Birkbeck
(University of London)

MSc Examination

Department of Computer Science and Information Systems

COMPUTER SYSTEMS (COIY060H7)

CREDIT VALUE: 15 credits

Date of examination: 23/05/2013
Duration of paper: 10:00–12:00

There are five questions in this paper; each of them is compulsory and worth 20 marks.
The paper is not prior-disclosed.
The use of electronic calculators is not permitted.

1. Consider the following assembly code:

```
 I1: LOAD r3 (r1)
 I2: MOVE r4 #1
 I3: ADD r3 r3 r4
 I4: LOAD r2 (r2)
 I5: MOVE r4 #2
 I6: MUL r2 r2 r4
 I7: MUL r3 r3 r2
 I8: LOAD r4 (r1)
 I9: MOVE r1 #3
I10: ADD r4 r4 r1
I11: MUL r3 r3 r4
```

   (a) Describe in a single mathematical formula the result of the above code. (4 marks)

   (b) List and briefly describe the different addressing modes appearing in the above code. (6 marks)

   (c) List all the data (true or otherwise) dependencies in the above code. (10 marks)

2. (a) Describe the main techniques used by superscalar processors to achieve a high degree of machine-level parallelism. (6 marks)

   (b) Using register renaming reorganise the code from the previous question and show the pipeline activity when it is executed on a superscalar processor. There are three pipeline stages: fetch–decode, execute and write-back. There are two units for each of fetch–decode, execute (one adder and one multiplier) and write-back. (14 marks)

3. (a) What is the difference between a virtual and a physical address? (6 marks)

   (b) How does address translation work in a paging system? (6 marks)

   (c) A system has 48-bit virtual addresses and 36-bit physical addresses. If the system uses 4 KB pages, how many virtual and physical pages can the address space support? How many page frames are there if the size of main memory is 128 MB? (8 marks)

4. (a) Describe the three fundamental ways for performing I/O and compare their advantages and disadvantages. (8 marks)

   (b) A hard disk rotates at 15,000 rpm and has 1024 tracks, each with 2048 sectors. It takes 100 ms for the head to cross 1024 tracks. Assume that the head is above the innermost track.

i. What is the average seek time?

ii. What is the average rotational delay (latency)?

iii. What is the transfer time for one sector? You can round the result to the nearest microsecond.

iv. Using the above results compute the total average time to service a request of reading 1024 consecutive sectors. You can round the result to the nearest millisecond.

(12 marks)

5. (a) Explain the concepts of race condition, critical section (or region) and mutual exclusion in the context of interprocess communication. (5 marks)

(b) Briefly describe the use of binary semaphores in the context of interprocess communication. (5 marks)

(c) Consider the following proposed solution to the Dining Philosophers problem for five philosophers:

```
semaphore fork[5] = 1;
semaphore s = 1;
int i
void philosopher(int i)
{
   while(true) {
   think();
   wait(s);
   wait(fork[i]);
   wait(fork[i+1 mod 5]);
   signal(s);
   eat();
   signal(fork[i]);
   signal(fork[i+1 mod 5]);
   }
}
```

Determine whether this program avoids deadlock and starvation. (10 marks)

