1. (a) X = java, X = haskell
(b) X = mary
(c) No.
(d) X = mary

2. A closure is a way to encapsulate the environment in which a function is declared so that if the function is passed as a parameter or returned from another function, it will still have access to any variables or other objects that were included within its original scope.

3. Encapsulation, inheritance, dynamic method binding (polymorphism)

4. (a) 7
(b) (a b c)
(c) (2 3 4 5)
(d) 2

5. (c) – the type of function f

6. A side effect is any action that changes the state of the environment in which expressions or functions are evaluated. Simply updating a variable with an assignment statement in a language such as C or Java is an example of a side effect.

7. i = 10, j = 0, k = 33, *p = 10

8. Answer: (a). In (b), the appearance of the “++” operator implies that all three parameters must be lists. In (c), there aren’t enough operands (there should be three) and no lists are involved (and the operands must be numeric). In (d), there aren’t enough operands and no lists are involved, only a tuple.

9. True or False:
   (a) False. Haskell is a pure functional language; it doesn’t have variables. The \texttt{let} command binds a value to a name within a given context.
   (b) False. Java is statically scoped.
   (c) True.
   (d) True.

10. Letting numrows = 20, numcols = 10, row = 2, col = 1, and using the fact that an int requires four bytes, the formula is \((row \times numcols + col) \times 4 = (2 \times 10 + 1) \times 4 = 84\).
11. \[ g(3) = f(2 \cdot 3 \cdot 3) = 2 \cdot 2 + 3 - 3 = 4 \]

12. The output is (b): Parent: Parent, Child: Child

13. The output is (d): Parent: Child, Child: Child

14. By default, C++ uses static method binding; Java uses dynamic method binding.

15. Program (a) prints the value 20 because the local variable \( x \) has scope equal to the entire function (not just the inner set of “{ . . . }” in which it is declared). Note that this scope hides (“shadows”) the value of the parameter \( x \). Program (b) prints the value 1 because the “let” declaration creates a variable whose scope is just the innermost block in which it is declared (in this case, the innermost curly braces). Since the \( \text{console.log} \) call appears outside this block, the value of \( x \) used is the one passed in as a parameter.

16. A binary operation \( \text{op} \) is right-associative if the default order of evaluation is from right to left, i.e., \( x \text{ op } y \text{ op } z = x \text{ op } (y \text{ op } z) \).

17. (a) needs(X,cs280).
   (b) \( X = \text{cs210}, X = \text{cs220}, X = \text{cs280} \)

18. Applicative order involves the evaluation of all parameters before executing the function.

19. \([4,9,16,25]\)

20. \((3 \cdot 3 \cdot 3 \cdot 3)\)

21. In a struct, all variables have their own memory locations. In a union, variables share a common area of memory.

22. Lexical analysis (scanning); syntactic analysis (parsing); semantic analysis; intermediate code generation; optimization; code generation. (In addition there is an optional preprocessing step and an optional final optimization step.)

23. The static pointer points to the activation record of the nearest enclosing function (in the sense of lexical scoping). The dynamic pointer points to the previously invoked function, i.e., the one that called the function containing the pointer in question.

24. In line 5, the string constant is statically allocated. In lines 3 and 4, variables \( i \) and \( j \) are allocated on the stack. In line 2, the newly-constructed stack is dynamically allocated from the heap.