

1. According to the IEEE standard, a 32-bit, single-precision, floating-point number N is defined to be

$$N = (-1)^S \times 1.F \times 2^{E-127}$$

where S is the sign bit, F the fractional mantissa, and E the biased exponent.

A floating-point number is stored as $S E F$,
where S , E , and F are stored in 1 bit, 8 bits, and 23 bits,
respectively.

What is the decimal value of the floating-point number C1 E0 00 00 (hexadecimal notation) ?

- (A) 26
- (B) -15
- (C) -26
- (D) -28
- (E) -59

2. Consider this grammar

Grammar G:

$$E \rightarrow E + T \quad | \quad T$$
$$T \rightarrow T * \mathbf{v} \quad | \quad \mathbf{v}$$

Answer the following 7 items.

A. The highest priority operator is +.

TRUE FALSE

B. * is in the set of Terminals

TRUE FALSE

C. The Start symbol is any element of the set { E, T }

TRUE FALSE

D. This grammar uses EBNF notation.

TRUE FALSE

E. The statement $v + v * v$ can be derived from this grammar.

TRUE FALSE

F. This is an ambiguous grammar.

TRUE FALSE

G. This grammar is left-associative.

TRUE FALSE

3. Which of the following is the name of the data structure in a compiler that is responsible for managing information about variables and their attributes?

- (A) Abstract Syntax Tree (AST)
- (B) Attribute Grammar
- (C) Symbol Table
- (D) Semantic Stack
- (E) Parse Table

4. Which of the following characteristics of a programming language is best specified using a context-free grammar?

- (A) Identifier length
- (B) Maximum level of nesting
- (C) Operator precedence
- (D) Type compatibility
- (E) Type conversion

5. This ML function split takes a list as its single argument.

```
fun split (nil)      = (nil, nil)
  | split ([a])      = ([a], nil)
  | split (a::b::cs) =
      let
        val (M,N) = split (cs)
      in
        (a::M, b::N)
      end;
```

Answer the following three items

A. How many patterns are specified for possible arguments:

- i. one
- ii. two
- iii. three
- iv. four

B. For the pattern $a :: b :: c$, give an example of a list that DOES match. You can give the complete function call or just the argument.

C. For the pattern $a :: b :: c$, give an example of a list that does NOT match. Again, complete function call or just the argument.

D. FOR EXTRA CREDIT - describe in English what the split function does.

6. A 2D array of bytes is specified in a row-major order implementation of a language.
`arr [ -1 .. +1, -2 .. +2 ] of byte;`

Answer the following 4 items.

A. The total number of bytes required is

- i. 3 bytes ii. 5 bytes iii. 8 bytes iv. 15 bytes

B. The base of the array corresponds to which element:

- i. `arr [ -2, +2 ]` ii. `arr [1, 2]`
 iii. `arr [-1, -2]` iv. `arr [-1, +1]`

C. The size of each element is:

- i. 1 byte ii. 5 bytes iii. 15 bytes iv. 0 bytes

D. the offset to `a [0, 0]` from element `a [-1, -2]` is:

- i. 8 bytes ii. 7 bytes iii. 6 bytes iv. 5 bytes

7. A 2D array is declared as:

`a [ rlb .. rub, clb .. cub ] of dataType;`

The size of `dataType` is `d`.

The formula to compute the address of element `a[r, c]` in a row-major 2D array is:

A. $\text{addr}(a[\text{rlb}, \text{clb}]) + (r - \text{rlb}) (\text{cub} - \text{clb} + 1)d + (c - \text{clb})d$

B. $\text{addr}(a[0, 0]) + (r - \text{rlb}) (\text{cub} - \text{clb} + 1)d + (c - \text{clb})d$

C. $\text{addr}(a[\text{rlb}, \text{clb}]) + (c - \text{clb}) (\text{rub} - \text{rlb} + 1) d + (r - \text{rlb})d$

D. $\text{addr}(a[\text{rlb}, \text{clb}]) + (r - \text{rlb}) (\text{cub} + \text{clb} - 1)d + (c - \text{clb})d$

8. Two datatypes, a structure named `rec`, and a union named `element` are declared as follows:

```
structure rec {
    int i1;
    int i2;
    int i3;
}

union element of int {

    struct rec:    item;
    String:       name;    // name is a reference
    int:          i1;
};

structure rec  r;
union element e;
```

Thus, you have declared two variables, `r` and `e`. `r` is a structure containing three `int` fields. `e` is a union of three fields, a structure, a reference and an `int`.

Assume union `element` does NOT have a tag.

The size of an `int` and the size of a reference is 4 bytes.

A. What is the total size required for variable `r` ?

B. What is the offset to `r.i2`?

C. What is the total size required for variable `e`?

D. What is the offset to `e.i1`?

E. What is the offset to `e.item.i3`?

9. Give two examples for something that is bound at each of the following binding times:

A. Language Specification (Definition) time

B. Compile time

C. Run time

10. Consider this grammar:

$S \rightarrow () \mid (S) \mid \mathbf{a}$

Non terminals = {S}

Terminals = { (,) , **a** }

A. Show the derivation tree for ((a))

B. The grammar is ambiguous

TRUE FALSE

C. Give an EBNF version.

11. Consider this program fragment with lexical scope. Fill in the table showing what variables are accessible in each procedure and where they are defined. I've filled in the second row.

```

program main {
  var g1: int;
  var g2: array 3 of bool;

  procedure P () {
    var p1: bool;
    var p2 : int;

    procedure Q() {
      var q: array 3 of char;

      procedure R() {
        var r: bool;
        . . .
      } //end R

      . . .
    } //end Q

    procedure S() {
      var s : array 3 of int;

      procedure T() {

        var p1: bool;
        var t: bool;
        . . .
      } // end T

      . . .
    } // end S

    . . .
  } // end P

  . . .
} // end main

```

<u>routine</u>	<u>local variables</u>	<u>non-local</u>
main		
P	p1, p2	main.g1, main.g2
Q		
R		
S		
T		

12. EXTRA CREDIT QUESTIONS

12. A. For # 6, which answer (A - D) corresponds to column major addressing.

12. B. Give the corresponding address computation for $b[i]$ where $b[]$ is defined:

$b \text{ [lb .. ub] of int;}$

12. C. Give the expression tree for this arithmetic expression:

$(a + b) * (c + a) - b$

12. D. Store + 2.0 in IEEE floating point format.

12. E. Give one example of a language implementation time binding.

Give one example of a link time binding.