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CS 381 Homework 6 – Scope and Parameters

Problem 1. Runtime Stack (static scoping and call-by-value parameter passing)

```
1   [x:?]
2   [z:?, x:?]
3   [z:4, x:?]
4   [f:{}, z:4, x:?]

11 >>
    4 [x:3, f:{}, z:4 ,x:?]
    8 >>
        4 [x:2 x:3 f:{} z:4 x:?]
        8 >>
            4 [x:1 x:2 x:3 f:{} z:4 x:?]
            8 >>
                4 [x:0 x:1 x:2 x:3 f:{} z:4 x:?]
                6 [x:0 x:1 x:2 x:3 f:{} z:1 x:?]
                9 [ret:1 x:0 x:1 x:2 x:3 f:{} z:1 x:?]
              <<
             8 [x:1 x:2 x:3 f:{} z:3 x:?]
             9 [ret:3 x:1 x:2 x:3 f:{} z:3 x:?]
           <<
         8 [x:2 x:3 f:{} z:11 x:?]
         9 [ret:11 x:2 x:3 f:{} z:11 x:?]
        <<
        8 [x:3 f:{} z:123 x:?]
        9 [ret:123 x:3 f:{} z:123 x:?]
        <<
       11 [f:{} z:123 x:123]
       12 [z:123, x:123]
       13 []
```

Thus the fila value z = 123, x=123.

Problem 2. Static and Dynamic Scope (call-by-value parameter passing)

a) Draw the runtime stack after each line executes under static scoping. What value is assigned to z in line 12?

```
1  [x:?]
2  [y:?, x:?]
3  [z:?, y:?, x:?]
4  [z: ?  , y: ?,  x:4]
5  [z:?, y:6, x:4]
6  [f:{}, z:? y:6, x:4]
7  [y: ?, f:{}, z:?, y:6, x:4]
8  [y:13, f:{}, z:?, y:6, x:4]
9  [g:{}, y:13, f:{}, z:?, y:6, x:4]
11  [y:14, g:{}, y:13, f:{}, z:?, y:6, x:4]
12 >>
    9 [x:3, y:14, g:{}, y:13, f:{}, z:?, y:6, x:4]
     >>
        6[y:13, x:3, y:14, g:{}, y:13, f:{}, z:?, y:6, x:4]
        6[ret:52,y:13, x:3, y:14, g:{}, y:13, f:{}, z:?, y:6,
  x:4]
        <<
    9 [ret:52,x:3, y:14, g:{}, y:13, f:{}, z:?, y:6, x:4]
    <<
 12 [y:14, g:{}, y:13, f:{}, z:52, y:6, x:4]
```

Thus the value assigned to z in line 12 is 52.

b) Draw the runtime stack after each line executes under dynamic scoping. What value is assigned to z in line 12?

```
1  [x:?]
2  [y:?, x:?]
3  [z:?, y:?, x:?]
4  [z: ?  , y: ?,  x:4]
5  [z:?, y:6, x:4]
6  [f:{}, z:? y:6, x:4]
7  [y: ?, f:{}, z:?, y:6, x:4]
8  [y:13, f:{}, z:?, y:6, x:4]
9  [g:{}, y:13, f:{}, z:?, y:6, x:4]
11  [y:14, g:{}, y:13, f:{}, z:?, y:6, x:4]
12 >>
    9 [x:3, y:14, g:{}, y:13, f:{}, z:?, y:6, x:4]
    9 >>
       6[y:14, x:3, y:14, g:{}, y:13, f:{}, z:?, y:6, x:4]
       6[ret:42,y:14, x:3, y:14, g:{}, y:13, f:{}, z:?, y:6,
  x:4]
       <<
    9 [ret:42,x:3, y:14, g:{}, y:13, f:{}, z:?, y:6, x:4]
    <<
 12 [y:14, g:{}, y:13, f:{}, z:42, y:6, x:4]
```

Thus the value assigned to z in line 12 is 42.

Problem 3. Parameter Passing (dynamic scoping)

a) Draw the runtime stack after each line executes given that both parameters a and x are passed using **Call-by-Name**. What are the values of y and z after line 13 executes?

Call-by-Name:

```
3[z:?, y:6]
4[f:{}, z:?, y:6]
14 [g:{}, f:{}, z:?, y:6]
12  >>
     10 [x:y*2, g:{}, f:{}, z:?, y:6]
     11 >>
          4[a:x+1, x:y*2, g:{}, f:{}, z:?, y:6]
          5[a:x+1, x:y*2, g:{}, f:{}, z:?, y:14]
               {x=12, a=13, y=a+1=14}
          8[ret:43, a:x+1, x:y*2, g:{}, f:{},z:?,y:14]
               {x=28, a=29, y=14, ret= y+a=14+29=43}
          <<
     11 [x:y*2, g:{}, f:{}, z:?, y:45]
     12  >>
          4[a:x-y+2, x:y*2, g:{}, f:{}, z:?, y:45]
          5[a:x-y+2, x:y*2, g:{}, f:{}, z:?, y:48]
               {x=90, a=90-45+2=47, y = a+1=48}
          8[ret:96, a:x-y+2 , x:y*2 , g:{}, f:{},z:?,y:48]
             {x =48*2=96, a=96-48+2=50, y= 48, ret=y+a=48+50=98}

          <<
       12   [x:y*2, g:{}, f:{}, z:98, y:48]
       13   [res:99, x:y*2, g:{}, f:{}, z:99, y:48]
           <<
```

```
15 [g={}, f={}, z=99, y:48]
```

Therefore, the value z =99, y=48.

b) Draw the runtime stack after each line executes given that both parameters a and x are passed using **Call-by-Need**. What are the values of y and z after line 13 executes?

Call-by-Need:

```
14 [g:{}, f:{}, z:?, y:6]
15  >>
      10 [x:y*2, g:{}, f:{}, z:?, y:6]
      11 >>
           4  [a:x+1, x:y*2, g:{}, f:{}, z:?, y:6]
           5  [a:13, x:12, g:{}, f:{}, z:?, y:14]
                {x=y*2=12, a:x+1=13, y:a+1=14}
           8  [ret:27, a:13, x:12, g:{}, f:{}, z:?, y:14]
                {y:14, a:13 ,ret:y+a=14+13=27}
          <<
      11  [x:12, g:{}, f:{}, z:?, y:29]
      12  >>
           4[a:x-y+2, x:12, g:{}, f:{}, z:?, y:29]
           5[a:-14, x:12, g:{}, f:{}, z:?, y:27]
               {x=12,a=12-29+2=-15, y= -15+1= -14}
           8[ret:-29, a:-15 , x:12 , g:{}, f:{},z:?,y:-14]
             {y=-14, a=-15, ret=y+a= -14+(-15)=-29}


      12 [x:12, g:{}, f:{}, z:-29, y:-14]
      13 [res:-28, x:12, g:{}, f:{}, z:-29, y:-14]
      <<
  15 [g:{}, f:{}, z:-28, y:-14]
```

Therefore, the value z = -28, y= -14