

```

~
7  {- Exercise 1: Runtime Stack
8
9      Assume static scoping and call-by-value parameter passing.
10
11  0  [ ]
12  1  [x:?]
13  2  [y:?, x:?]
14  3  [y:1, x:?]
15  4  [f:{}, y:1, x:?]
16  11 [f:{}, y:1, x:?]
17  11 >>
18      5 [x:2, f:{}, y:1, x:?]
19      8 [x:2, f:{}, y:1, x:?]
20      4 >>
21          5 [x:1, x:2, f:{}, y:1, x:?]
22          8 [x:1, x:2, f:{}, y:1, x:?]
23          4 >>
24              5 [x:0, x:1, x:2, f:{}, y:1, x:?]
25              6 [x:0, x:1, x:2, f:{}, y:1, x:?]
26              9 [res:1, x:0, x:1, x:2, f:{}, y:1, x:?]
27              <<
28                  8 [x:1, x:2, f:{}, y:2, x:?]
29                  9 [res:2, x:1, x:2, f:{}, y:2, x:?]
30                  <<
31                      8 [x:2, f:{}, y:5, x:?]
32                      9 [res: 5, x:2, f:{}, y:5, x:?]
33                      <<
34  11 [f:{}, y:5, x:5]
35  12 [y:5, x:5]
36  13 [ ]
37
38  -}
39
40  {- Exercise 2: Static and Dynamic Scope
41
42      Note: <x,y> denotes <static, dynamic>
43
44      [ ]
45      1  [x:?]
46      2  [y:?, x:?]
47      3  [z:?, y:?, x:?]
48      4  [z:?, y:?, x:3]

```

```

49 5 [z:?, y:7, x:3]
50 6 [f:{}, z:?, y:7, x:3]
51 7 [y:?, f:{}, z:?, y:7, x:3]
52 8 [y:11, f:{}, z:?, y:7, x:3]
53 9 [g:{}, y:11, f:{}, z:?, y:7, x:3]
54 10 [y:?, g:{}, y:11, f:{}, z:?, y:7, x:3]
55 11 [y:13, g:{}, y:11, f:{}, z:?, y:7, x:3]
56 12 >>
57     9 [x:2, y:13, g:{}, y:11, f:{}, z:?, y:7, x:3]
58     >>
59     6 [res: <21, 26>, y: <7, 13>, x:2, y:13, g:{}, y:11, f:{}, z:?, y:7, x:3]
60     <<
61     9 [res: <21, 26>, x:2, y:13, g:{}, y:11, f:{}, z:?, y:7, x:3]
62     <<
63 12 [y:13, g:{}, y:11, f:{}, z:<21, 26>, y:7, x:3]
64 13 [g:{}, y:11, f:{}, z:<21, 26>, y:7, x:3]
65 14 [y:11, f:{}, z:<21, 26>, y:7, x:3]
66 15 [z:<21, 26>, y:7, x:3]
67 16 [ ]
68

```

69 (a) Which value will be assigned to z in line 12 under static scoping?

70

71 z: 21

72

73 (b) Which value will be assigned to z in line 12 under dynamic scoping?

74

75 z: 26

76

77 -}

78

79 {- Exercise 3: Parameter Passing

80

81 Assume dynamic scoping.

82

83 What are the values of y and z at the end of the above block under the  
84 assumption that both parameters a and x are passed:

85

86 (a) Call-By-Name

87

88 0 [ ]

89 1 [y:?]

90 2 [z:?, y:?]

91 3 [z:?, y:7]

-- - - - -

```

92 4 [f:{}, z:?, y:7]
93 8 [g:{}, f:{}, z:?, y:7]
94 13 [g:{}, f:{}, z:?, y:7]
95 >>
96 8 [x:y*2, g:{}, f:{}, z:?, y:7]
97 9 >>
98 4 [a:x+1, x:y*2, g:{}, f:{}, z:?, y:7]
99 5 [a:x+1, x:y*2, g:{}, f:{}, z:?, y:16]
100 6 [res:49, a:x+1, x:y*2, g:{}, f:{}, z:?, y:16]
101 <<
102 9 [x:y*2, g:{}, f:{}, z:?, y:50]
103 10 >>
104 4 [a:x-y+3, x:y*2, g:{}, f:{}, z:?, y:50]
105 5 [a:x-y+3, x:y*2, g:{}, f:{}, z:?, y:55]
106 6 [res:113, a:x-y+3, x:y*2, g:{}, f:{}, z:?, y:55]
107 <<
108 10 [x:y*2, g:{}, f:{}, z:113, y:55]
109 11 [res:114, x:y*2, g:{}, f:{}, z:113, y:55]
110 <<
111 13 [g:{}, f:{}, z:114, y:55]
112 14 [z:114, y:55]
113 15 [ ]
114
115 --
116 y:55, z:114
117
118 (b) Call-By-Need
119
120 1 [y:?]
121 2 [z:?, y:?]
122 3 [z:?, y:7]
123 4 [f:{}, z:?, y:7]
124 8 [g:{}, f:{}, z:?, y:7]
125 13 [g:{}, f:{}, z:g(y*2), y:7]
126 >>
127 8 [x:y*2, g:{}, f:{}, z:g(14), y:7]
128 9 [y:(f(15)+1), x:14, g:{}, f:{}, z:g(14), y:7]
129 >>
130 4 [a:15, y:(f(15)+1), x:14, g:{}, f:{}, z:g(14), y:7]
131 5 [y:16, a:15, y:(f(15)+1), x:14, g:{}, f:{}, z:g(14), y:7]
132 6 [y:32, x:14, g:{}, f:{}, z:g(14), y:7]
133 10 [z:f(-15), y:32, x:14, g:{}, f:{}, z:g(14), y:7]
134 >>

```

```
135      4 [a:-15, z:t(-15), y:32, x:14, g:{}, t:{}, z:g(14), y:/]
136      5 [y:-14, a:-15, z:f(-15), y:32, x:14, g:{}, f:{}, z:g(14), y:7]
137      6 [z:-29, y:32, x:14, g:{}, f:{}, z:g(14), y:7]
138    11 [g:{}, f:{}, z:-28, y:7]
139    14 [z:-28, y:7]
140    15 []
141
142    --
143    y:7, z:-28
144
145    -}
```