Exercise 8: Introduction to Programming (Solution)

Problem 1: Java

1. The following function is defined:

```
1  public static int foo(int[] arr)
2  {
3      int m = arr[0];
4      for (int i=1; i<arr.length; i++)
5      {
6          if (arr[i] > m)
7            m = arr[i];
8      }
9      return m;
10 }
```

(a) What will be the returned value of `foo` for the array `arr=[2,−3,3,4,−7]` ?

> **Answer:**
> The function will return 4.

(b) What operation does the function perform?

> **Answer:**
> The function returns the maximum value in the array; it iterates over the array, element by element, using `i` as an index and starting at the second element (`i=1`):
>
> ```
> 4      for (int i=1; i<arr.length; i++)
> ```
>
> If the element in the `i` -th position is bigger than the previous stored maximum `m` (which is set to the first element before the loop starts: see line 3), than it sets `m` to equal this element:
>
> ```
> 6          if (arr[i] > m)
> 7            m = arr[i];
> ```
>
> After the loop finishes it simply returns the value of `m` :
>
> ```
> 9      return m;
> ```
>
> In the case of the above given array, the following values will be calculated (remember that `m` is set to `2` before the loop starts, and so there is no need to start the iteration at `i=0`):
>
i	i < arr[i] ?	arr[i]	i>m ?	m
-	-	-	-	2
1	yes	−3	no	2
2	yes	3	yes	3
3	yes	4	yes	4
4	yes	−7	no	4
5	no	-	-	

(c) How will the answer change if, instead of `if (arr[i] > m)`, the code would be `if (arr[i] < m)`?

> **Answer:**
> The function will return the minimum value in the array.

2. The following function is defined:

```
1  public static boolean bar(int n)
2  {
3      if (n < 2 || (n % 2 == 0 && n != 2))
4        return false;
5
6      int i = 3;
7      while (i < n)
8      {
```

```
        if (n % i == 0)
            return false;
        i = i + 2;
    }
    return true;
}
```

Note: the operator `||` means 'OR', the operator `&&` means 'AND'. The operator `%` is the modulo operator (i.e. it returns the remainder of the division. For example: `3%2=1`, `4%2=0`).

(a) What are the returned values of `bar` for the following numbers: $-3, 1, 2, 3, 4, 5, 9, 11, 16$?

Answer:

n	bar(n)
−3	false
1	false
2	true
3	true
4	false
5	true
9	false
11	true
16	false

(b) Which operation does the function perform?

Answer:
The function checks whether the input integer `n` is a prime number. If it is, it returns `true`, and if it isn't it returns `false`.
The lines

```
    if (n < 2 || (n % 2 == 0 && n != 2))
      return false;
```

check whether `n` is either smaller than `2`, or an even number that is not `2`. If these conditions are met, the function immediately returns `false`. If `n` is an odd number bigger than `2` (or `2` itself) the function continues to the main loop, where it checks whether `n` is divisible without remainder for any odd number smaller than itself (why are the odd numbers sufficient?):

```
    while (i < n)
    {
        if (n % i == 0)
            return false;
        i = i + 2;
    }
```

If this is true for any number (i.e. `9` is divisible by `3` without remainder) it immediately returns `false`. Only if `n` is not divisible by any number smaller than it will the function return `true`.

3. The following function is defined:

```
public static int baz(int n)
{
    int x = 1;
    for (i=1; i<=n; i++)
    {
        x = x * i;
    }
    return x;
}
```

(a) What are the returned values of `baz` for the following numbers: $1, 2, 3, 4, 5$?
Note: `i++` means `i=i+1` (i.e. it increases `i` by one).

Answer:

n	baz(n)
1	1
2	2
3	6
4	24
5	120

(b) Which operation does the function perform?

Answer:
The function returns the factorial of `n`.
It does so by multiplying all integers form `1` to `n` (including both):

```
4     for (i=1; i<=n; i++)
5     {
6         x = x * i;
7     }
```

Problem 2: L-Systems

1. For the following L-systems, write the first N strings (N is given for each system):

(a)

variables: A B
constants: None
axiom: A
rules: A→AB, B→A
N: 4

Answer:
$n = 0$: A
$n = 1$: AB
$n = 2$: ABA
$n = 3$: ABAAB
$n = 4$: ABAABABA

(b)

variables: A B C
constants: None
axiom: A
rules: A→C, B→A, C→AB
N: 10

Answer:
$n = 0$: A
$n = 1$: C
$n = 2$: AB
$n = 3$: CA
$n = 4$: ABC
$n = 5$: CAAB
$n = 6$: ABCCA
$n = 7$: CAABABC
$n = 8$: ABCCACAAB
$n = 9$: CAABABCABCCA

(c)

variables: B, A
constants: (,)
axiom: B
rules: A→AA, B→A(B)B
N: 3

Answer:
$n = 0$: B
$n = 1$: A(B)B
$n = 2$: AA(A(B)B)A(B)B
$n = 3$: AAAA(AA(A(B)B)A(B)B)AA(A(B)B)A(B)B

2. For system 1c ($N = 0, 1, 2, 3, 4$), draw using the following rules:
   'A': draw a line segment.
   'B': draw a line segment ending in a leaf.
   '(': push position and angle, turn left 45 degrees.
   ')': pop position and angle, turn right 45 degrees.

Answer: