

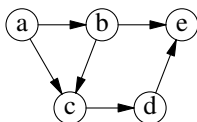
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No books ; No calculator ; No computer ; No email ; No internet ; No notes ; No phone. Do your scratch work elsewhere and enter only your final answer into the spaces provided. Points will be deducted for messy answers. Unreadable answers will be presumed incorrect.

1. For each language described here, fill in the name of the language. Choose from among the following languages : Algol 60, AWK, Bash, Basic, BCPL, C, C++, COBOL, Forth, FORTRAN, Haskell, Intercal, Java, Lisp, ML, OCaml, Pascal, Perl, PL/I, Prolog, Simula 67, Smalltalk. Grading : deduct ½ point for each wrong or missing answer, but do not score less than 0. **[3✓]**

	Bjarne Stroustrup's most noted contribution to language design.
	Business data processing language, designers included Grace Hopper.
	Designed in Europe to express algorithms in a structured way.
	First version of Unix was 9000 lines of this language (plus some assembly code).
	List processing language typically used in artificial intelligence.
	Numeric and scientific computation language developed at IBM.
	Simulation language that influenced the design of C++.
	Small language for structured programming designed by Niklaus Wirth.
	Sun Microsystems claimed this language is "write once, run anywhere".

2. **Prolog.** Define some facts called **arrow** which describe this graph. If $a \rightarrow b$, then **a** is the first argument and **b** is the second argument. **[2✓]**



3. **Prolog.** Write a relation **ispath(X,Y)** if there is a path from **X** to **Y** in one or more steps. It fails if $X=Y$. Assume an acyclic graph. **[2✓]**
4. **Prolog.** Write a relation **findpath(X,Y,P)** so that if there is a path from **X** to **Y** in the previous question, it returns the path. For example, in the first question, **findpath(a,e,P)** could return $P=[a,c,d,e]$ or $P=[a,b,e]$, etc. Assume an acyclic graph. **[3✓]**

5. **Ocaml.** Define the function `max` which finds the largest element in a list, given a comparison operator and a list. Use `failwith` if the list is empty. The solution must be tail-recursive. Do not use a higher-order function. **[4✓]**

```
# max;;
- : ('a -> 'a -> bool) -> 'a list -> 'a = <fun>
# max (>) [1;2;3;4];;
- : int = 4
# max (<) [1;2;3;4];;
- : int = 1
# max (>) [];;
Exception: Failure "max".
```

6. **Ocaml:** Define a function `zip` which takes two lists and returns a list of tuples, pairing each corresponding element. If the lists are of different lengths, ignore excess elements in the longer list. **[2✓]**

```
# zip [1;2;3] ['a';'b';'c';'d'];;
- : (int * char) list = [(1, 'a'); (2, 'b'); (3, 'c')]
```

7. **Ocaml:** Define a function `unzip` which takes a list of tuples and returns a tuple of lists, the first list containing the first item in each tuple, and the second list, the second item. **[2✓]**

```
# let l1, l2 = unzip [(1, 'a'); (2, 'b'); (3, 'c')];;
val l1 : int list = [1; 2; 3]
val l2 : char list = ['a'; 'b'; 'c']
```

8. **Prolog.** Write rules for determining the greatest common divisor of two positive integers. Write code equivalent to the following C function :

```
int gcd (int x, int y) {
    while (x != y) if (x > y) x -= y; else y -= x;
    return x;
}
```

An example of interaction is given here. **[2✓]**

```
| ?- gcd(111,259,Z).
Z = 37 ?
(1 ms) yes
```

9. Name the two general types of polymorphism, and for each of them, name the specific kinds that represents each of them. [2✓]

general	specific

10. **Scheme.** Write a function that takes two lists as arguments and which returns a single list where each element is a list of corresponding pairs. If the lists are of different lengths, trailing elements of the longer list are ignored. [2✓]

```
> (pairthem '(1 2 3 4) '(a b c d e))
((1 a) (2 b) (3 c) (4 d))
> (pairthem '(1 2 3 4 5) '(a b))
((1 a) (2 b))
```

11. **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 )
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. **[12✓]**

number of correct answers		$\times 1 =$	$= a$
number of wrong answers		$\times \frac{1}{2} =$	$= b$
number of missing answers		$\times 0 =$	0
column total $c = \max(a - b, 0)$	12		$= c$

- Language designed primarily to handle scalars, vectors, matrices, and higher order arrays.
 - APL
 - COBOL
 - FORTRAN
 - PL/I
- Scripting language covered during the last few lectures.
 - Bash
 - Perl
 - Python
 - Ruby
- First two characters of a script source file.
 - #!
 - /*
 - //
 - ;;
- Earliest language which is an ancestor of Scheme.
 - BCPL
 - Cobol
 - Fortran
 - Lisp
- Besides C, the object-oriented language which is an ancestor of C++.
 - Algol 60
 - Fortran IV
 - Pascal
 - Simula 67
- In Smalltalk : $\sqrt{2.0}$
 - (sqrt 2.0)
 - 2.0 sqrt
 - 2.718281828459045
 - sqrt (2.0)
- In a “lazy” language, unevaluated arguments are passed into functions by means of a :
 - closure
 - curry
 - thunk
 - tuple
- Lisp was designed when, by whom, and where ?
 - 1953, John Backus.
 - 1958, John McCarthy.
 - 1959, Grace Hopper, *et al.*
 - 1964, John Kemeny, Thomas Kurtz.
- Unification is part of the static type checking algorithm used by what language ?
 - C++
 - Ocaml
 - Prolog
 - Smalltalk
- Prolog :


```
| ?- X is sin(pi).
```

 - X = -1.0
 - X = 1.2246467991473532e-16
 - X = 2.7182818284590451
 - X = 3.1415926535897931
- Smalltalk determines if an object can respond to a message by the method of :
 - same as in Java
 - duck-typing
 - generic parameters
 - multiple inheritance
- A C++ compiler does object-oriented dispatch via :
 - duck typing
 - heap allocated closure
 - type inference
 - virtual function table



The Antikythera mechanism, built ca. 150–100 BCE, is the oldest known complex scientific calculator, and is sometimes called the first known analog computer, with operational instructions written in Greek. http://en.wikipedia.org/wiki/Antikythera_mechanism

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. [12✓]

number of correct answers		$\times 1 =$	$= a$
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- A closure is :
 - A special field of a structure or class used to point at a base class when implementing shared multiple inheritance.
 - A special type declaration in Ocaml used to distinguish sum types from product types.
 - A structure on the heap, used to hold variables of an outer function when referenced by an inner function.
 - A table used to dynamically dispatch virtual functions in an object-oriented environment.
- The classic paper “Go To Statement Considered Harmful”, CACM, 1968, was written by :
 - John Backus
 - Edsger Dijkstra
 - Grace Hopper
 - Donald Knuth
- What Perl regex matches a sequence of letters, digits, and underscores ?
 - `\d+`
 - `\n+`
 - `\s+`
 - `\w+`
- Which of the following C++ operators is “lazy” ?
 - `*=`
 - `==`
 - `>>`
 - `? :`
- What is 6 ?
 - `(apply + '(1 2 3))`
 - `(cons + '(1 2 3))`
 - `(list + '(1 2 3))`
 - `(map + '(1 2 3))`
- Where is the variable **a** kept, given the following function definition ?


```
int f() { int a; return a; }
```

 - function call stack
 - heap
 - initialized data segment
 - uninitialized data segment
- The PL/1 language allows a non-local **goto** directly from a function to a label in a function deeper down in the function call stack, thus returning past several levels of function calls. In Java, something similar can be accomplished by what statement ?
 - goto**
 - implements**
 - synchronized**
 - throw**
- What kind of memory management fails to handle a cyclic data structure ?
 - copying collector with semispaces
 - malloc and free
 - mark and sweep
 - reference counting
- If multiple threads sharing global variables are not synchronized by means of a critical section, what program problem will appear ?
 - deadlock
 - race condition
 - segmentation fault
 - semaphores
- What is the type of


```
let f x y z = x + y + z;;
```

 - `val f : int * int * int -> int`
 - `val f : int * int -> int -> int`
 - `val f : int -> int * int -> int`
 - `val f : int -> int -> int -> int`
- Which expression causes a list of length zero to be passed into the function **f** ?
 - `(f '())`
 - `(f ())`
 - `(f null?)`
 - `(f nullptr)`
- What is the signature of Ocaml's **List.map** ?
 - `('a -> 'b) -> 'a list -> 'b list`
 - `('a -> bool) -> 'a list -> 'a list`
 - `('a -> 'b -> 'a) -> 'a -> 'b list -> 'a`
 - `'a list -> int`