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CS 3160-001
Assignment #4
10/25/18

1. What can types be used for?
   a. Catch errors in the program early at compile time.
   c. Help categorize the key concepts of programs into meaningful groups.
   d. Enable polymorphic functions.

2. Which are must-have components of a type system?
   a. Basic types and their built-in operators.
   b. Compound types, their constructors, and operations to extract their values.
   c. Ways to determine whether two types are the same.
   e. Ways to check whether each operation is applied to the correct types.

3. What is the difference between transparent and opaque type declaration?
   a. A transparent declaration introduces a synonym for an existing type; an opaque one introduces a new compound type that didn't exist before.

4. Which of the following is NOT an example of type errors?
   c. Null pointer dereference.

5. Which of the following type errors can be caught at compile time?
   a. Adding an integer with a string.
   b. An array being accessed out-of-bounds.
   d. A value being casted to an unrelated type.
   e. Dividing a value by zero.

6. Map the components to the information they store.
   Runtime stack – dynamically allocated memory
   Heap – values of variables
   Code space – instructions of the program
   Code pointer – the next statement to evaluate

7. Which of the following is NOT a block?
   e. x = x + 2; y = y + 2;

8. What value should be returned for the following ML code if static scoping is used? What value should be returned if dynamic scoping is used?

```
let val x = 3
   in let fun foo(y) = x * y
      in let val x = 5 in foo(5)
        end
     end
end;
```

   Static scoping: 15
   Dynamic scoping: 25

9. What is the result of the following pseudocode when each of the parameter passing mechanisms, pass-by-name, pass-by-value, and pass-by-reference, is used?

```
int f (int x) {
    x:= x+1; return x;
};
main() {
    int y = 0;
    print f(y)+y;
}
```

Pass-by-name: f(y) → y:=y+1 → (y+1) +y → 1

Pass-by-value: f(0) → x:=0+1 → 1 → 1 +0 → 1

Pass-by-reference: f([ref]y) → y:=0+1 → 1 +1 → 2

10. Draw a pictorial snapshot of the run-time stack memory for the following ML code.

```
val x = 1;
fun g(z) = x+z;
fun h(z) =
    let
        x = 2
    in
        g(z)
    end;
h(3);
```

	Run-time Stack	
outer block	x	1
g block	Control Link	
	Access Link	
	g	x+z
f block	Control Link	
	Access Link	
	h	g(z)
	x	2
h(3) block	Control Link	
	Access Link	
	z	3
g(3) block	Control Link	
	Access Link	
	z	3