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1. ***Ocaml :*** Define a function **split** which takes a predicate and a list and returns a 2-tuple of lists, where all elements of the first list cause the predicate to return true, and all other elements are in the second list. The elements must remain in the same order as on input. **[3✔]**

```
# split;;
- : ('a -> bool) -> 'a list -> 'a list * 'a list = <fun>
# split even [1; 3; 5; 2; 8; 4; 1; 10];;
- : int list * int list = ([2; 8; 4; 10], [1; 3; 5; 1])
```

2. ***Prolog :*** Define a function **filter** which takes three arguments : a predicate, an input list, and an output list. The output list contains all elements of the input list for which the predicate is true, and in the same order. **[2✔]**

```
| ?- filter( even, [1,2,3,4,5,6,7,8], X).
X = [2,4,6,8] ?
```

3. ***Scheme :*** Define a function **maxzip** which takes a predicate and two lists and zips the lists into a single list by taking the larger of each of the paired elements. The length of the result is the same as the length of the shorter list. **[3✔]**

```
> (maxzip > '(1 3 5 7 9) '(9 7 5 3 1))
(9 7 5 7 9)
> (maxzip < '(1 3 5 7 9) '(9 7 5 3 1))
(1 3 5 3 1)
> (maxzip <= '(1 3 5 7 9) '(9 9))
(1 3)
```

4. ***Perl :*** Write a program which uses **<>** to read files and at end prints the number of characters, words, and lines in these files. A word is anything that matches **/\S+/**. **[2✔]**

```
% wc.perl foo
4 28 149
```

5. Name the two general kinds of polymorphism, and for each of them, name the two sub-kinds of polymporhism into which they may be classified. **[1✔]**

6. ***Scheme :*** Define a function **exclude** which takes a count and a list and returns a list with the first count items removed. A negative count is the same as 0. If more items are excluded than exist in the list, return the empty list. **[2✔]**

```
> (exclude 2 '(1 2 3 4 5))
(3 4 5)
> (exclude -5 '(1 2 3 4 5))
(1 2 3 4 5)
> (exclude 10 '(1 2 3))
()
```

7. ***Ocaml :*** Define a function **exclude** which does the same. **[2✔]**

```
# exclude 2 [1;2;3;4;5];;
- : int list = [3; 4; 5]
# exclude (-5) [1;2;3;4;5];;
- : int list = [1; 2; 3; 4; 5]
# exclude 10 [1;2;3];;
- : int list = []
```

8. ***Prolog :*** Define A function **exclude/3** with the same semantics. The first two arguments are as before, and the third argument is the output list. Do not consider the result of backtracking from the **?** prompt. **[2✔]**

```
| ?- exclude(2,[1,2,3,4,5],U).
U = [3,4,5] ?
yes
| ?- exclude(-5,[1,2,3,4,5],U).
U = [1,2,3,4,5] ?
yes
| ?- exclude(10,[1,2,3],U).
U = [] ?
yes
```

9. ***Smalltalk :*** Define a class **Find** with a single class method **key:array:** which accepts a key and an array and returns the first position in the array equal to the key. If not found, return V>= nil. **[3✔]**

```
st> Find key: 5 array: #(1 3 5 7 9).
3
st> Find key: 11 array: #(1 3 5 7 9).
nil
```

10. ***Java :*** Finish the following program by specifying the class >V= say . When started from the main function, it prints the message "hello" and then quits. **[2✔]**

```
class hello {
   // What goes here?
   public static void main (String[] args) {
      Thread say = new Thread (new say ());
      say.start();
   }
}
```

11. Give an example of how memory leak might occur in Java. **[2✔]**

12. ***Smalltalk :*** Define the class **Stack**. Internally it has an array of fixed size and no attempt is made to verify pre- or post-conditions. It simply crashes on overflow or underflow. Define the following methods : **[6✔]**
    (a) Class method **new** uses **new**: to create a stack of maximum capacity 10.
    (b) Class method **new**: creates a stack of the size given by its argument.
    (c) Instance method **init**: initializes the array representation and sets the top to 0
    (d) Instance method **pop** removes and returns the top item on the stack.
    (e) Instance method **push**: pushes a new item onto the top of the stack.
    (f) Instance method **empty** reports on whether the stack is empty or noT.

```
bash-3.2$ cat stack.test.st
FileStream fileIn: 'stack.st'.
s := Stack new.
s push: 1; push: 5; push: 10.
s inspect.
[s empty not] whileTrue: [
   stdout << s pop << Character nl].
bash-3.2$ gst <stack.test.st
An instance of Stack
  array: (1 5 10 nil nil nil nil nil nil nil )
  top: 3
10
5
1
```

Multiple choice. To the ***left*** of each question, write the letter that indicates your answer. Write ***Z*** if you don't want to risk a wrong answer. Wrong answers are worth negative points. **[11✔]**

number of correct answers		× 1 =	$= a$
number of wrong answers		× ½ =	$= b$
number of missing answers		× 0 =	0
column total $c = \max(a - b, 0)$	11		$= c$

1. What will make Smalltalk print `9`?
   (A) `(4 + 5) value.`
   (B) `(4 + 5) value:.`
   (C) `[4 + 5] value.`
   (D) `[4 + 5] value:.`

2. In Smalltalk, what is 1.4142135623730951?
   (A) `(sqrt 2)`
   (B) `2 ** .5`
   (C) `2 sqrt`
   (D) `sqrt (2)`

3. In Ocaml, what is the type of `List.tl`? (Hint: like `cdr` in Scheme).
   (A) `'a list * 'a list -> 'a list`
   (B) `'a list -> 'a`
   (C) `'a list -> 'a list`
   (D) `'a list -> 'a list -> 'a list`

4. What kind of type equivalence is used to determine if two different `typedef`s in C declare the same type?
   (A) anonymous
   (B) name
   (C) structural
   (D) value

5. A process that has exited, either by calling exit or from a signal, but has not yet been waited for by its parent process is called a:
   (A) daemon
   (B) fork bomb
   (C) init
   (D) zombie

6. In Perl, the default argument to a function requiring an argument, when none is given, is:
   (A) `$!`
   (B) `$0`
   (C) `$_`
   (D) `@_`

7. Which of the following functions is a higher-order function whose arguments are a function and a list, and whose result is a list containing the result of applying the function to each of the elements of the list?
   (A) filter
   (B) foldl
   (C) foldr
   (D) map

8. Which of the following functions can take a function, a unit, and a list as arguments, and which applies the function between each element of the list, along with the unit at one end, and which can use up constant stack space?
   (A) filter
   (B) foldl
   (C) foldr
   (D) map

9. How might one declare an array variable in Perl with lexical scope?
   (A) `local @a;`
   (B) `my @a;`
   (C) `our @a;`
   (D) `use @a;`

10. Which of the following programs will cause a dangling pointer?
    (A) `int *f() {int i = 6; return &i; }`
    (B) `int *f() {int i = 6; return *i; }`
    (C) `int *f() {int i = 6; return  i; }`
    (D) `int  f() {int i = 6; return  i; }`

11. In PL/I, a `goto` statement had the capability of being executed in one function and transver control to another function, perhaps the one that called it. The equivalent feature of Java uses what keyword?
    (A) `break`
    (B) `continue`
    (C) `throw`
    (D) `synchronized`

Multiple choice. To the ***left*** of each question, write the letter that indicates your answer. Write ***Z*** if you don't want to risk a wrong answer. Wrong answers are worth negative points. **[11✔]**

number of correct answers		× 1 =	$= a$
number of wrong answers		× ½ =	$= b$
number of missing answers		× 0 =	0
column total $c = \max(a - b, 0)$	11		$= c$

1. In Java, if two functions have the same name in the same class, but have different signatures, this is referred to as :
   (A)
2. In Java, if two functions in different classes have the same signature, but one of the classes is a subclass of another, this is referred to as :
   (A)
3. Allowing partial parameterization of a function in a functional language such as Ocaml is called :
   (A) currying
   (B) lambda lifting
   (C) tupling
   (D) unification
4. In an object-oriented language like C++, a virtual function (instance method) is called based on a :
   (A) duck-typing response
   (B) generic declaration
   (C) heap-allocated closure
   (D) virtual function table
5. Which of the following data structures violates the spirit of functional programming ?
   (A) array
   (B) list
   (C) stack
   (D) tree
6. All imperative featurs of Haskell must be isolated from the rest of the program and contained in a :
   (A) closure
   (B) monad
   (C) proxy
   (D) thunk
7. Unification is an important algorithm in performing automatic type inference in which of these languages ?
   (A) Java
   (B) Ocaml
   (C) Prolog
   (D) Scheme
8. Given the declarations `int *p;` and `int i;`, which C expression is not valid ?
   (A) `i + i`
   (B) `i + p`
   (C) `p + i`
   (D) `p + p`
9. From what memory segment does the `malloc`(3) function allocate memory ?
   (A) test
   (B) data
   (C) heap
   (D) stack
10. A process that sleeps in the background and wakes up whenever a request is made on its port, then performs that service, and returns to sleep to wait for the next request is called a :
    (A) daemon
    (B) fork bomb
    (C) init
    (D) zombie
11. The first language to be described using Backus-Naur form was :
    (A) Algol 60
    (B) Basic
    (C) Cobol
    (D) Fortran