Exercise 1: Language discovery

For each of the following program or fragment of program, please indicate: (a) What the fragment does (b) Is it written using the imperative or functional paradigm (c) In which language the fragment is written.

1. PROGRAM HELLO
   WRITE(6,*) 'HELLO WORLD'
   STOP
   END

2.  
   PROGRAM FACT
   J=1
   DO 1 I=1,10
    J=J*I
   1 CONTINUE
   WRITE(6,2) J
   2 FORMAT(I8)
   STOP
   END

3. IDENTIFICATION DIVISION.
   PROGRAM-ID. 'HELLO'.
   ENVIRONMENT DIVISION.
   CONFIGURATION SECTION.
   SOURCE-COMPUTER. IBM-360.
   OBJECT-COMPUTER. IBM-360.
   SPECIAL-NAMES.
   CONSOLE IS CNSL.
   DATA DIVISION.
   WORKING-STORAGE SECTION.
   77 HELLO-CONST PIC X(12) VALUE 'HELLO,WORLD'.
   PROCEDURE DIVISION.
   000 DISPLAY.
   001 DISPLAY HELLO-CONST UPON CNSL.
   010 STOP RUN.

4.  
   J=1
   FOR I=1 TO 10
    J=J*I
   NEXT I
   PRINT J
   END

5. (defun fact (n)
   (do* ((i 1 (+ i 1)) (j 1 (* j i)))
        ((>= i n) j)))
6. (define (fact n)
   (cond
     ((<= n 1) 1)
     (t (* n (fact (- n 1))))))

7. \( \square \leftarrow */_{10} \)

8. def factorial(n):
    result = 1
    for i in range(1, n+1):
        result *= i
    return result

9. function fact (n:integer):integer
   begin
     var i,j : integer;
     j:=1;
     for i:=1 to n do
       j := j*i;
     fact := j
   end

10. int fact (int n)
    { 
        int i, j;
        j = 1;
        for (i=1; i<=n; i++)
            j *= i;
        return j;
    }

11. fact :: Int -> Int
    fact 1 = 1
    fact n = n * fact (n-1)

12. let rec fact n =
    if n==1
        then 1
    else n * fact (n-1);

13. fun fact n =
    if n=1
        then 1
    else n * fact (n-1);

14. fact(1, 1).
    fact(N, M) :- N > 1, fact (N-1, M1), M=M1*N.

15. counter=$1
    factorial=1
    while [ $counter -gt 0 ]
    do
        factorial=$(( $factorial * $counter ))
        counter=$(( $counter - 1 ))
    done
    echo $factorial

16. : fact
    dup 1 = if
    else dup 1 - fact *
    endif ;
17. \texttt{/factorial \{ \\
  \texttt{dup 1 eq \\
  \texttt{dup 1 sub factorial mul} \\
  \texttt{ifelse} \\
  \texttt{def} \\
\}}

18. \texttt{function Factorial (N : Positive) return Positive is} \\
  \texttt{Result : Positive := N; } \\
  \texttt{Counter : Natural := N - 1; } \\
  \texttt{begin } \\
  \texttt{for I in reverse 1..Counter loop } \\
  \texttt{Result := Result * I; } \\
  \texttt{end loop; } \\
  \texttt{return Result; } \\
  \texttt{end Factorial; } \\

19. \texttt{function fac(n){ \\
  return(n<2)?1:fac(n-1)*n; } \\

Exercise 2: Representation of numbers

1. How many values can a 1 bit integer take? What about 3 bits? What about \( n \) bits?
2. You’re building a fence 100 feet long, with posts every 10 feet. How many posts do you need?

<table>
<thead>
<tr>
<th>Unsigned numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>The sequence ( \vec{a} \triangleq a_{n-1} \cdots a_0 ) of digits is interpreted as</td>
</tr>
<tr>
<td>( \left[\vec{a}\right]<em>u \triangleq \sum</em>{k=0}^{n-1} a_k 2^k )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Two’s complement. AKA signed numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>The sequence ( \vec{a} \triangleq a_{n-1} \cdots a_0 ) of digits is interpreted as</td>
</tr>
<tr>
<td>( \left[\vec{a}\right]<em>{tc} \triangleq -a</em>{n-1} 2^{n-1} + \sum_{k=0}^{n-2} a_k 2^k )</td>
</tr>
</tbody>
</table>

3. What values can a natural number represented using \( n \) bits take? What about a signed number?
4. Compute the following additions on 4 bit unsigned numbers :
   (a) \( 0010 + 0110 \) 
   (b) \( 0101 + 1010 \) 
   (c) \( 1011 + 1101 \) 
   (d) \( 1010 + 0110 \) 
   (e) \( 1111 + 1111 \) 
5. Interpret the operations when using (a) unsigned numbers (b) signed numbers.
One’s complement

The sequence \( \bar{a} \triangleq a_{n-1} \cdots a_0 \) of digits is interpreted as

\[
[\bar{a}]_{tc} \triangleq \begin{cases} 
\sum_{k=0}^{n-2} a_k 2^k & \text{if } a_{n-1} = 0 \\
\sum_{k=0}^{n-2} (a_k - 1) 2^k & \text{otherwise}
\end{cases}
\]

6. How does one write 1 using One’s complement? What about \(-1\)? How can you negate a number?

7. What is a huge drawback of this representation?

8. Using previous examples, build an algorithm to add two numbers in One’s complement. (Hint: the question is, how to handle the carry).

9. Why does your algorithm terminate?

10. What is printed by the Java program below?

```java
byte i = 101, j = 87, k = -101, l = -99;
byte m, n, o;

m = i+j; n = j+k; o = k+l;
System.out.println(m);
System.out.println(n);
System.out.println(o);
```

Exercise 3: Representation of text

1. Decode the following ASCII chain (written using hexadecimal codes)
   
   64 6f 6e 27 74 20 70 61 6e 69 63

2. The ASCII code is defined only from 00 up to 7f. Some extensions exists for 80 up to ff; however they depend on the page. One page is Latin-1 (ISO 8859-1). Decode the following text using Latin-1:
   
   55 6e 20 70 ea 63 68 65 75 72
   20 e0 20 6c 61 20 6c 69 67 6e 65

3. I receive an email containing the following text. What happened?
   
   Je vais à Sète cet â©tâ©.

A few Unicode characters

<table>
<thead>
<tr>
<th>Unicode</th>
<th>Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>U+000A</td>
<td>LINE FEED (LF)</td>
</tr>
<tr>
<td>U+0020</td>
<td>SPACE</td>
</tr>
<tr>
<td>U+0021</td>
<td>EXCLAMATION MARK</td>
</tr>
<tr>
<td>U+002C</td>
<td>COMMA</td>
</tr>
<tr>
<td>U+0030</td>
<td>DIGIT ZERO</td>
</tr>
<tr>
<td>U+0041</td>
<td>LATIN CAPITAL LETTER A</td>
</tr>
<tr>
<td>U+0061</td>
<td>LATIN SMALL LETTER A</td>
</tr>
</tbody>
</table>

4. Unicode solves some of the precedent problems. However, there are several formats to write Unicode. Decode the following UTF-32 (UCS-4) chain:

   00 00 00 6d 00 00 00 61 00 00 00 6d 00 00 00 6d
   00 00 00 61 00 00 00 20 00 00 00 6d 00 00 00 69
   00 00 00 61 00 00 00 21

5. What could be the shortcomings of UTF-32?
6. Decode the following UTF-8 chain
6a 61 6b 20 7a 65 20 6d 6c c4 85 0a

7. Does UTF-8 have the same shortcomings as UTF-32? How and why?

8. On the following website
http://www.dptinfo.ens-cachan.fr/Conferences/conferences15.php
one can read the following text:

Pierre-Alain Fouque
Aspects Algorithmiques de Cryptanalyse
Dans cette conférence, je présenterai quelques algorithmes importants en cryptanalyse au travers d’exemples issus de cryptographie symétrique et asymétrique comme par exemple : les attaques génériques sur les fonctions de hachage, les algorithmes de factorisation ou du logarithme discret, les schémas de signature construit sur la difficulté à résoudre des systèmes quadratiques en plusieurs variables ou la difficulté à résoudre des systèmes linéaires avec du bruit.

However, the server projects.lsv.ens-cachan.fr has sent to my web browser the following (extract) of code:

```html
<h2> <a name="Pierre-Alain_Fouque" href="http://www.di.ens.fr/~fouque/"> Pierre-Alain Fouque </a> </h2>
<p><big><b>
   <a> Aspects Algorithmiques de Cryptanalyse </a>
</b></big></p>
```

(a) Why does the previous code illustrate another answer to the encoding issues?
(b) What is the name of this language?

9. When fetching the following webpage
my web browser displays:

However, the server projects.lsv.ens-cachan.fr sent to my browser the following (extract) of code:

Now remember that $(x_i)_{i \in I}$ converges to $x$ if and only if every open subset $U$ that contains $x$ is such that $x_i$ is eventually in $U$. One obtains an equivalent definition by stating that every neighborhood $A$ of $x$ (i.e., in $N_x$) is such that $x_i$ is eventually in $A$. In other words, if and only if $N_x$ is included in the convergence filter of the net.

How does it compare to Unicode?

10. Going back to the first example of HTML, the file started with:

```html
<?
$EXTRA_HEAD="antispam.html";
$ARG_BODY="onload="onLoad()""
SETLANG("fr");
STYLEDPINFO();
HEAD("Conférences de rentrée 2015");
ADDTITLE("Conférences de rentrée 2015");
MKPAGEDPINFO();
?>
```

This is not HTML. What language is used? What does it compute?