Total Marks: 20 **Duration: 50 min**

CS2011 Foundations of Computing Systems, Test 2

Oct 16, 2025

Q1. Consider the language of expressions over integers with operators `+` and `*`.

(a) (5 points) Give an OCaml data type `expr` to capture the abstract syntax tree of expressions.

(b) (5 points) Write a function `eval : expr -> int` which evaluates the expression to the corresponding value.

Q2. Answer the following questions based on the Hack assembly language program (with symbolic variables and labels) given below:

1	@1
2	$D = A$
3	@X
4	$D = M$
5	$M = D$
6	$0; 0$
7	@Y
8	$D = A$
9	$M = D + 1$
10	$(LOOP)$
11	@X
12	$D = M$
13	@Y
14	$M = D + M$
15	@X
16	$D = M$
17	$M = D + 1$
18	@10
19	$D = D - A$
20	@$LOOP$
21	$D; JLE$

(a) (1 point) What are the symbols that are used in the code?

(b) (2 points) Resolve each of the above symbols by assigning 15-bit values to each. Your answer should be in the tabular format given below:

Symbol	Variable or Label	Allocation
foo	variable	0
bar	variable	1
WHILE	label	15

The middle column indicates whether the symbol is a program *variable* or a program *label*.

(c) (3 points) Hand assemble the above program. You do not have to give the binary values of the instructions but only resolve the symbolic values in accordance with the table that you gave above.

(d) (4 points) Explain what the program does by explaining what each chunk of code does. By a chunk we mean lines of code separated by an empty line.