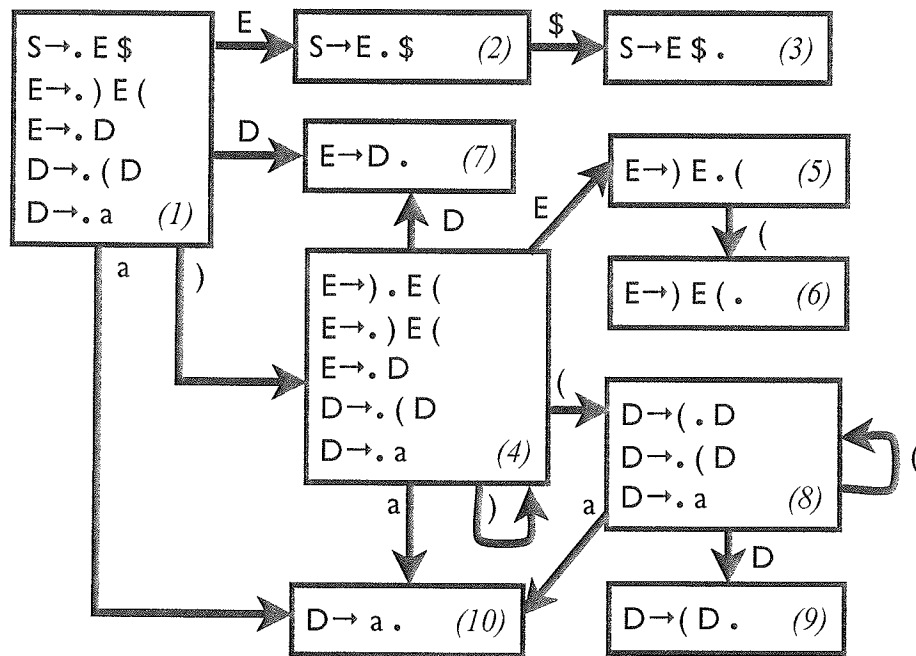


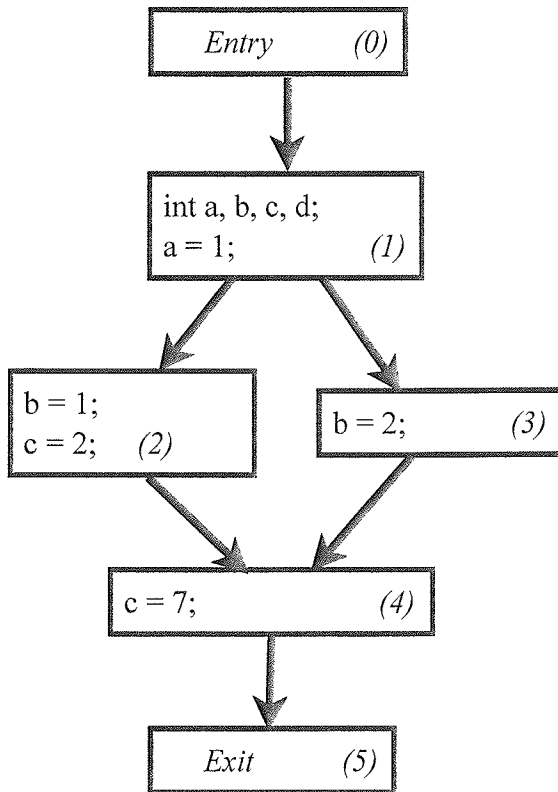
1. **(6 points)** Consider the language  $L_1$  defined by the regular expression  $0^n 1^{n+k}$ ,  $k \geq 0$ . Can a finite state machine recognize  $L_1$ ?
2. **(6 points)** Express  $L_1$  from Question 1, above, using a grammar with  $S$  as the start symbol. Tell what the terminals and non-terminals for  $L_1$  are. *Note: this can be done with a grammar with four productions, but points will not be deducted if your grammar has eight or fewer productions.*
3. Use the CFM at the bottom of the page to answer parts a, b and c of this question.
  - a. **(6 points)** Let the symbol stack be  $) ($  (where  $($  is the top of the stack), the state stack is  $1 4 8$ , and the next symbol is  $a$ . What is the next parser action, and the state of the symbol and state stack after that parser action? When specifying the parser action, give the action and the production recognized if a reduction.
  - b. **(6 points)** Let the symbol stack be  $) E ($  (where  $($  is the top of the stack), the state stack is  $1 4 5 6$ , and the next symbol is  $\$$ . What is the next parser action, and the state of the symbol and state stack after that parser action. When specifying the parser action, give the action and the production recognized if a reduction.



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4. This question pertains to *uninitialized variable* analysis. A variable  $V$  is uninitialized in a function  $foo$  if there is some path from the beginning (entry point) of  $foo$  to a use of  $V$  in  $foo$  along which  $V$  never initialized (assigned a value). For the purpose of this problem we ignore parameters and global variables.
- i. (20 points) Fill in a table like the one below *in your blue books – do not fill in the table below*.
  - ii. (4 points) Based on your analysis, what variables are uninitialized with entering block 4?

Block	GEN	KILL	IN	OUT
1				
2				
3				
4				



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5. Given the loop nest:

```

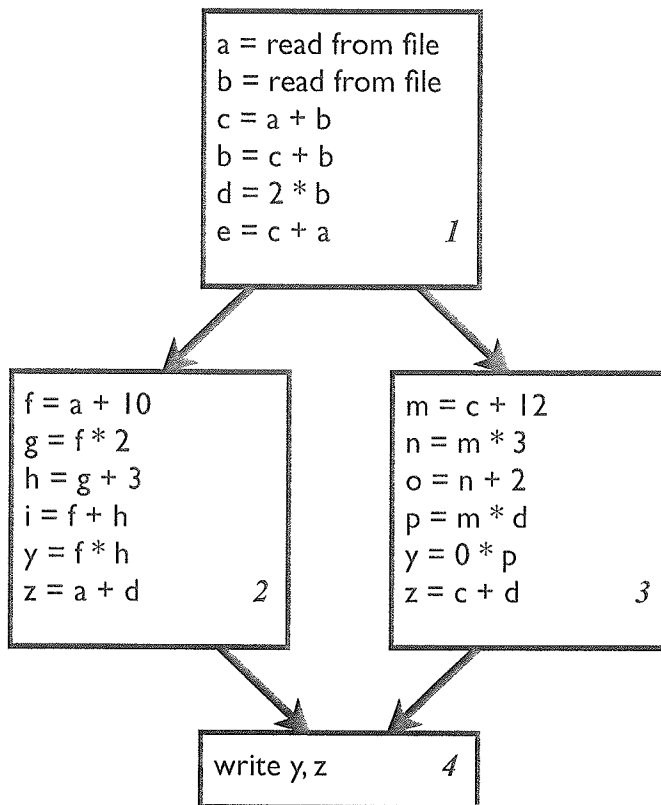
for (i = 0; i < n; i++) {
  for (j = 0; j < n; j++) {
    a[b[i], j] = c[i, j] + d[i, j-1];
    c[i+1, j] = . . .;
    d[i-1, j] = a[i, j];
  }
}

```

- a. (5 points) Describe the dependences, if any, on the “c” array in the loop nest above. Either say “no dependence”, or, if one or more dependences exists, give the type(s) (flow or true, output or anti), the direction and the distance.
  - b. (5 points) Describe the dependences, if any, on the “d” array in the loop nest above. Either say “no dependence”, or, if one or more dependences exists, give the type(s) (flow or true, output or anti), the direction and the distance.
  - c. (5 points) Name the dependences, if any, on the “a” array in the loop nest above. Either say “no dependence”, or, if one or more dependences exists, give the type(s) (flow or true, output or anti). There is no need to give the distance and direction.
  - d. (5 points) Which loop(s), if any, can be parallelized in the loop nest above, without performing any other transformation?
6. Sloth Computers, Inc. slows the clock rate on their new processor such that all memory accesses can occur in a single cycle. Previously, memory accesses took 100 cycles, cache accesses took 2 cycles, and register accesses took 1 cycle. For each of the four transformations below, say if the transformation is more important, less important or of the same importance with the new processor as with the old processor, and explain why in 40 words or less.
- a. (4 points) Register allocation
  - b. (4 points) Loop interchange
  - c. (4 points) Loop parallelization
  - d. (4 points) Loop tiling

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7. Given the following control flow graph, answer questions a, b, c and d below



(a) (4 points) What variables are *live* upon exit from block 1?

(b) (4 points) What variables are *live* upon exit from block 2?

(c) (4 points) Make the following assumptions:

1. All variables used in Block 1 are held in registers;
2. All possible uses of the variable are shown in in the control flow graph above;
3. Register allocation occurs independently within each block in the control flow graph;
4. And, because of (3), the register allocator assumes that every register is free and available at the start of each basic block.

What variables need to be saved upon leaving Block 1 in the control flow graph above?

(d) (4 points) Make the following assumptions (identical to those in (c) above:

1. All variables used in Block 3 are held in registers;
2. All possible uses of the variable are shown in in the control flow graph above;
3. Register allocation occurs independently within each block in the control flow graph;
4. And, because of (3), the register allocator assumes that every register is free and available at the start of each basic block.

What variables need to be saved upon leaving Block 3 in the control flow graph above?