

# Memory Overview

Last updated 7/1/21

# Memory

- Many Types of memory
  - Paper tape
  - Cards
  - Magnetic Tape
  - Floppy Disk
  - Hard Drive (Magnetic)
  - Optical Drive
  - Integrated Circuit Memory

# Memory

- 2 Key Concepts for Integrated Circuit memory
  - ROM
    - ROM – read only memory
    - fixed values - memory cannot be changed
  - RAM
    - RAM – random access (really R/W)
    - memory can be changed

# Memory

- Integrated Circuit Memory
  - Non – Volatile
    - Retains it's values even when power is removed
    - ROM
    - NAND and NOR Flash
    - EPROM, EEPROM
  - Volatile
    - Loses its values when power is removed
    - Static – Retains value without any extra effort
      - Registers
      - SRAM – Static RAM
    - Dynamic – Requires periodic refresh or values will degrade
      - DRAM – Dynamic RAM
      - SDRAM – Synchronous DRAM (DDR, DDR2, DDR3, DDR4, ... )

# Memory

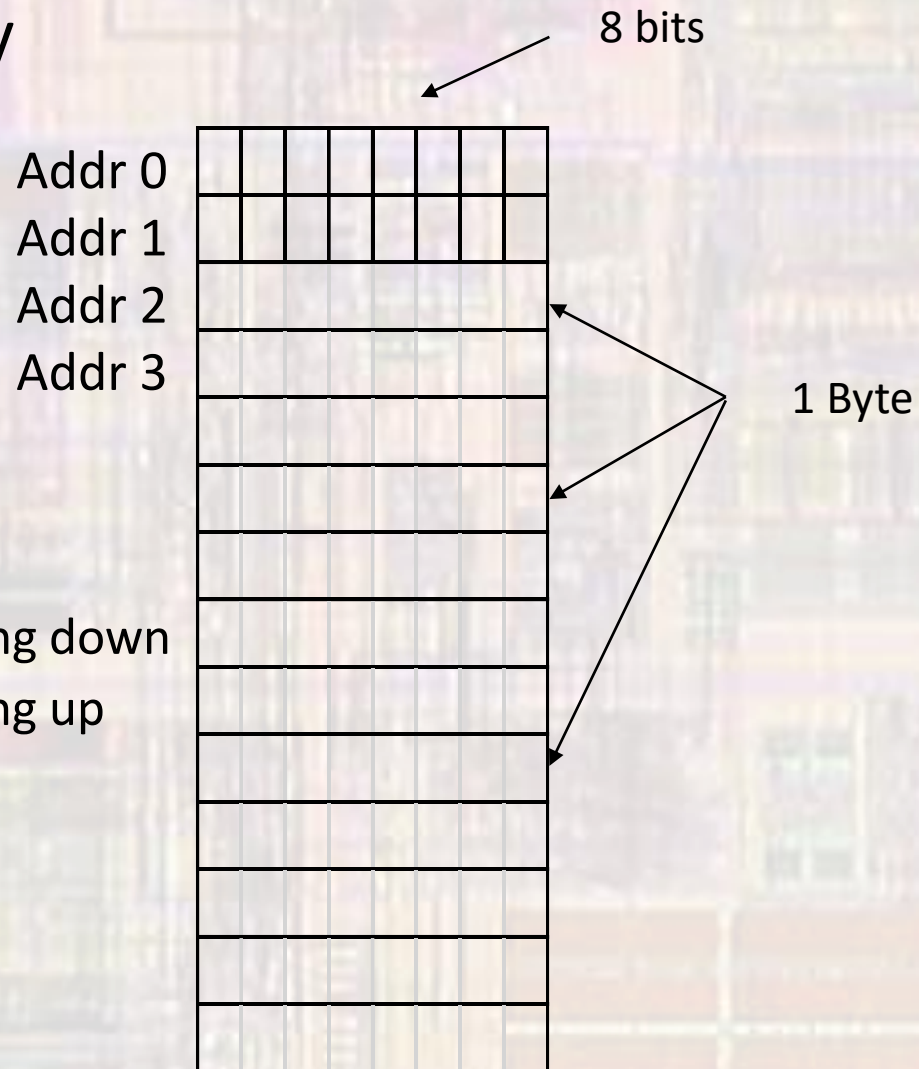
- Integrated Circuit Memory
  - Minimum logical element
    - 1 – bit (b)
    - Has a logical value of '0' or '1'
    - Has a physical value of “vdd” or “gnd”
      - 5v, 3.3v, 2.4v, 1.8v, 1.2v
  - Minimum accessible storage element
    - 1- Byte (B)
    - 8 bits
  - Minimum Addressable element
    - 1 – Word
    - Situational dependent length
    - 1B, 2B, 4B, 8B, 16B, ...

# Memory

- Integrated Circuit Memory

- Logical configuration

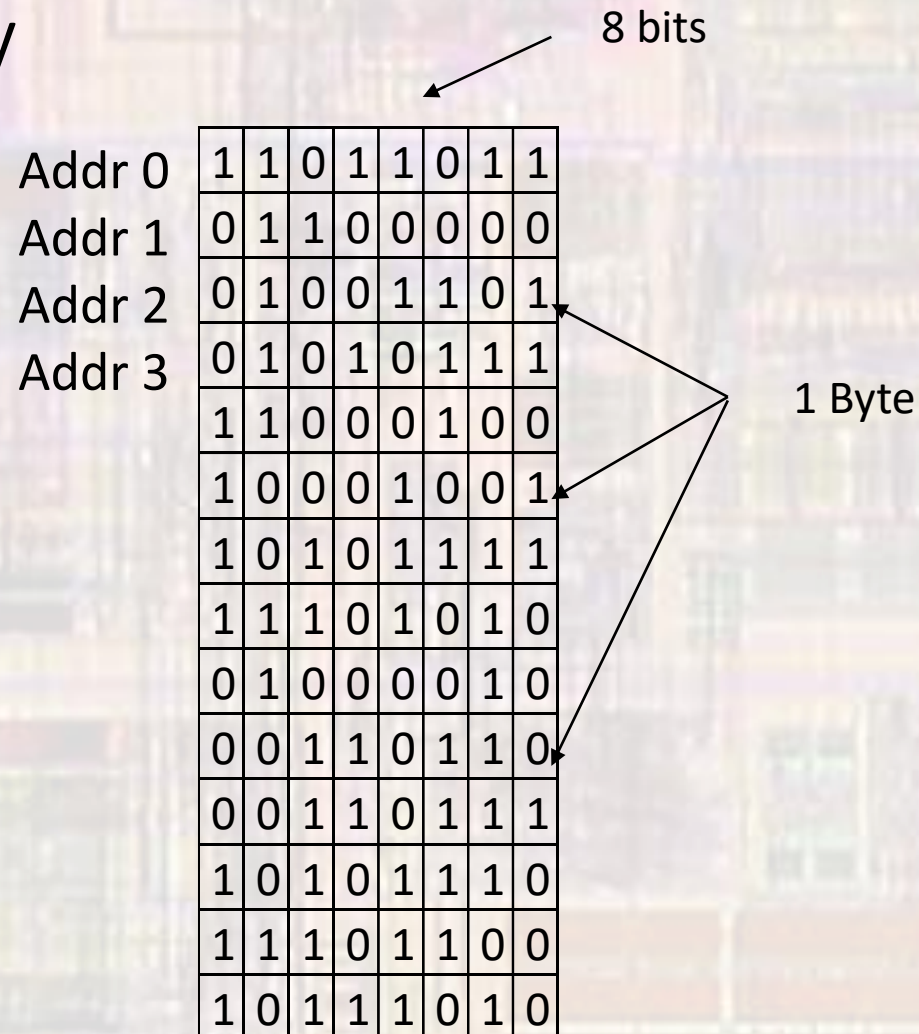
- Long column of bytes
- 1<sup>st</sup> address is "0"
- Sometimes thought of as growing down
- Sometimes thought of as growing up



# Memory

- Integrated Circuit Memory

- Even though we may not have stored anything in a specific memory location
  - It has a value
  - the value is likely random



# Memory

- Integrated Circuit Memory

- Write

- Provide Address and Data

- Write (addr 3, 01100110)
- Write (addr 7, 11010000)
- Write (addr 9, 00000000)

- **Note: Writing overwrites existing data**

Addr 0								
Addr 1								
Addr 2								
Addr 3	0	1	1	0	0	1	1	0
	1	1	0	1	0	0	0	0
	0	0	0	0	0	0	0	0



# Memory

- Integrated Circuit Memory

- Read

- Provide Address

- Read (addr 3) → 01100110
- Read (addr 7) → 11010000
- Read (addr 8) → ????????

- **NOTE: Reading does not destroy the data**

Addr 0								
Addr 1								
Addr 2								
Addr 3	0	1	1	0	0	1	1	0
	1	1	0	1	0	0	0	0
	0	0	0	0	0	0	0	0

# Memory

- Integrated Circuit Memory

- Addresses

- Addresses are NOT part of the memory array
    - Addresses are logic circuits to choose which part of the array to read from or write to – **decoders determine the location**

Addr 0								
Addr 1								
Addr 2								
Addr 3	0	1	1	0	0	1	1	0
	1	1	0	1	0	0	0	0
	0	0	0	0	0	0	0	0

# Memory

- Integrated Circuit Memory
  - Word Alignment
    - Processors work with data WORDS
    - Size of the internal registers
      - 1 Byte – 8 bit processor
      - 2 Bytes – 16 bit processor
      - 4 Bytes – 32 bit processor
      - 8 Bytes – 64 bit processor
    - Memory is word aligned
      - Must access the entire word
      - Not allowed/possible to access inside a word\*

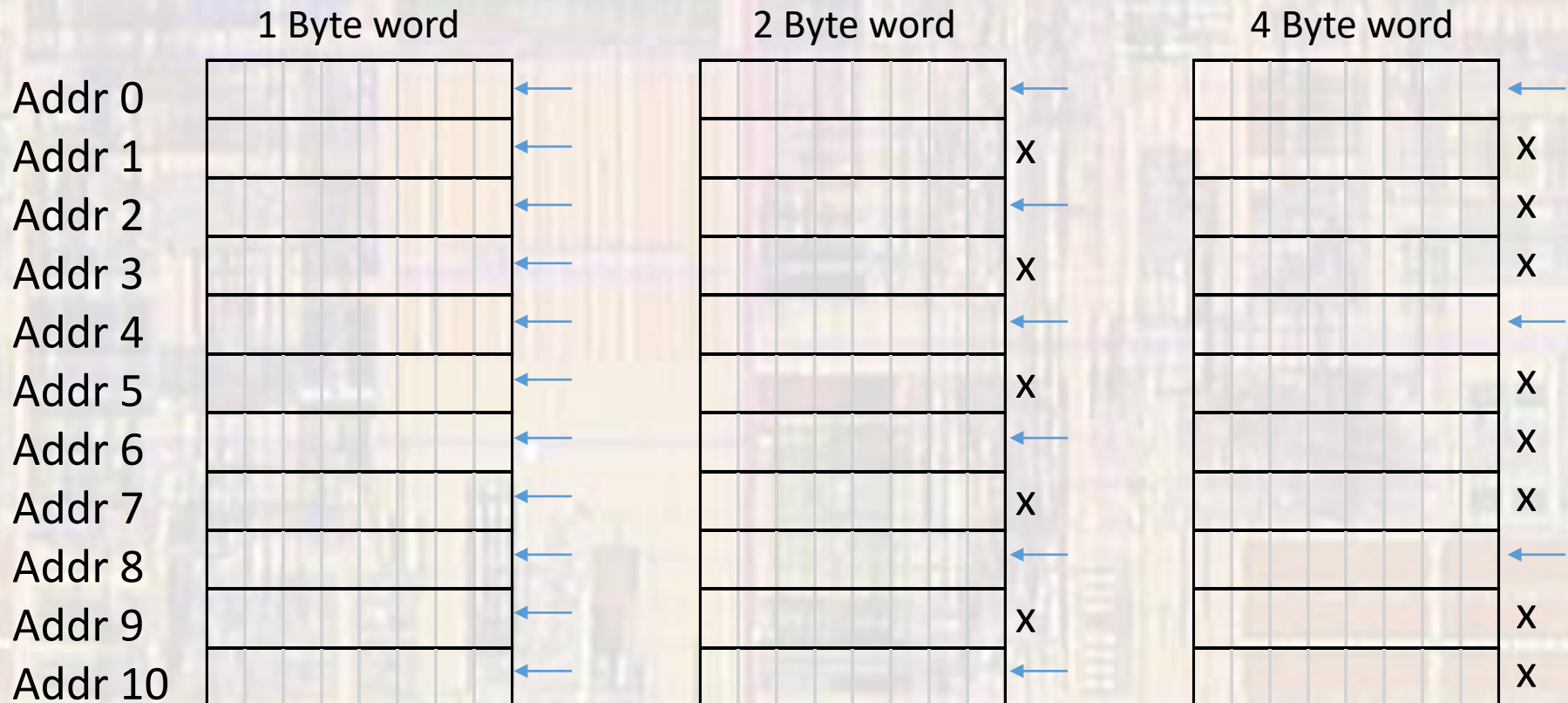
\* exceptions exist

# Memory

- Integrated Circuit Memory

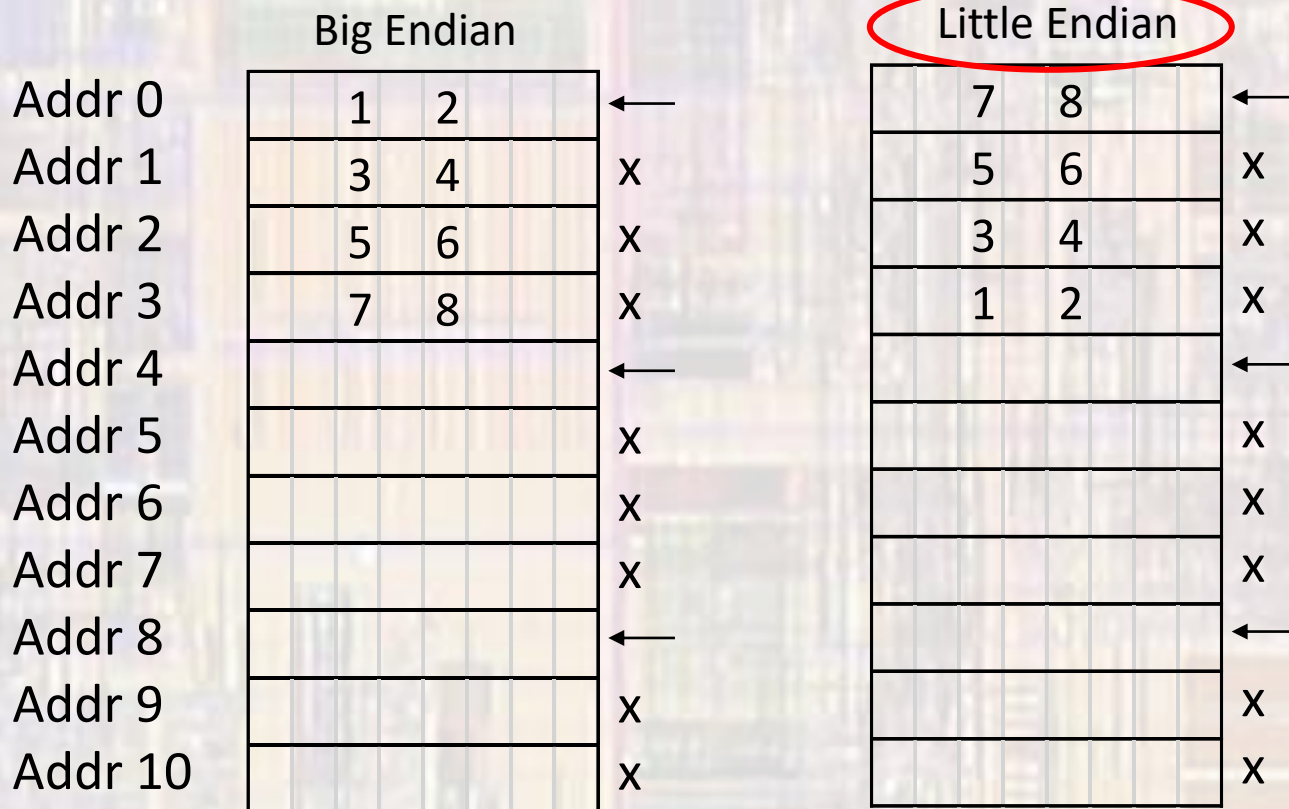
- Word Alignment

- Allowed addresses indicated by ←



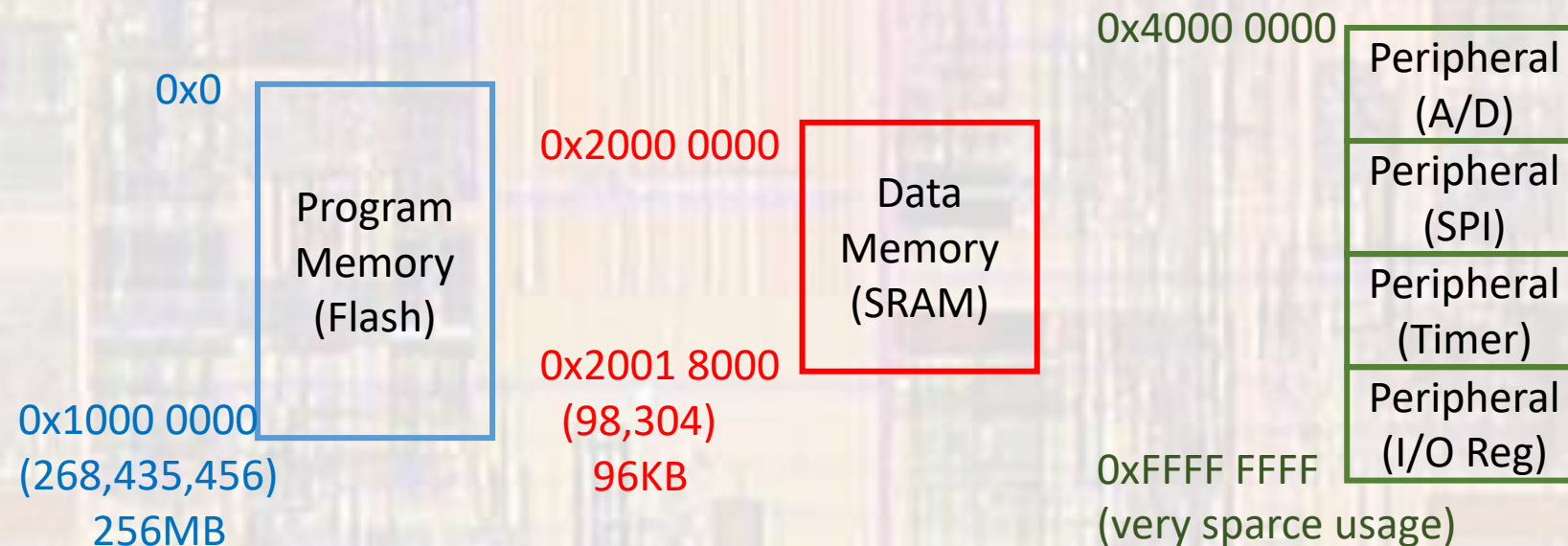
# Memory

- Integrated Circuit Memory
  - Big-Endian vs Little-Endian
  - data value 0x12345678 in a 4 byte word



# Memory

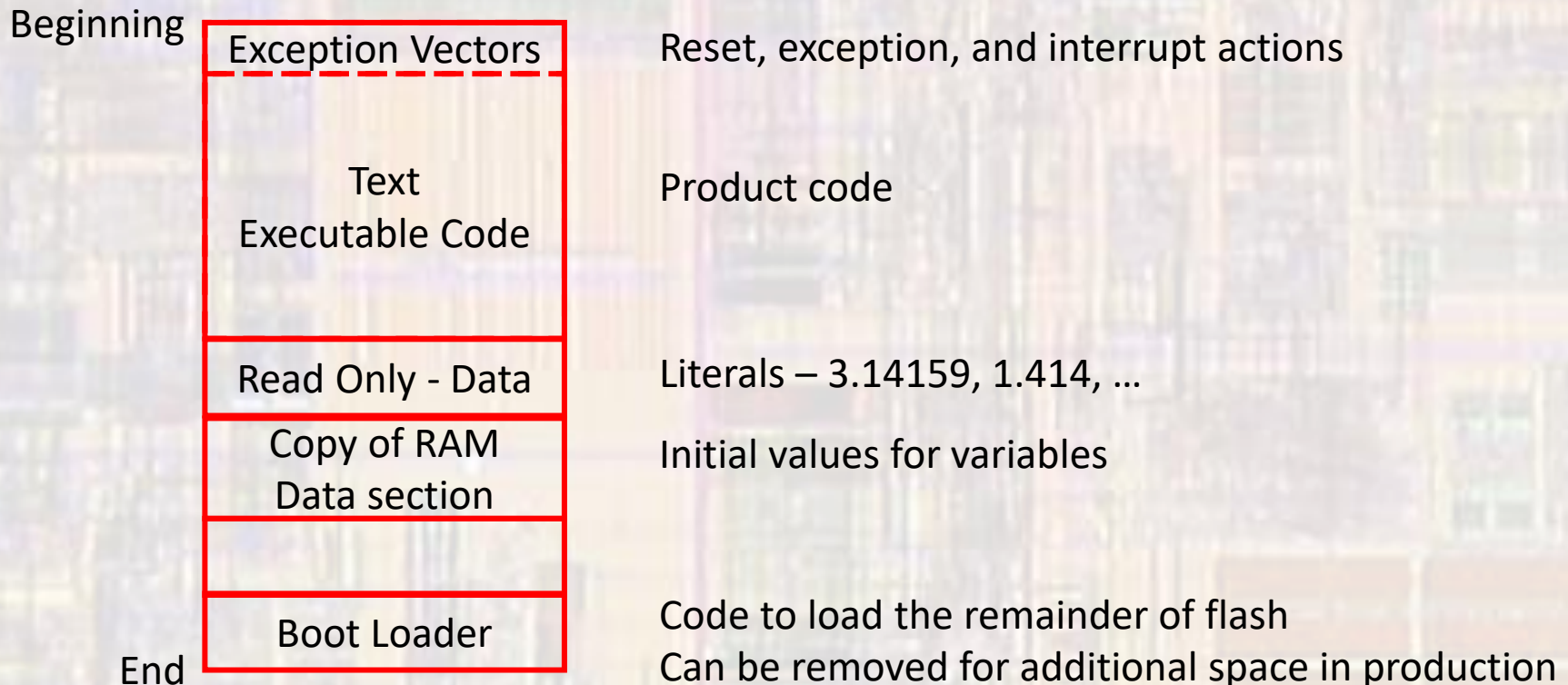
- Memory Mapped Architecture (embedded)
  - Treat memories and peripherals the same
  - Assign separate memory “spaces” to each type of storage
  - Some architectures include registers in memory map



STM32L47x memory map

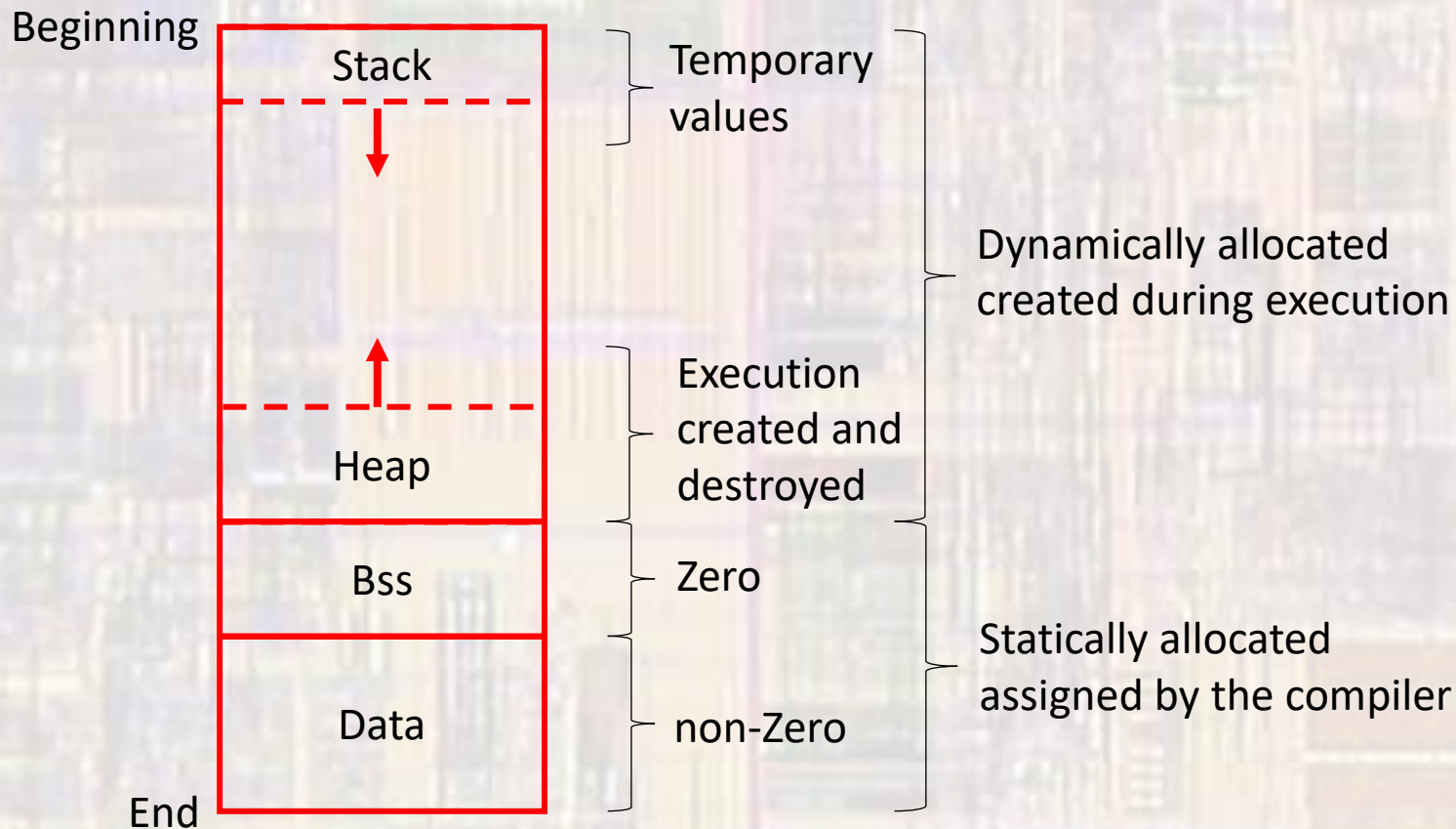
# Memory

- Program Memory (embedded)
  - Flash
  - Accessible Double Word format



# Memory

- Data Memory (embedded)
  - Accessible in Byte, Half-Word, and Word format
  - Has some Bit level access





# Memory

- Peripheral Memory (embedded)
  - 4 Bytes (Word) accesses

