Storage

- Main memory
  - Random access memory (RAM)

    - One-dimensional array of bytes

    - Every byte has an address

    - Bytes are read and written by address

    - If you choose 2 random bytes, it should take approximately the same time to read both

- Requires constant electricity to retain data
  - If you turn off your computer you lose the contents of main memory

- The stack, the heap, statically allocated memory, and program instructions are all stored in main memory during program execution

- When a program exits, its memory allocations are freed

- Programming languages allow us to use variables with convenient names to refer to data in main memory

- Persistent storage
  - Hard disk drives (HDDs), solid-state drives (SSDs), flash drives, etc.

  - Does not require constant electricity to retain data

  - Allows data created by a process to outlive the process's execution

- Files

    - Named array of bytes

    - Programs interact with files through various operations

        - Open

        - Read

        - Write

        - Seek - move to a position in a file

        - Stat - get information about a file

- The operating system implements file operations
  - Layer of abstraction, programs don't need to worry about what type of storage is used

- Database
  - Managed by a database management system (DBMS)
  - MySQL, SQLite, PostgreSQL, Microsoft SQL server, Mongo DB, etc.

- Stores data in an organized fashion

  - Tables with rows and columns
  - Collections of key/value pairs

- Supports querying data

  - Get info about all students expected to graduate in 2023

- DBMS can exist locally or on another computer accessible via network

Serialization

- Transforming an object or data structure into a one-dimensional format

- Typically used for persistent storage or transmission over a network

- Strings and other arrays are often easy

  - Already one-dimensional

- More difficult

    - Associative arrays (dictionaries in Python)

    - Objects created from classes or structures

    - Data structures composed of multiple objects with references, like linked lists

- Options in Python

  - pickle module

    - Can serialize the basic Python objects

      - Lists, dicts, tuples, sets

      - Numbers, strings, Boolean, None

    - Not human readable

    - Has security concerns

      - Don't unpickle untrusted data

- JSON

    - Text format

    - Human readable

    - Interoperable with other programming languages

    - Can't serialize as many things as pickle

- Kivy's Storage classes

    - keeps serialized data synchronized in a file

      and a running program