CS591-5 Final

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Total marks = 60, Time = 120 min

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Read the instructions and questions carefully. You may make any reasonably assumptions that you think are necessary; but state them clearly. Answer briefly. For questions with sub-parts, the division for the sub-parts are given in square brackets.

1. [20] **End-to-end**: Consider the following snippet of C code.

```
// Assume: i, num, val are integer variables.
//         Array A is a one dimensional array of integers.
//         print is an method that takes two integers as args.
//         Size of integer = 32 bits.
//         Number of available registers = 4; each of size 32 bits.

    for (i=0;i<num;i=i+1)
        if (A[i] == 0)
            break;
    print(i,0);
```

   List ten unique tokens identified by the scanner [4]. Generate the corresponding three-address-codes [6]. Show the live-range interference graph [6]. Using the Kempe's heuristic do the register allocation (state the variables that gets registers/spilled) and show the generated code [4]. [Bonus] Use a hypothetical architecture and its assembly code to generate the final code [2].

2. [20] **Reaching definitions**. (a) Define reaching definition [2].
   (b) Give two example program snippets (smaller the better) to show how reaching definitions can be used by the compiler to do something meaningful [4].
   (c) Define IN and OUT functions for any basic-block n in terms of (other) IN, OUT, GEN and $KILL$ maps [3].
   (d) Argue that the worklist based algorithm (discussed in the class) that computes reaching definitions terminates [3].
   (e) What is the complexity of the algorithm in big O notation? [3]. Briefly discuss.
   (f) To compute reaching definitions, in the algorithm, we initialize the OUT maps to the empty set. If it was initialized to the set of all the definitions then will we get the desired solution? Yes, No, Sometime? Explain [3]. Feel free to explain using examples.
   (g) What would happen if IN maps (for all the nodes except $entry$) were initialized to the empty set? To the set of all the definitions? [1+1]

3. [20] **Mixed-Bag** (a) Consider the following grammar to derive while loops:

```
S -> WhileStmt
     | SeqStmt
     | BreakStmt
WhileStmt -> while (cond) { S }
SeqStmt -> S  S
BreakStmt -> break;
```

   For each of the possible nodes in the syntax tree, specify how you will process them to generate three-address codes [10].
   (b) Draw the constant-propagation lattice, and define the meet and join rules [2].
   (c) Which all C language constructs lead to merge points where we take meet of the constants, during our constant propagation algorithm? [3]
   (d) Present an extension to the discussed constant propagation algorithm to handle conditional constants [5]. That way, your algorithm should be able to identify conditional constants in codes of the following form:

```
a = 2; c = a;
...
if (c == 2){
    ...
    b = 3
    ...
}else {
    ...
    b = 4
    ...
}
print a, b, c; // a, c are simple constants.
               // b is a conditional constant that evaluates to 3. Since it can
               // proven that only one branch is ever taken - since we know
               // the value of the condition is always the same (true, in this case).
```