1. Suppose that activation records (AR) for a C implementation are stack allocated with the form:

| control link | return-result address | return address | parameter 1 | ... | parameter n | local variable 1 | ... | local variable n | temporary 1 | ... | temporary n |

(The stack grows towards the bottom.)

... and consider the C program:

```c
int f(int n)
{
    if (n <= 0) {
        return 0;
    } else {
        int x = -5;
        x = f(n - 1);
        return n + x;
    }
}
```

(a) Draw the activation records that are on the stack just after the execution of line 7 during the call to f() with the parameter 1. Use the line numbers for return addresses. Draw directed arcs for the control links and return-result addresses. Clearly label the values of parameters and local variables. Label each activation record with the procedure name. Also show which activation record is pointed to by the environment pointer. The activation record for main is shown:

```
main()
```

CONTROL STRUCTURES

2. Rewrite the following structured C program fragment simple using single-line if's with goto's and labels instead of compound statement blocks and else's:

```c
int x = getchar(), y = getchar(), z;
while (x != 'q') {
    if (x > y) {
        z = x - y;
    } else {
        z = y - x;
    }
    f(z);
    x = getchar();
}
```

3. Draw the control flow graph of the following C program fragment, creating a node for each label and using L10 as the start node and L50 as the end node:

```
L10: x = 0;
L20: if(x >= 10) goto L50;
L30: x++;
L40: goto L20;
L50: printf("%d\n", x);
```

4. Besides handling unexpected error conditions, to what other purpose can exceptions be put?
5. List three effects of raising an exception.

6. Consider the following ML fragment:

   ```ml
   exception e of int;
   val f = ...
   val x = ...

   (if x < 3 then 3.15 else raise e(x)) handle e(y) => f(y);
   ```

   (a) What type does `x` need to have for the ML expression to be correctly typed. Explain your answer.

   (b) What type does `f` need to have for the ML expression to be correctly typed. Explain your answer.

   (c) Translate the ML code into a into equivalent Scala code.

Note: If you collaborated with your classmates or used their notes, please note which classmates you collaborated with. If you use an external source, besides the text book, lectures, notes provided by the instructor, and your own intellect, please cite that source. Use quote marks if you are quoting material word-for-word from any source (including the text book).