

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

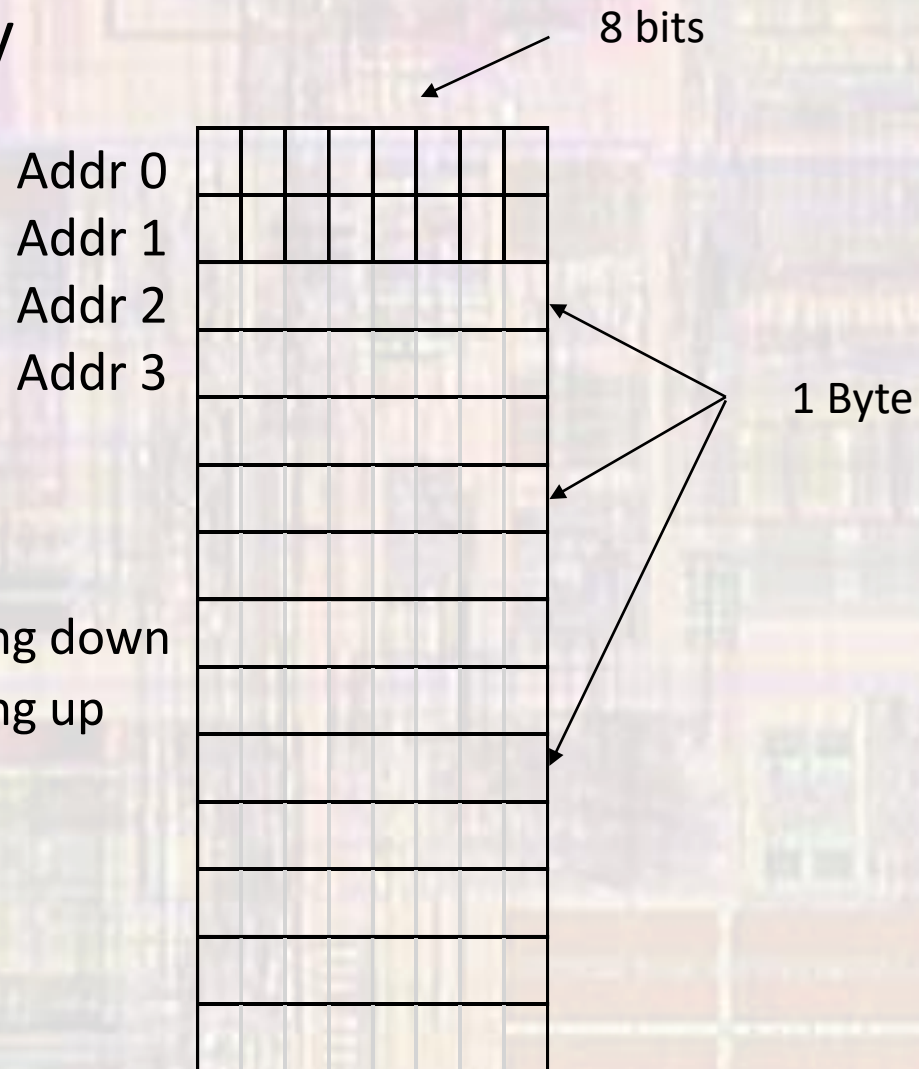
- Integrated Circuit Memory
 - Minimum logical element
 - 1 – bit (b)
 - Has a logical value of '0' or '1'
 - Has a physical value of “vdd” or “gnd”
 - 5v, 3.3v, 2.4v, 1.8v, 1.2v
 - Minimum accessible storage element
 - 1- Byte (B)
 - 8 bits
 - Minimum Addressable element
 - 1 – Word
 - Situational dependent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

Memory

- Integrated Circuit Memory

- Logical configuration

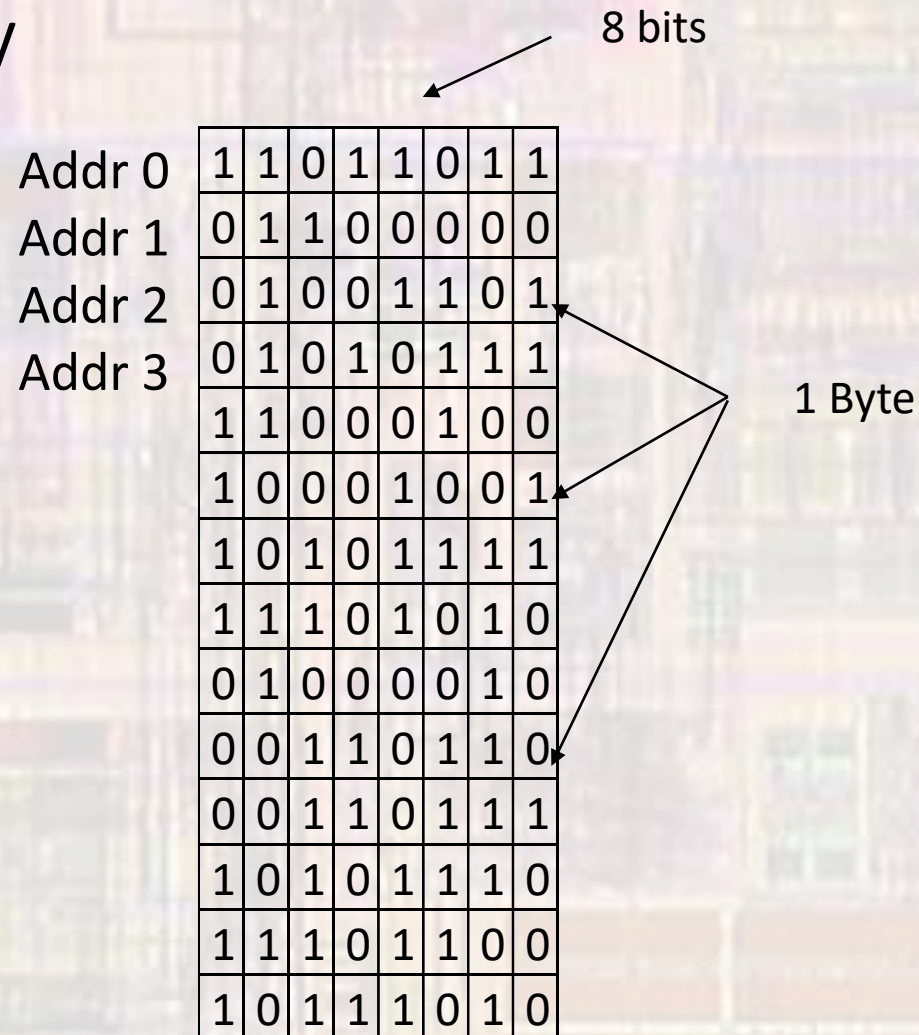
- Long column of bytes
- 1st address is "0"
- Sometimes thought of as growing down
- Sometimes thought of as growing up



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*

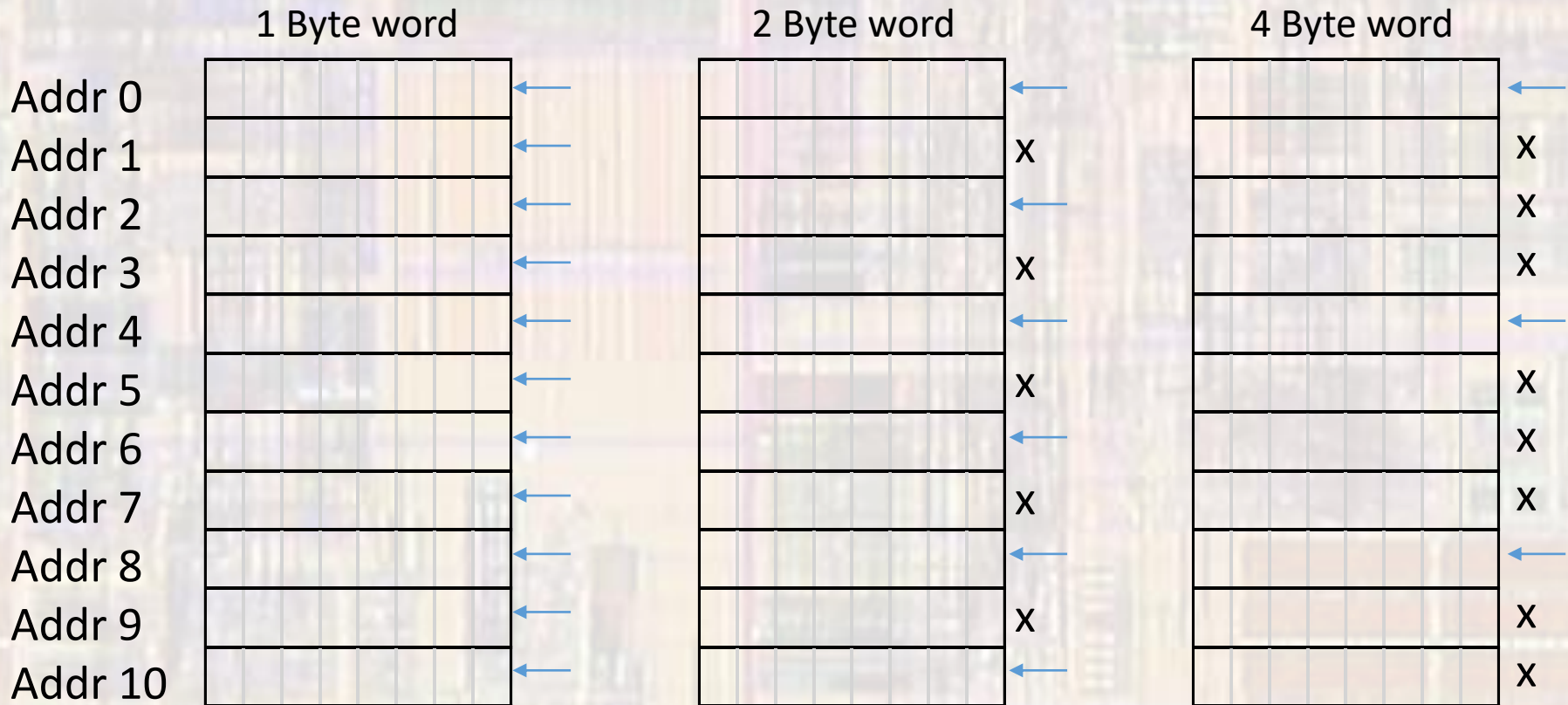
* exceptions exist

Memory

- Integrated Circuit Memory

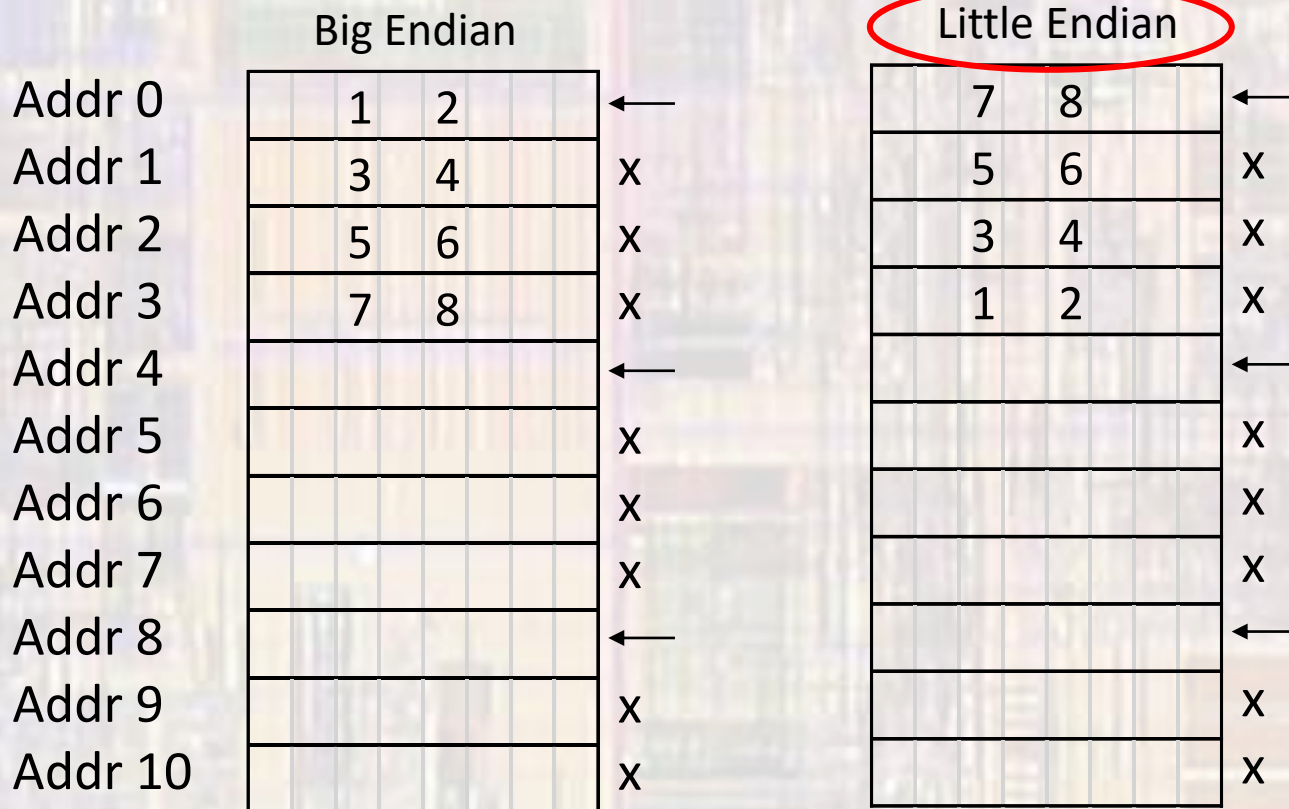
- Word Alignment

- Allowed addresses indicated by ←



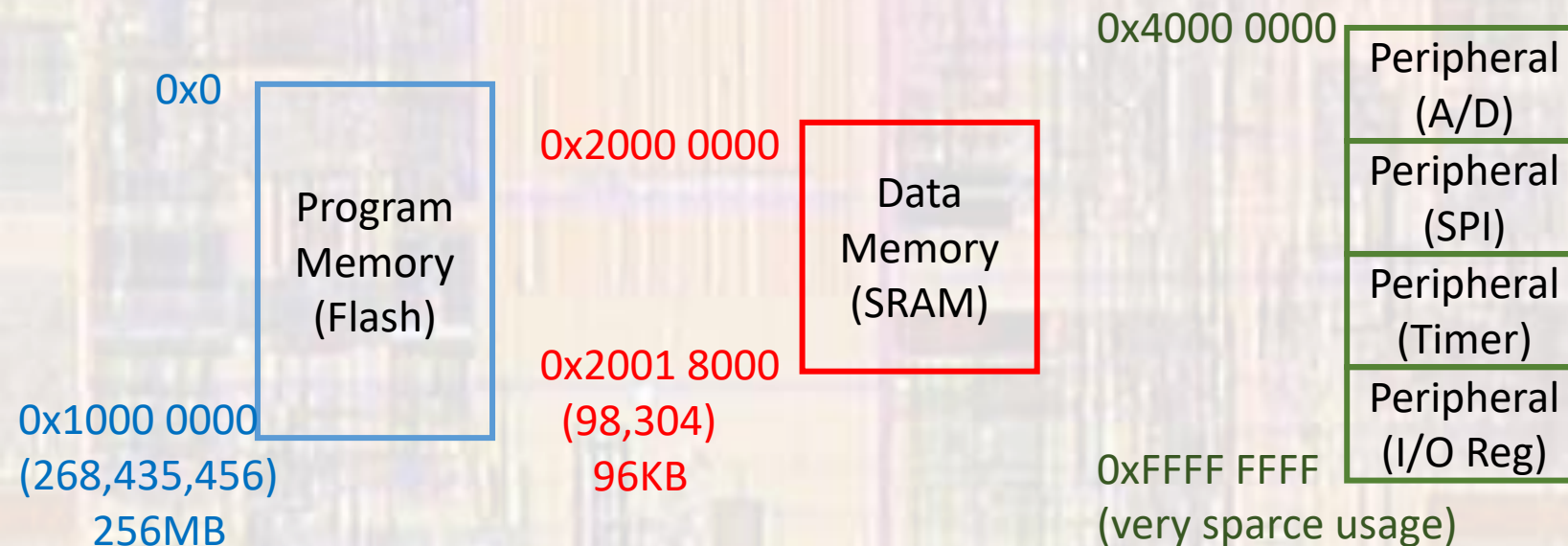
Memory

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



Memory

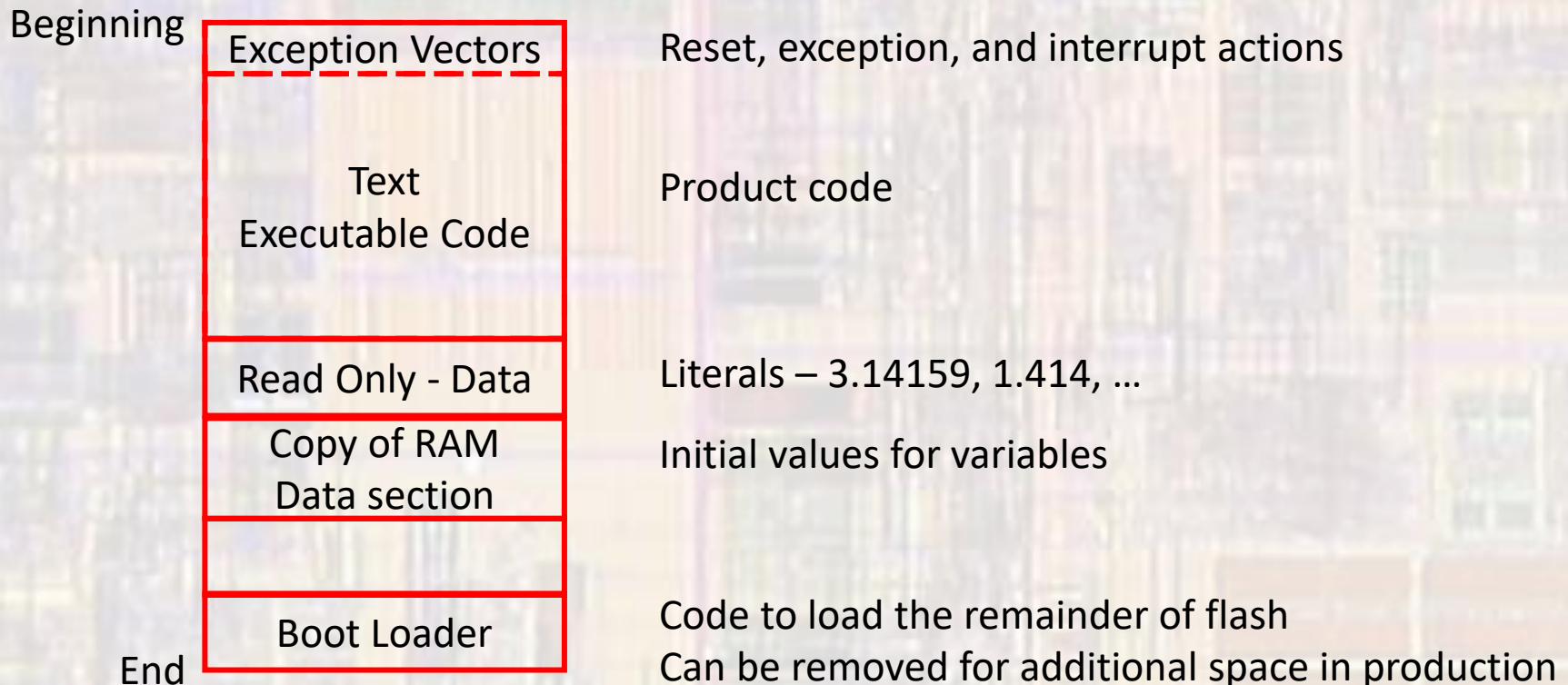
- Memory Mapped Architecture (embedded)
 - Treat memories and peripherals the same
 - Assign separate memory “spaces” to each type of storage
 - Some architectures include registers in memory map



STM32L47x memory map

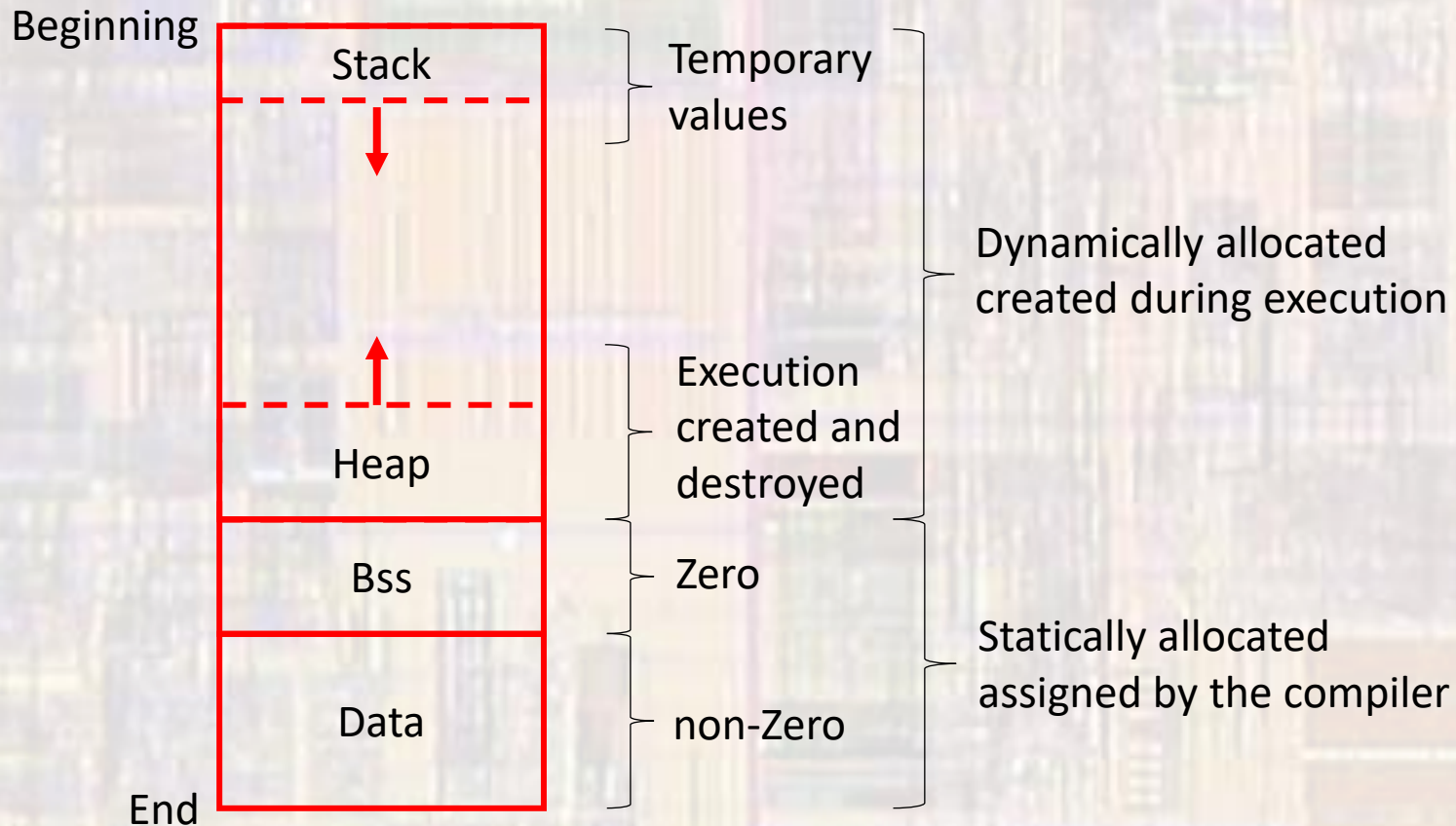
Memory

- 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

