B1. Compilers (25 points) Answer all parts.

1. (8 points) Each phase of a compiler is able to detect and attempt recovery from errors. For the scanning, parsing, semantic analysis, and code generation phases, indicate an error that is most appropriately identified by that phase and describe a good strategy for recovery from that error.

2. (6 points) Explain the differences between a symbol table and a string table in terms of their purpose, operations performed on them, and when they are used during compilation.

3. (4 points) Give an example that demonstrates the difference between structural and name equivalence. What are the tradeoffs between these different strategies for type equivalence?

4. (7 points) Object-oriented programming languages add a level of complexity to compilation. Describe the additional data structures needed during compilation and/or runtime for implementing an object-oriented language, and how these data structures are used during compilation and/or runtime.

B2. Compilers (25 points) Answer all parts.

1. (12 points) Clearly justify the following TRUE statements.
   a. A display requires only a constant amount of overhead on each function call and on each nonlocal variable access.
   b. The access link of a callee may be the same as the callee's control link.
   c. Once a basic block begins to execute, the whole block is guaranteed to execute.
   d. Mark-sweep garbage collection is guaranteed to identify and reclaim all the garbage in the heap.

2. (13 points) You have been hired by Crazy Compilers Inc. They need you to add some features to the compiler. For each feature below, describe which phases need to be modified: scanning, parsing, semantic analysis, code generation, and justify why other phases do not need to be modified.

   a. Replace the WHILE statement by a REPEAT-UNTIL statement.

   b. Enable methods of classes to be either public or private, by using keywords private or public as part of the method header. Insure that proper checks are imposed by the compiler upon misusing a private method outside the class.

   c. Change the semantics of an IF statement to short circuit the evaluation of the predicate when possible to save on runtime expression evaluation.

B3. Compilers (25 points) Answer all parts.

1. (6 points) Identify a language feature that motivates the use of a stack storage allocation policy instead of a static store only. Identify 2 features of languages that motivate the use of a heap for storage. Justify your answers.

2. (9 points)
(a) For the following code segment, show the live variables after each statement.

Defs of X and Y before first statement below
1. A = X + Y
2. B = A + Y
3. Z = A * 2
4. C = A
Uses of Z and C after this point

(b) Show a rewrite of this code segment using only 2 physical registers, adding other statements as needed to maintain semantic correctness.

(c) Explain the difference in goals between global and local register allocation, and the issues that need to be addressed by a global register allocator.

3. (5 points) Describe the actions of a type checker at a function call for a dynamic dispatch.

4. (5 points) Describe the actions of a code generator for the statement

stackit.push(c, d) where the language is object-oriented and the call requires a dynamic dispatch.

B4. Compilers (25 points) Answer all parts.

1. (7 points) Give a regular expression that recognizes C-style comments of the form:

/* comment text */

where the comment text doesn't include /* or */

2. (8 points) Augment the RE to also support C99 (C++) style comments:

// comment line

These are all valid:

// This has new // C++ style comment
// This has an /* old style comment */ in it
/* This has a // C++ style comment */

Consider the following grammar:

S -> A B
A -> A A | B C | a
B -> b
C -> c

3. (4 points) Compute the FIRST and FOLLOW sets for all the nonterminals in the grammar.

4. (6 points) Construct an SLR parsing table for this grammar. Show your work.