix' which could be applied to make the statement meaningful.

i) 100°C is the boiling point of water.
ii) It is twice as hot today as yesterday.
iii) Length of program A is 50.
iv) Length of Program A is 50 executable statements.
v) Program A took 3 months to write.
vi) Program A is twice as long as Program B.
vii) Program A is 50 lines longer than Program B.
viii)The cost of maintaining Program A is twice that of maintaining Program B.
ix) Program B is twice as maintainable as ProgramA.
x) Program A is more complex than Program B.

b Assume the relation system for measurement defined as follows:

Consider the attribute of *criticality of software failures*. The set of values of interest C will thus be the set of software failures. Suppose that we will distinguish only 3 types of software failures: *syntactic*, *semantic*, and *system crash*. (Every failure lies in exactly one of these classes.) So our relation system is (C,R) where R consists of 3 unary relations (R_1 corresponds to 'is syntactic', R_2 to 'is semantic' and R_3 to 'is system crash') and a binary relation R_4 corresponding to 'is more critical than'. R_4 is defined by: all system crashes are more critical than all semantic and syntactic failures and all semantic failures are more critical than all syntactic failures.

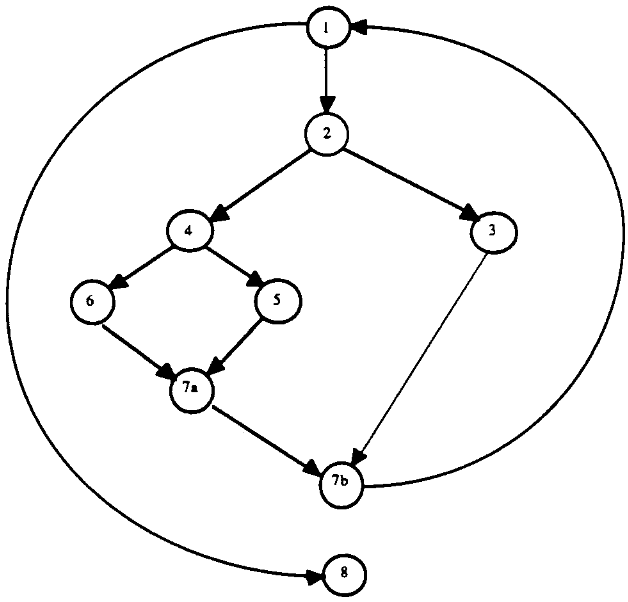
Determine the meaningfulness or otherwise of the following statements with respect to (C,R). Indicate your justification in each case.

i) A system crash is more critical than either a semantic or a syntactic failure.
ii) A semantic failure is twice as critical as a syntactic failure.
iii) The difference in criticality between system crashes and semantic failures is not the same as that between semantic and syntactic failures.

The two parts carry respectively 70% and 30% of the marks.

Turn over ...

3 Consider the following control flowgraph:



a Define the flowgraph representation of each of the 'primitive' constructs: (single) command, if-then-else, while-loop and do-until.

b Define the rules for the sequential composition and nesting operations for flowgraphs. Can a flowgraph be nested for any edge in another flowgraph? Justify your answer.

c Show how the above flowgraph may be obtained from the primitives of (a) using the rules defined in (b).

d Give the expression for *cyclomatic complexity* in terms of the numbers of edges and nodes of a flowgraph. What is the cyclomatic complexity of the above flowgraph? Another possible definition of cyclomatic complexity is the number of predicate nodes plus one. How would you argue that the two definitions give the same result for any given flowgraph built using the primitives of (a) and the rules of (b)?

The four parts carry, respectively,20%, 30%, 25% and 25% of the marks.

Turn over ...

4 Consider the following program:

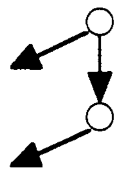
```
PROCEDURE average

[This procedure computes the average of 100 or fewer numbers that lie between bounding values; it
also computes the sum and the number valid.]

INTERFACE RETURNS average, total.input, total.valid;
INTERFACE ACCEPTS value, minimum, maximum;

TYPE value[1:100] IS SCALAR ARRAY;
TYPE average, total.input, total.valid, minimum, maximum, sum IS SCALAR;
TYPE i IS INTEGER;
i=1;
total.valid=total.input=0;
sum=0;
DO WHILE value[i] < > -999 AND total.input < 100
        increment total.input by 1;
        IF value[i] >= minimum AND value[i] <= maximum
                THEN increment total.valid by 1;
                        sum=sum+value[i]
                ELSE skip
        ENDIF;
        increment i by 1;
ENDDO;
IF total.valid>0
        THEN average=sum/total.valid;
        ELSE average=-999;
ENDIF;
END average
```

a Derive the control flowgraph corresponding to this program with the following small change in the procedure presented during the course: for compound conditions of the form p AND q, assume that the conditions are evaluated in 2 consecutive steps (and <u>not</u> concurrently). Hence, the condition in the while loop will be represented by:



Note that the 2 edges on the left will both go to the node representing the (entry to the) conditional after the loop. (Recall that sequenced commands, like the first 3 executable lines of the program, should be grouped together using a single node in the resulting flowgraph.)

b Given a set of paths through a flowgraph (each consisting of a sequence of nodes visited), an *independent path* through the flowgraph (with respect to the given set of paths) is any path that introduces at least one new set of processing statements or a new condition into some corresponding execution of the program. We can thus define a set of *linearly* independent paths in a flowgraph as a set of paths each of which is linearly independent of the others. Find a set of independent paths for the flowgraph you have derived. (There should be 6.)

c Find (the 6) test cases that will force execution of the paths you have found in (b).

The threee parts carry, respectively, 30%, 30% and 40% of the marks.

Turn over ...

5 Consider the following information about two past projects in Sydney, Australia:

The Sydney Harbour Bridge was completed according to specification and on time in 1932. While the requirements for the bridge had been very clear from the outset, implementing the novel design proved to be more difficult. As a result, the bridge cost Aus $9M to build - over double the original estimate of Aus $4M. Since its completion, the bridge has been adapted to carry eight rather than six lanes of car traffic, and costs Aus$3M annually to maintain. The Sydney Harbour Bridge was, and is, regarded as the high qualtiy product of a successful civil engineering project.

Over twenty five years on, the design and construction of another Sydney landmark began. Actual construction of the Sydney Opera House commenced in 1959 and was estimated to take five years to complete at an estimated cost of Aus $7M. The opera house was actually completed and officially opened in 1973 at a total cost of Aus $102M! After completion, one of the dressing room areas for the main concert hall was converted into a Playhouse, an underground car park complex was constructed at a cost of Aus $40M, and a ten-year maintenance programme costing Aus $20M is currently underway. Nevertheless, the Sydney Opera House is also generally regarded as a high quality engineering product.

a If we had been talking about software systems projects, these examples might have been quoted to support the argument in favour of there being a 'software crisis'. What is the 'software crisis'? In what ways do the examples illustrate the characteristics of 'unsuccessful' software projects? (You might wish to relate your discussion to the various components of the development process: requirements, design, implementation, (adaptive and corrective) maintenance.)

b Discuss in what ways the concept of *quality* and the practice of *quality management* can be used to define mechanisms for more effective software development.

End of paper

