Lecture 1, 6 January 2026

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Programming Language Concepts
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What is this course about?

Which PLs do you "know"? / know about

Haskell	Python	Java	Javascript
C	C++	Rust	Swift
R	Go	Pascal	Perl
Prolog	Cobol	Fortran	SQL

Why so many?

Are they different? How?

Haskell

Functional

Declarative

↓

What we want

Prolog, SQL

Python

Imperative

Map, Filter, List comprehension

↓

Give "instructions"

How to do it

Tradeoffs

Declarative vs Imperative

Cannot manage memory "resources"

Prove correctness

Finer control over resources

Disconnect between "intent" & "implementation"

Language complexity

Functions – pass parameters, return result

Space wasted

update "in place"

x

y – updated

factorial(n)

Pascal

```
def f(x, var y):
```

Choice → no argument can be updated ✓ Less dangerous

Pass "address"

↓

any argument is updatable

Python

f(x, &y) &y = "address of y"

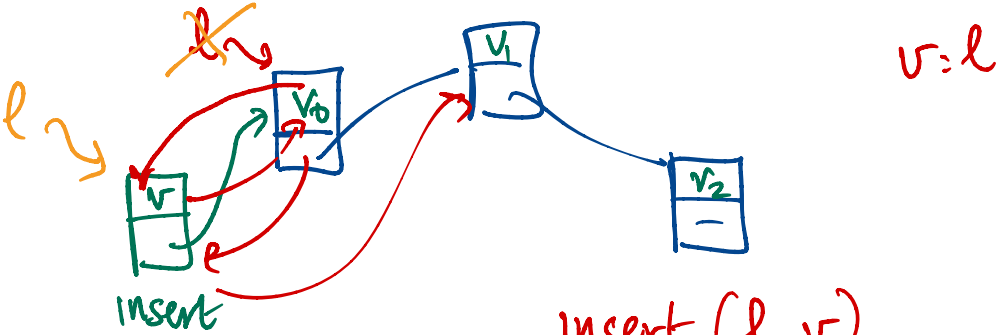
Mutable vs immutable

Lists

Dictionaries

Call by value

Call by reference


l
v
v_0
v_1
v_2
insert
v := l
insert (l, v)
"by reference"

Storage

```
def factorial(n):
    result = 1
    :
    result = n * factorial(n-1)
    return result
```

Store local variables for each instance of a function?

Storage

How data is stored

- "Scalars"
- Arrays vs lists

Fixed size

Contiguous memory

l[i] "random access"

"Uniform time access"

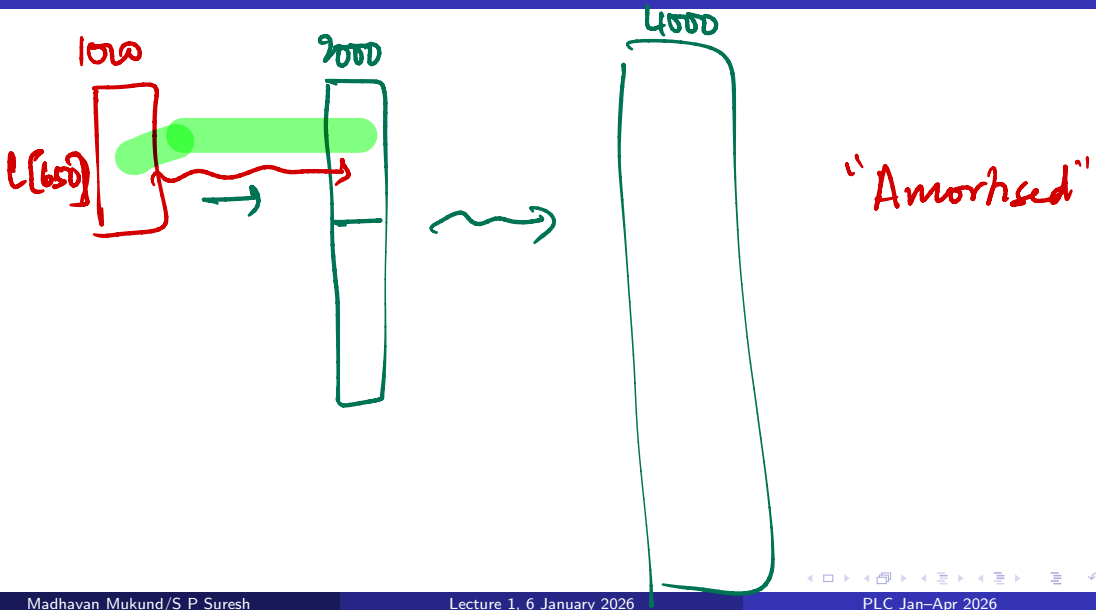
Python lists

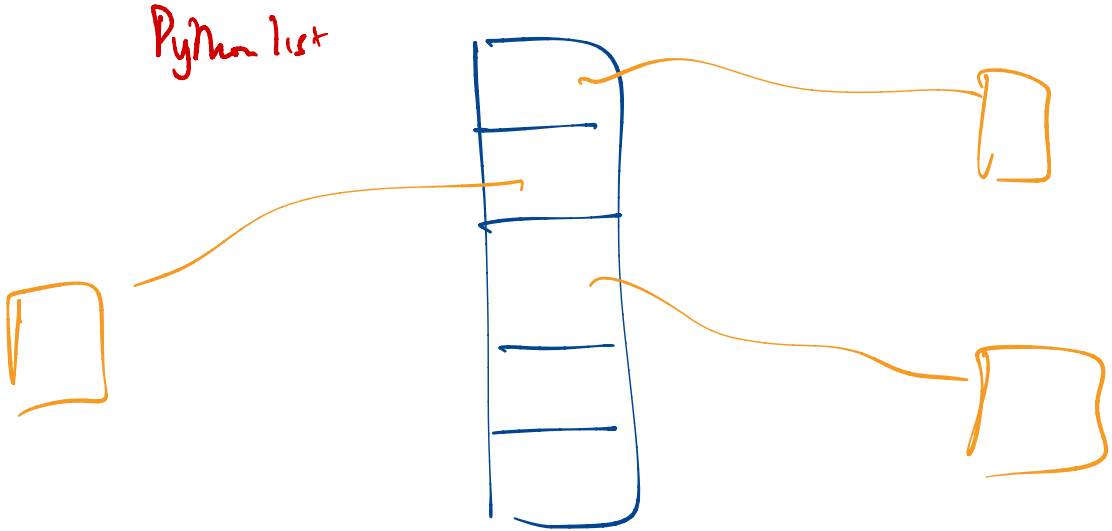
```
l = [1,2,3,4]
l.append(5)
x = l[2]
```

```
l = list(range(10..0))
l.append(7)
x = l[-1]
```

lists stored as arrays (with trailing empty space)

run out of space → double space


1000
2000
L(650)
4000
"Amortised"


Python list

User defined data structures

List

Dictionaries

Tuples

Heaps ~ binary tree

Binary Trees

"Linked" lists

parent $\longleftrightarrow$ child

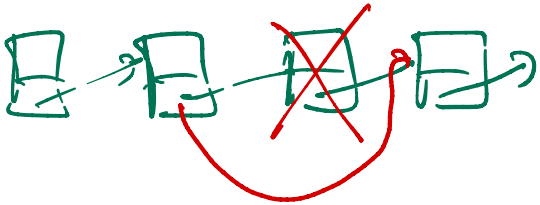
$i \longrightarrow 2i+1, 2i+2$

In general

Allocate space

Return space

C



"Memory leak"

Garbage collection

Handling errors

Concurrent execution

Polymorphism

Declarative programming

λ-calculus

Rewriting as computation

Untyped

Add types

Type inference

Quizzes + Assignments

Midsem

Final

Java

Rust