Warm-Up Quiz: 3 of 14 Students Scored Below 50%

IIT Madras Zanzibar

Rank	Mark (out of 10)	Band
1	10	Secure
2	9	Secure
3	9	Secure
4	8	Secure
5	8	Secure
6	7	Developing
7	7	Developing
8	7	Developing
9	6	Developing
10	6	Developing
11	5	Developing
12	3	Needs support
13	2	Needs support
14	1	Needs support

Formative quiz, Wed 7 Oct · n = 14 · marks anonymised

Summary	Value
Cohort size (n)	14
Mean mark	6.3
Median mark	7
Range	1 – 10
Below 50% (marks 1–4)	3 of 14

Implications for teaching

5 students (8–10), secure: ready to extend

6 students (5–7), developing: consolidate key terminology

3 students (1–3), need support: revisit fundamentals together and follow up



Indian Institute of Technology Madras
ZANZIBAR CAMPUS

Z5007 · PROGRAMMING AND DATA STRUCTURES

Foundations: What Are Data, Data Structures and Algorithms?

Lecture 3 · Thursday 8 October 2026 · Canning, Broder & Lafore, Ch 1 (Overview)

Dr. Innocent Nyalala | MTech Semester 1 | IIT Madras Zanzibar

Today's Plan

IIT Madras Zanzibar

1. (0–8 min) What is data? Examples from your own day
2. (8–20 min) What is a data structure? Organizing data, with pictures
3. (20–32 min) What is an algorithm? Step-by-step recipes
4. (32–42 min) Why efficiency matters: the library search game
5. (42–50 min) Exercise, solution, summary

Learning Outcomes

IIT Madras Zanzibar

By the end of this session, you will be able to:

Define	data, a data structure and an algorithm, in your own words
Recognize	data structures in everyday life: rows, piles, lines, trees, maps
Describe	an algorithm as clear steps, and trace it by hand
Explain	why two correct algorithms can take very different amounts of time

Foundations: Data, Structures and Algorithms

→ **What Is Data?**

What Is a Data Structure?

What Is an Algorithm?

Why Efficiency Matters

Exercise

Data: Facts We Record

IIT Madras Zanzibar

T **Text**

your name, a WhatsApp message, a Swahili news article

N **Numbers**

clove price per kg, your exam mark, your phone balance

I **Images**

a photo: millions of colored dots (pixels)

S **Sound and time**

a voice note; temperature every hour; your daily steps

? **Think:** name ONE piece of data you created this morning, before coming to class.

Data = recorded facts. Useful when there are MANY of them and we can find and use them fast.

One Fact Is Easy. A Million Facts Need Organizing.

IIT Madras Zanzibar

5

receipts on your desk

5,000

receipts in a shop's drawer

5,000,000

M-Pesa transactions in a day (order of magnitude)

easy to search by hand → slow → impossible without organization

? **Think:** how does a shopkeeper with 5,000 receipts find last Tuesday's receipt quickly? What did they organize?

Big idea: the more data you have, the more the ORGANIZATION matters.

IIT Madras Zanzibar

- What Is Data?
- → **What Is a Data Structure?**
- What Is an Algorithm?
- Why Efficiency Matters
- Exercise

A Data Structure Is a Way of Organizing Data

IIT Madras Zanzibar

Data structure: a way of organizing data so that the jobs we need (find, add, remove, sort) are easy and fast.

1 **Bookshelf, sorted**

find a book: fast. Add a book: must make space

2 **Pile on the floor**

add a book: instant. Find a book: slow

3 **Labelled drawers**

go straight to the right drawer

? **Think:** which is better, the shelf or the pile? (Careful: the answer depends on something. On what?)

Rule: the best structure depends on which jobs you do MOST often.

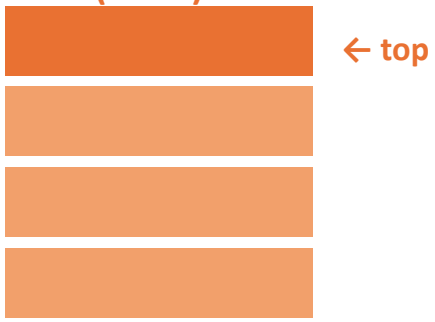
Five Everyday Shapes of Data

IIT Madras Zanzibar

1. ROW (array)



2. PILE (stack)

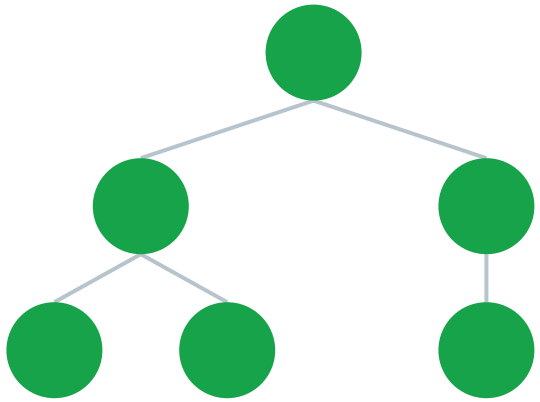


3. LINE (queue)

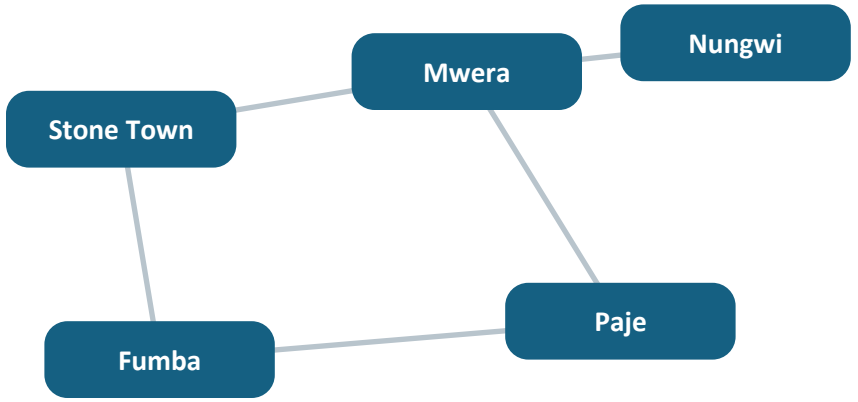


first in → first served

4. FAMILY TREE (tree)



5. ROAD MAP (graph)



1 **We study them**

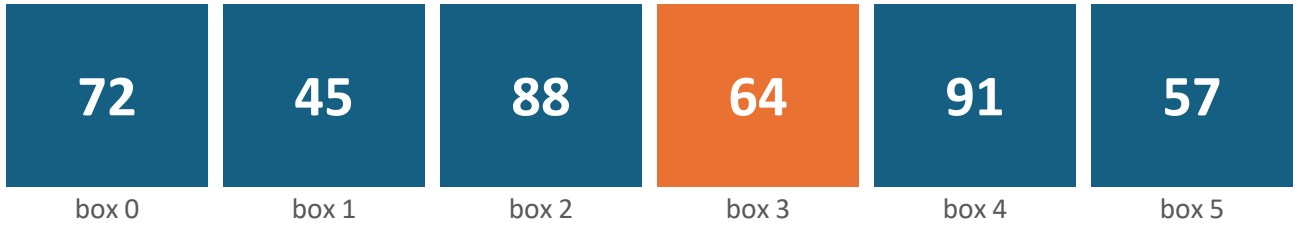
one at a time, in this order

Today: just recognize the five shapes. Details come week by week.

The Row (Array): Numbered Boxes Side by Side

IIT Madras Zanzibar

Exam marks stored in a row of 6 numbered boxes



1 **Job 1: 'What is in box 3?'**

walk straight there: 1 step, always

2 **Job 2: 'Which box holds 91?'**

open boxes one by one: up to 6 steps here, n steps for n boxes

? **Think:** the row has 1,000,000 boxes. How many steps for Job 1? For Job 2 in the worst case?

Next week: we study the row (array) properly: adding, removing, searching, sorting.

Foundations: Data, Structures and Algorithms

What Is Data?

What Is a Data Structure?

→ **What Is an Algorithm?**

Why Efficiency Matters

Exercise

An Algorithm Is a Recipe: Clear Steps That Always Work

IIT Madras Zanzibar

1 Mix

2 cups flour, 1 cup water, pinch of salt

2 Knead

10 minutes until smooth

3 Roll

into 8 flat circles

4 Cook

each side 1 minute on a hot pan

a chapati recipe is an algorithm

1 Clear

every step is exact: '1 teaspoon', not 'some'

2 Finishes

it always stops

3 Correct

right answer for EVERY valid input

A program = an algorithm written in a language a computer understands (for us, Python).

? **Think:** is 'keep stirring until it looks ready' a good algorithm step? Why not?

Tracing an Algorithm by Hand: Find the Highest Mark

IIT Madras Zanzibar

Algorithm, in plain words

```
1. best = the first mark
2. for each remaining mark:
       if mark > best:  best = mark
3. answer = best
```

Look at	Bigger than best?	best
72 (start)	—	72
45	no	72
88	yes	88
64	no	88
91	yes	91
57	no	91

6 marks → about 6 steps. 1,000,000 marks → about 1,000,000 steps.

? **Think:** does this algorithm still work if ALL marks are the same? If there is only one mark?

IIT Madras Zanzibar

- What Is Data?
- What Is a Data Structure?
- What Is an Algorithm?
- → **Why Efficiency Matters**
- Exercise

The Library Game: Two Ways to Find a Book

IIT Madras Zanzibar

Method A: one by one

check every title from the start

1,000

checks in the worst case

Method B: halve each time

middle, then ignore the wrong half

10

checks in the worst case

1,000 → 500 → 250 → 125 → 63 → 32 → 16 → 8 → 4 → 2 → 1 (10 halvings)

Structure + algorithm: method B works ONLY because the shelf is sorted. The structure makes the fast algorithm possible.

? **Think:** the library grows to 1,000,000 books. How many checks for A? For B? (Keep halving: try it!)

Why Speed Matters: More Data Makes the Gap Huge

IIT Madras Zanzibar

Books on the shelf	Method A (one by one)	Method B (halving)	A at 1 ms per check
10	10	4	0.01 s
1,000	1,000	10	1 s
1,000,000	1,000,000	20	about 17 minutes
1,000,000,000	1,000,000,000	30	about 11.6 days

The lesson: for small data, any method works. For big data, the choice of algorithm decides everything.

? **Think:** B needs only 30 checks for a billion books. Why does halving grow so slowly?

In-Class Exercise (6 minutes, in pairs)

IIT Madras Zanzibar

IN-CLASS TASK: no code needed: think and count

1. Give one everyday example of each shape: a row, a pile, a line, a tree, a road map.

2. Write, in plain numbered steps, an algorithm to find the LOWEST mark in a row of marks. Trace it on 72, 45, 88, 64, 91, 57.

3. A sorted list of 64 names. Using the halving method, at most how many checks to find one name? Show the halvings.

4. Your phone's contacts are sorted by name. Which job does that make fast? Which job does it make slower?

Solution

IIT Madras Zanzibar

1 **1: e.g.**

row: seats in a bus; pile: plates or chapatis; line: bank queue; tree: family tree or folders; road map: dala-dala routes.

2 **2: lowest = 45**

best = 72; 45 < 72 → 45; 88 no; 64 no; 91 no; 57 no. Answer 45. Same steps as 'highest' with < instead of >.

3 **3: 6 checks**

64 → 32 → 16 → 8 → 4 → 2 → 1: six halvings.

4 **4: finding is fast; adding is slower**

a new contact must be put in its correct place, not just at the end.

Remember: every structure makes some jobs fast and others slow.

Summary and Exam Checkpoints

IIT Madras Zanzibar

Data

recorded facts; useful when organized

Data structure

a way of organizing data: row, pile, line, tree, map

Algorithm

clear steps that finish and are always correct

Efficiency

for big data, the algorithm decides: 1,000,000 vs 20 steps

Next

Fri 9 Oct: Counting steps: how we measure an algorithm's speed (Big-O cont…)

Read: Canning, Broder & Lafore, Chapter 1

Try: visualgo.net: watch 'binary search' on a sorted row

References and Further Reading

1. Canning, J., Broder, A. & Lafore, R. (2022). Data Structures & Algorithms in Python. Addison-Wesley. Chapter 1, Overview.
2. Miller, B. & Ranum, D. Problem Solving with Algorithms and Data Structures using Python. runestone.academy (Chapter 1, Introduction).