CSE340 SPRING 2020
Homework 5
DUE Monday 13 April 2020

PLEASE READ THE FOLLOWING CAREFULLY

- Your answers for all problems must be types
- On Gradescope, you should submit the answers to separate problems separately.

PROBLEM 1

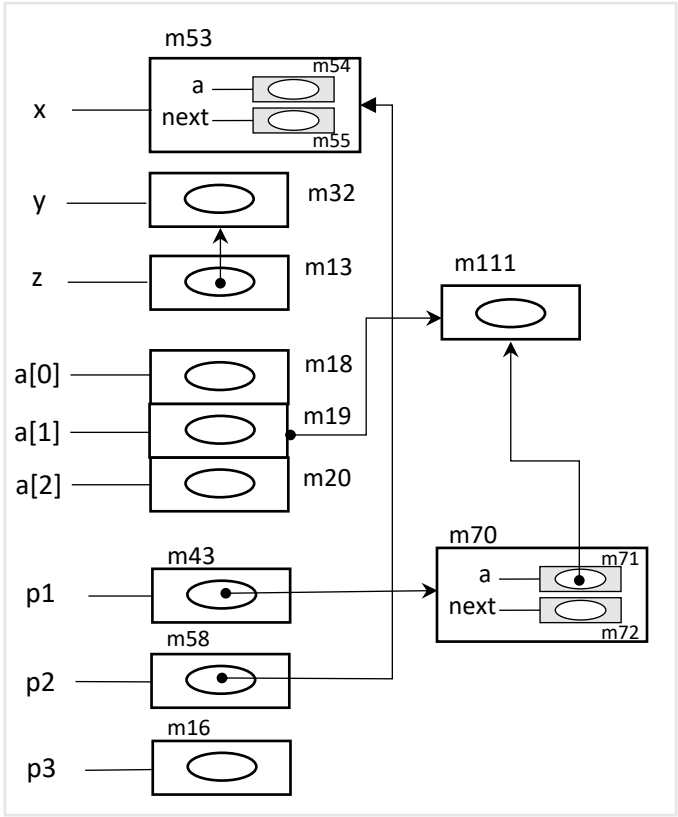
Assume stack memory allocation for nested scopes is used (which means that memory for variables in a scope is allocated on the stack and that it is deallocated when the scope is exited). Consider the following code below and the box-circle diagram to the right which illustrates the situation at **point 1.**

```
struct T {
    int *a;
    struct T* next;
};

int *y;
int **z;
int **w;
struct T   x;
struct T*  p1;
struct T*  p2;
struct T**  p3;

void f()
{ // the following malloc() call allocates m102
  // (which is not shown in the diagram because
  // f() is called after point 1)
  y = (int *) malloc(sizeof(int));
  x.a = y;
}

main()
{  p1 = (struct T*) malloc(sizeof(struct T));
   p2 = &x ;
   { int* a[3];
     a[1] = (int *) malloc(sizeof(int));
     (*p1).a = a[1];
     z = &y ;
     w = &a[1];            // point 1
   }
   f();                    // point 2
   free(y);
   (*p1).next = &x;        // point 3
   // point 4
}
```



Question 1. What is the location associated with *p1 at point 1?

Question 2. What is the location associated with *z at point 2?

Question 3. What is the location associated with *(x.a) at point 2?

Question 4. What is the location associated with *((*p1).next) at point 2?

Question 5. What are the dangling references, if any, at point 2?

Question 6. What are the locations that are garbage, if any, at point 3?

Question 7. What are the dangling references, if any, at point 3?

Question 8. Assume that the following is executed at point 3 (this applies only to this question):

```
p3 = &p1;
*p3 = &(*((*p1).next));
```

This will results in news arrows, if any, from where to where?

Question 9. Assume the following is executed at point 4:

```
p2 = (struct T*) malloc(sizeof(struct T));
(*p1).next = p2;
p1 = p2;
```

what location become garbage due to the execution of the code?

Question 10. If we execute free(p2) after the code above, what are the new dangling references, if any, that result from that?

Question 11. What is an alias of x at point 1 (the alias should have a variable other than x. Something like *&x does not count)

Question 12. What is an alias of a[0] at point 1. Tthe alias should have a variable other than a.

PROBLEM 2: Lambda Calculus

Question 1. Write a non-recursive lambda expression to compute the n'th Fibonacci number. The Fibannaci numbers are defined as follows

$F_1 = 1$
$F_2 = 1$
$F_n = F_{n-1} + F_{n-2}$ if $n > 1$

Question 2. Write a recursive lambda expression to compute the n'th Fibonacci number.

Question 3. Write a non-recursive lambda expression to calculate the sum of the first n squares:

$$1^2 + 2^2 + 3^2 + 4^2 + \ldots + n^2$$

You should not use a closed-form formula for the sum

Question 4. Write a recursive lambda expression to calculate the sum of the first n squares:

$$1^2 + 2^2 + 3^2 + 4^2 + \ldots + n^2$$

You should not use a closed-form formula for the sum

PROBLEM 3: Type Systems

This problem refers to the type system of the Go Programming Language. You can find the specification at https://golang.org/ref/spec. In particular you should consult the section on types: https://golang.org/ref/spec#Properties_of_types_and_values.

I expect you to consult the specification to answer the questions below.

Question 1. What is the term used in the Go language to refer to type compatibility?

Question 2. What term is used in the Go language to refer to type equivalence?

Question 3. Can a function type with a variable number of parameter be identical to a function type with a fixed number of parameters?

Question 4. If two types are structurally equivalent according to the definition we covered in class, would the two types be identical according to the Go language? Explain or give a counterexample.

Question 5. If two types are identical according to the Go language, are the two types structurally equivalent according to the definition we covered in class? Explain or give a counterexample.

The following are examples given in the Go language spec

```
type (
        A0 = []string
        A1 = A0
        A2 = struct{ a, b int }
        A3 = int
        A4 = func(A3, float64) *A0
        A5 = func(x int, _ float64) *[]string
)

type (
        B0 A0
        B1 []string
        B2 struct{ a, b int }
        B3 struct{ a, c int }
        B4 func(int, float64) *B0
        B5 func(x int, y float64) *A1
)

type    C0 = B0
```

For the following questions, you should give explanations that are more specific than what is given in the specification document.

Question 6. Are A2 and B2 in the example above identical? Why?
Question 7. Are struct {a, b int} and struct {a, c int} identical? Why?
Question 8. Are struct {a, b int} and B2 in the example above identical? Why?
Question 9. What is the return type of the function type A5 in the example above?
Question 10. Explain why A4 and A5 are identical.