UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 1996

MEng Honours Degrees in Computing Part IV
MSc Degree in Foundations of Advanced Information Technology
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the
Diploma of Membership of Imperial College
Associateship of the City and Guilds of London Institute

PAPER 4.19

COMPILERS II

Friday, May 10th 1996, 10.00 - 12.00

Answer THREE questions

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

1a Create a DAG representation for the following piece of three address code:

```
c := a + b
d := c * b
e := a + b
b := e * b
g := b * d
a := a / 4
g := a + g
```

b Using the DAG from part a, generate the three address code applying local common subexpression elimination, assuming that the variables a, g and b are live outside the basic block

c i) To which global optimizations does local common subexpression elimination correspond?

ii) What are the advantages of local common subexpression elimination compared with the optimizations you methioned in part i?

iii) When should local common subexpression elimination be applied- *i.e.* before, after or between the global optimizations? Justify your answer.

2a Consider the following attribute grammar:

`p1: Z ::= A`	`A.a1 = const1`
	`A.a2 = f1(A.a1)`
`p2: B ::= C`	`C.c1 = f2(B.b1)`
	`B.b2 = f3(C.c2)`
`p3: C ::= cc`	`C.c2 = f4(C.c1)`
`p4: A ::= A B`	A_1`.a1 = f5(A.a1)`
	A_1`.a2 = f6(B.b2,A.a2)`
	`A.a3 = f7(`A_1`.a3)`
	`B.b1 = f8(`A_1`.a3)`
	`A.a4 = f9(A.a2,`A_1`.a4)`
`p5: A ::= C`	`C.c1 = f10(A.a1)`
	`A.a3 = f11(C.c2)`
	`A.a4 = const2`

List the synthesized and inherited attributes for A, B and C

b Give the definition of the induced attribute dependencies.

c Calculate the induced attribute dependencies for A, B and C

d i) Give an admissible partition for nonterminal A.

ii) Give the visit sequences emitted for production p4.

The four parts carry, respectively, 10%, 20%, 40% and 30% of the marks.

3a When is an expression a+b available at a point p?

b The calculation of available expressions can be described in terms of expressions being generated or killed.

i) When is an expression a+b killed in a block B?

ii) When is an expression a+b generated by a block B?

c. Consider the language defined by the following syntactic rules, where G is the start symbol:

```
G -> S
S -> x := y op z
S -> S ; S
S -> if x then S else S
S -> while x do S
S -> exit
```

where execution of an exit statement causes termination of the innermost enclosing loop.

Write equations which describe available expressions using the following attributes:

S.in	set of expressions available immediately before S
S.out	set of expressions available immediately after S
S.gen	set of expressions generated by S
S.kill	set of expressions killed by S

The three parts carry, respectively, 15%, 15% and 70% of the marks.

4 Consider the following loop:

```
for i = 1 to N
   for j = i to N
S:   A[i,j] = A[i-1,j-1] - A[i-1,j];
```

a Draw the iteration space for this loop, showing all dependences.

b Write down the dependence distance vectors present.

c Write down the unimodular transformation matrix M_{int} representing the interchange of these two loops. Use M_{int} and the loop's dependence distance vectors to demonstrate that interchange is valid.

d Draw an iteration space diagram to explain the effect on the *original* example of the following unimodular transformation matrix. Is it valid?

$$U = \begin{pmatrix} 1 & -1 \\ 0 & 1 \end{pmatrix}$$

e Draw an iteration space diagram to explain the effect on the *original* example of the following unimodular transformation matrix. Is it valid?

$$V = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

f Is the composition $U \cdot V$ valid? Explain using an iteration space diagram.

The six parts carry, respectively, 10%, 10%, 20%, 20%, 20% and 20% of the marks.

End of Paper