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Prifysgol Glyndŵr Wrecsam | Wrexham Glyndŵr University

University of South Wales
Prifysgol De Cymru

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Welcome!

Unit 3 - CPD for Secondary Education

Introductions

Your lecturers for the course will be:

Daniel North
daniel.north@technocamps.com

Alex Southern
alex.southern@technocamps.com

Unit 3

Unit 3 will be 9 weekly sessions, with a 2-week break over the Easter holiday period and a further 5-week break over the May exam period:

Unit 3 Term 1:

1. 27th Feb | Assembly Language & LMC pt.1
2. 5th Mar | Assembly Language & LMC pt.2
3. 12th Mar | Number Systems pt.1
4. 19th Mar | Number Systems pt.2

** EASTER BREAK**

Unit 3

Unit 3 will be 9 weekly sessions, with a 2-week break over the Easter holiday period and a further 5-week break over the May exam period:

Unit 3 Term 2:

7. 9th Apr | File Types & Compression
8. 16th Apr | Boolean Algebra pt.1
9. 23rd Apr | Boolean Algebra pt.2

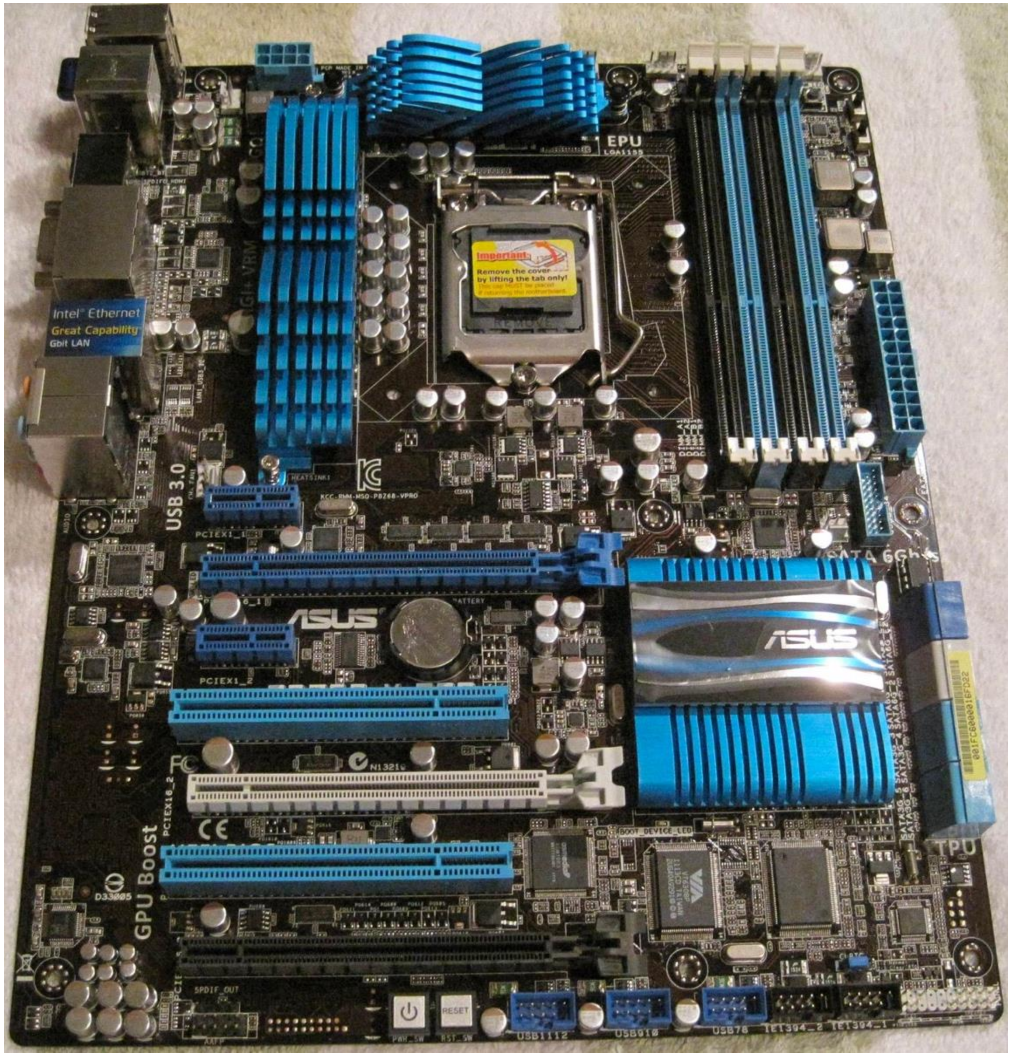
HALF TERM AND EXAMS

7. 4th Jun | Greenfoot pt.1
8. 11th Jun | Greenfoot pt.2

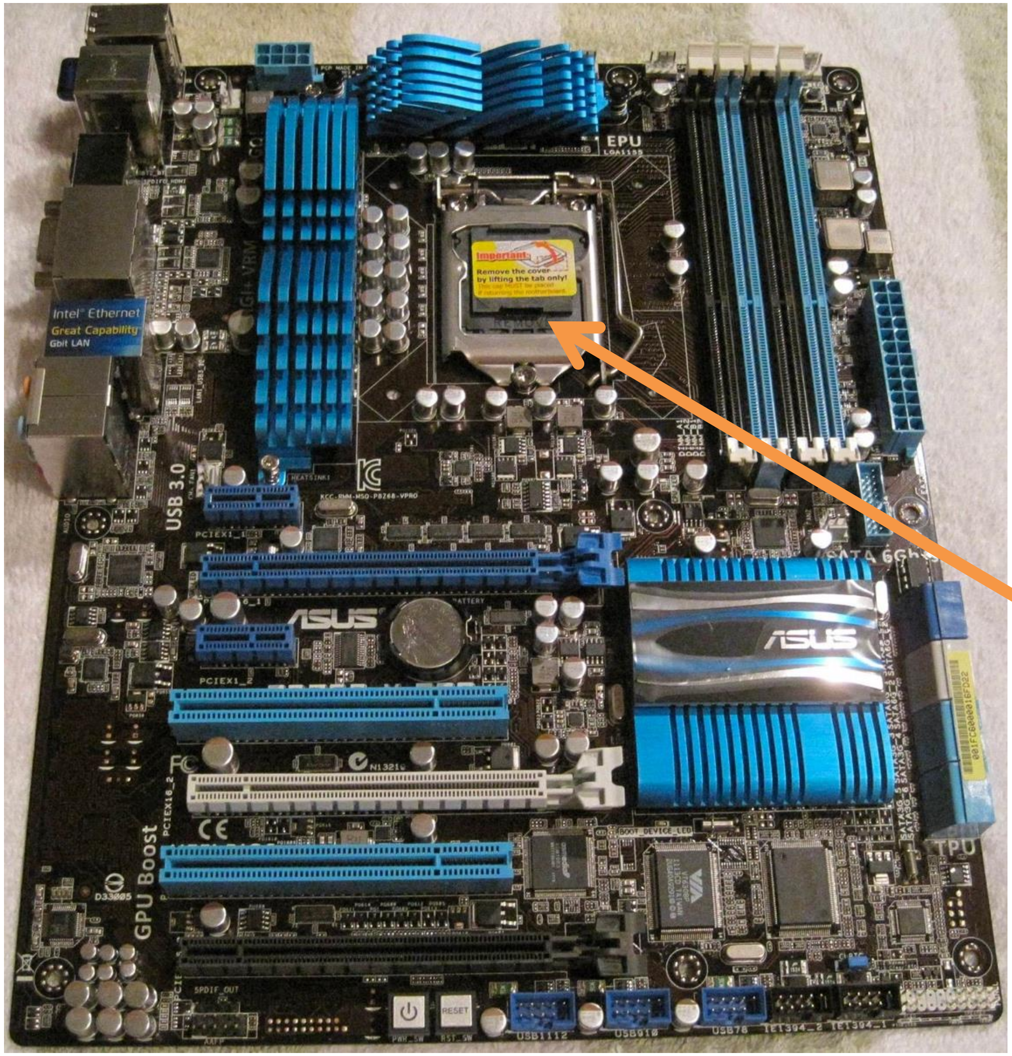
END OF UNIT

Components of Computer Systems

Motherboard



Computer Components



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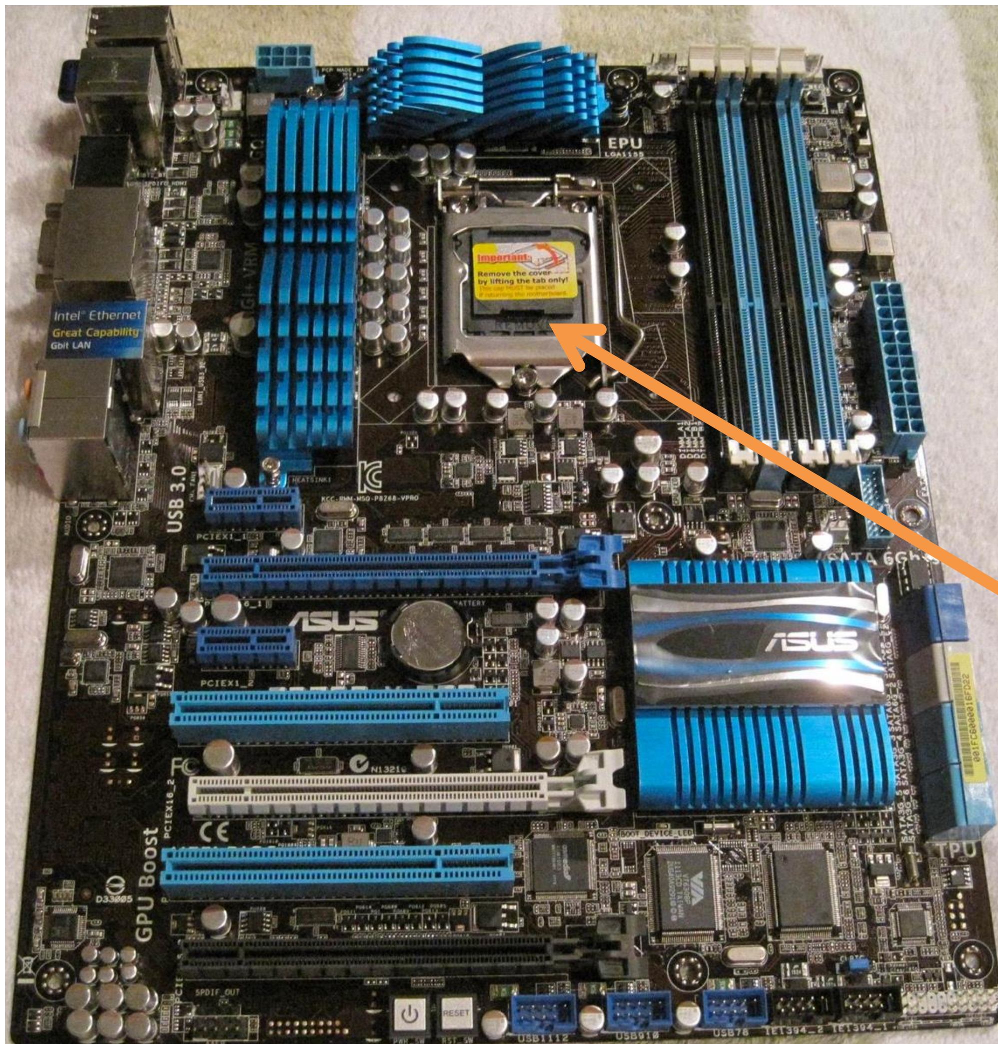

CPU Socket

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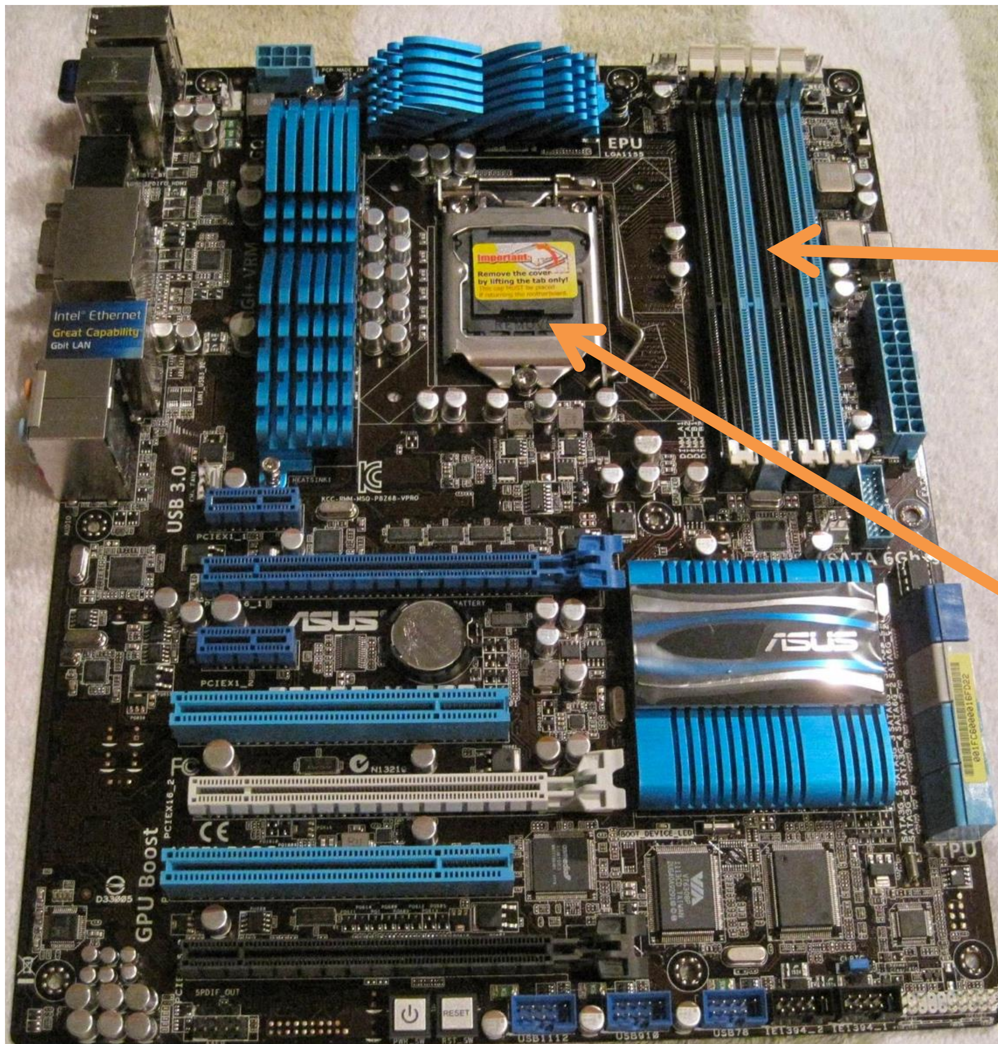
Computer Components



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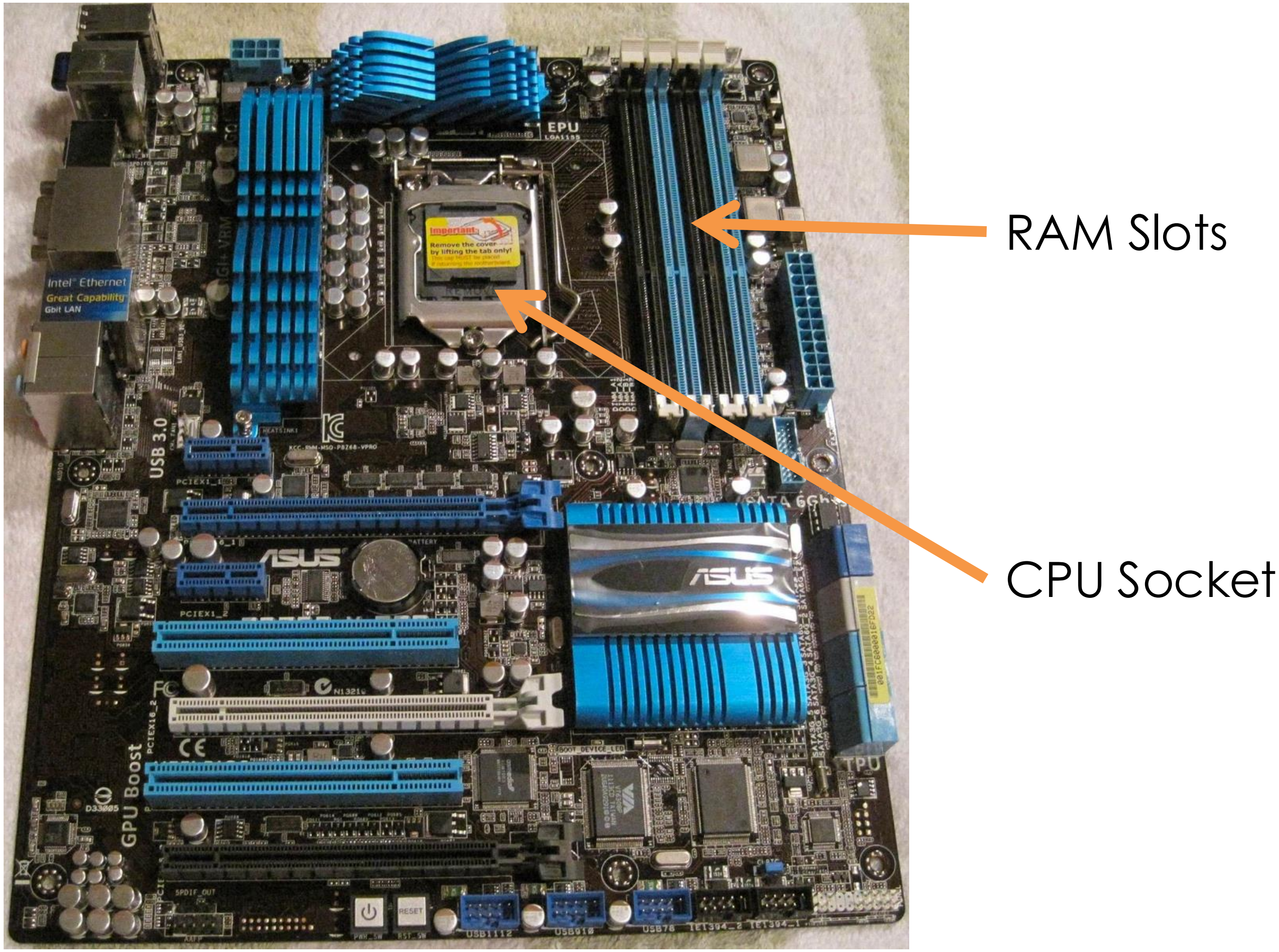
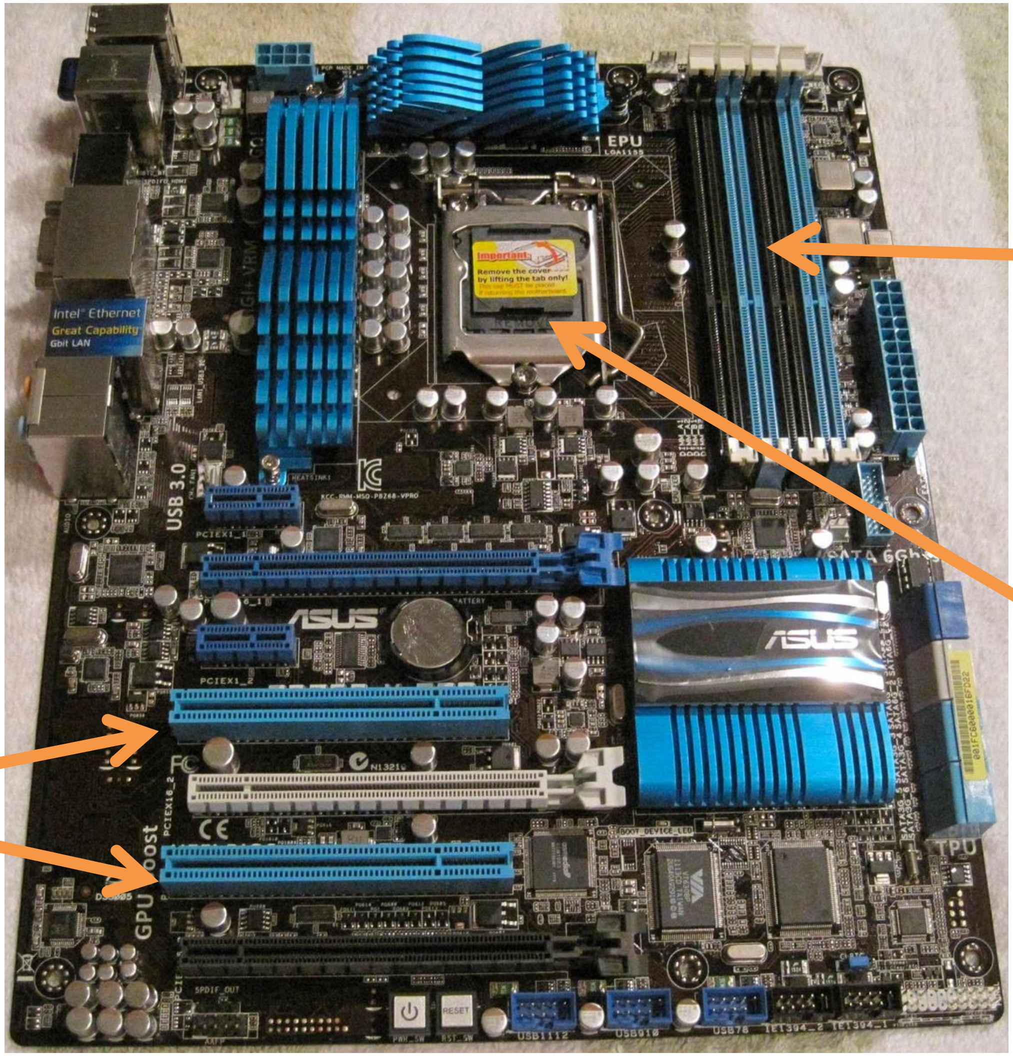


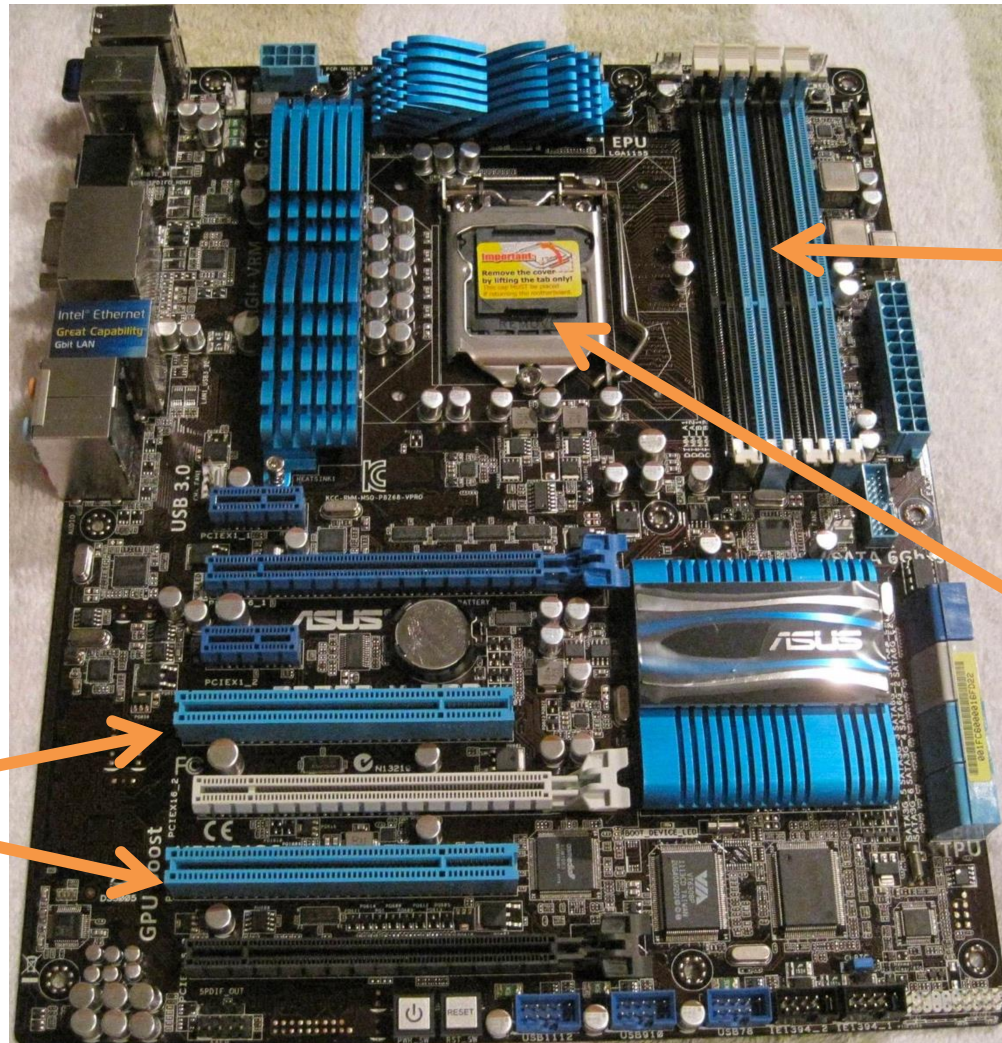
Computer Components



RAM Slots

CPU Socket

Computer Components



RAM Slots

CPU Socket

PCI Slots

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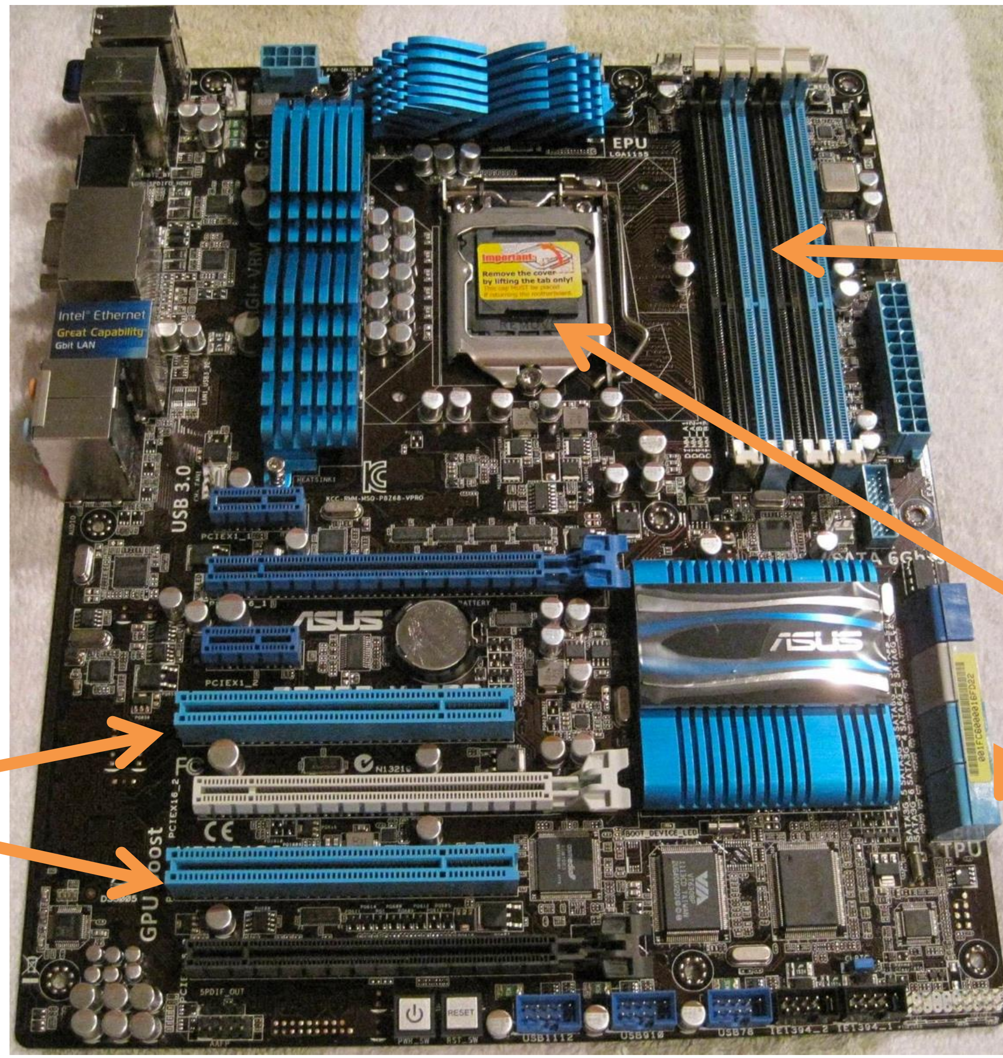
Computer Components



RAM Slots

CPU Socket

PCI Slots

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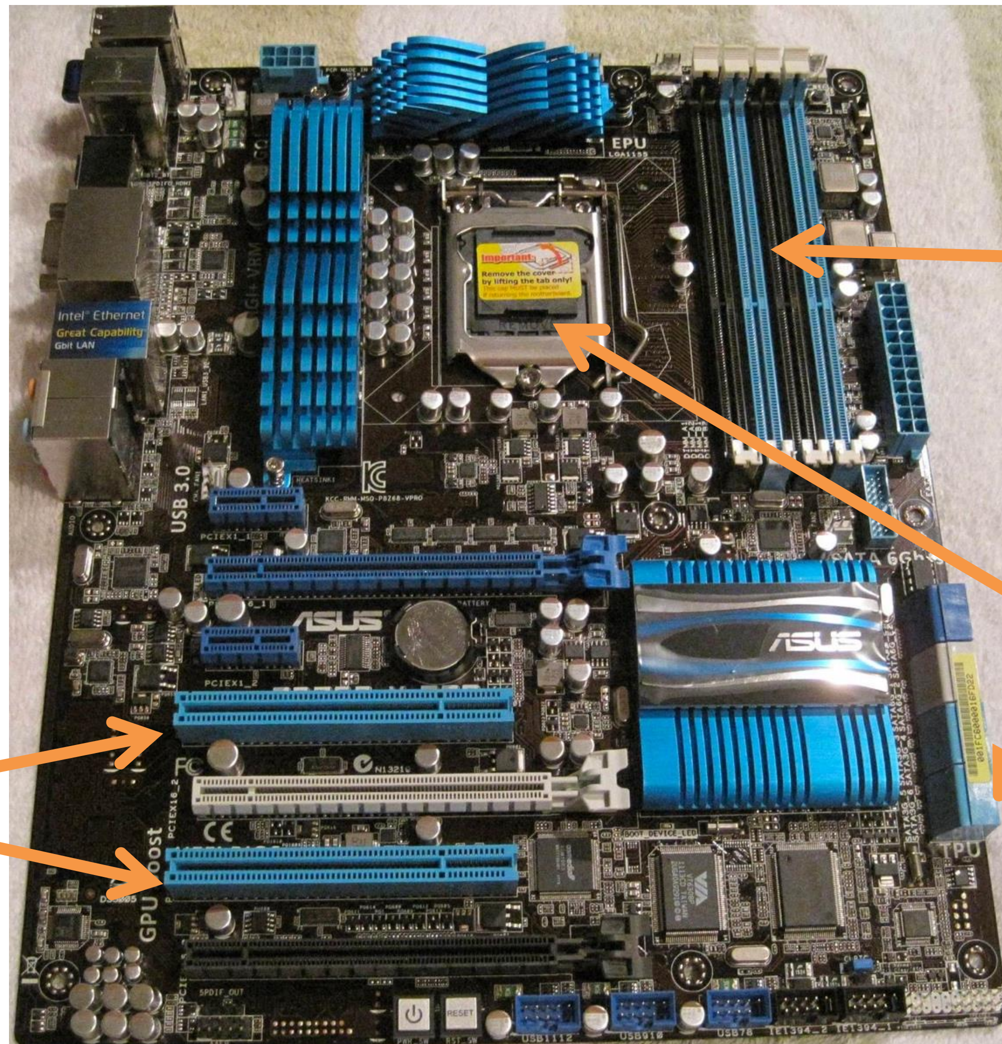
Computer Components



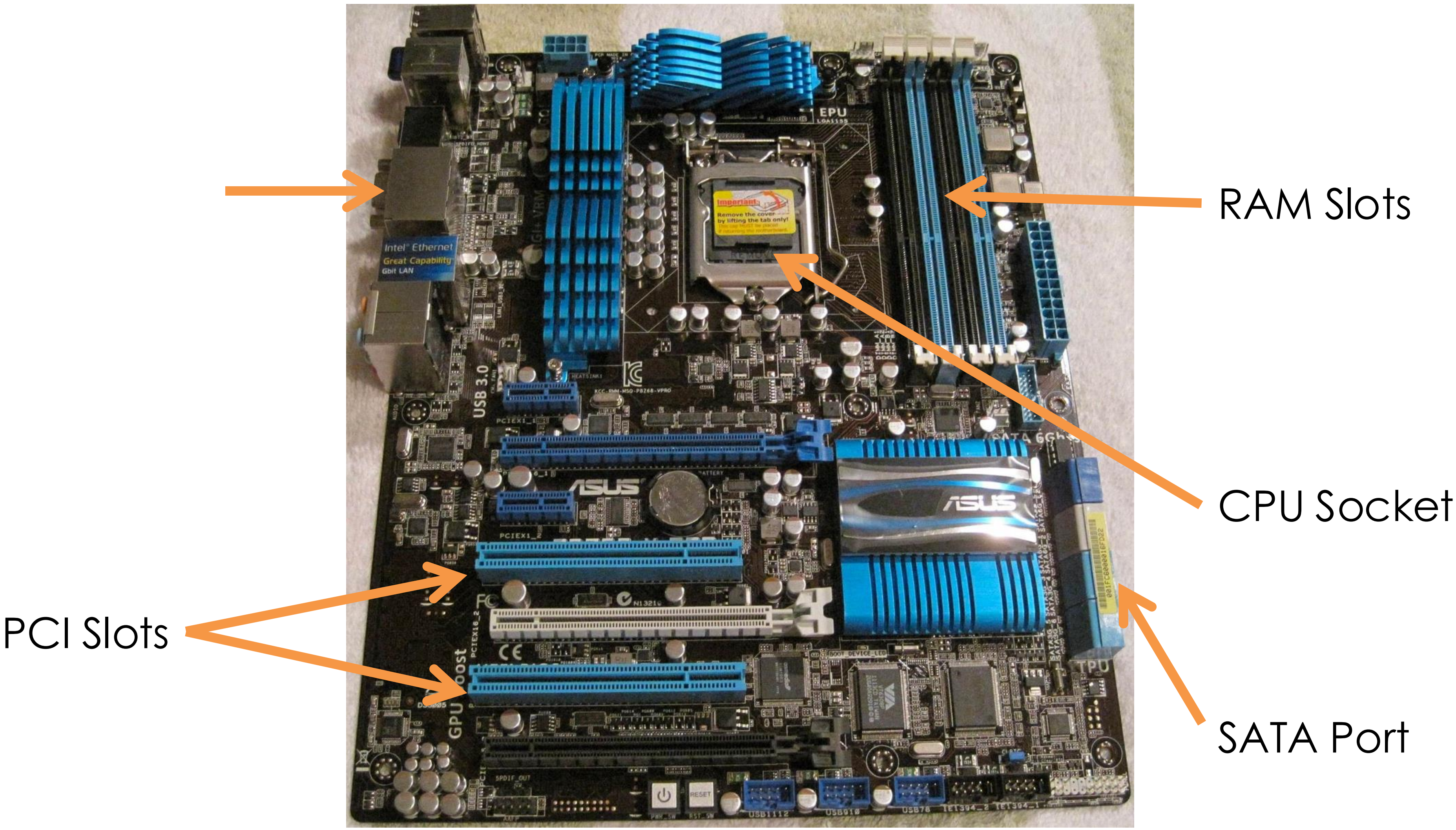
RAM Slots

CPU Socket

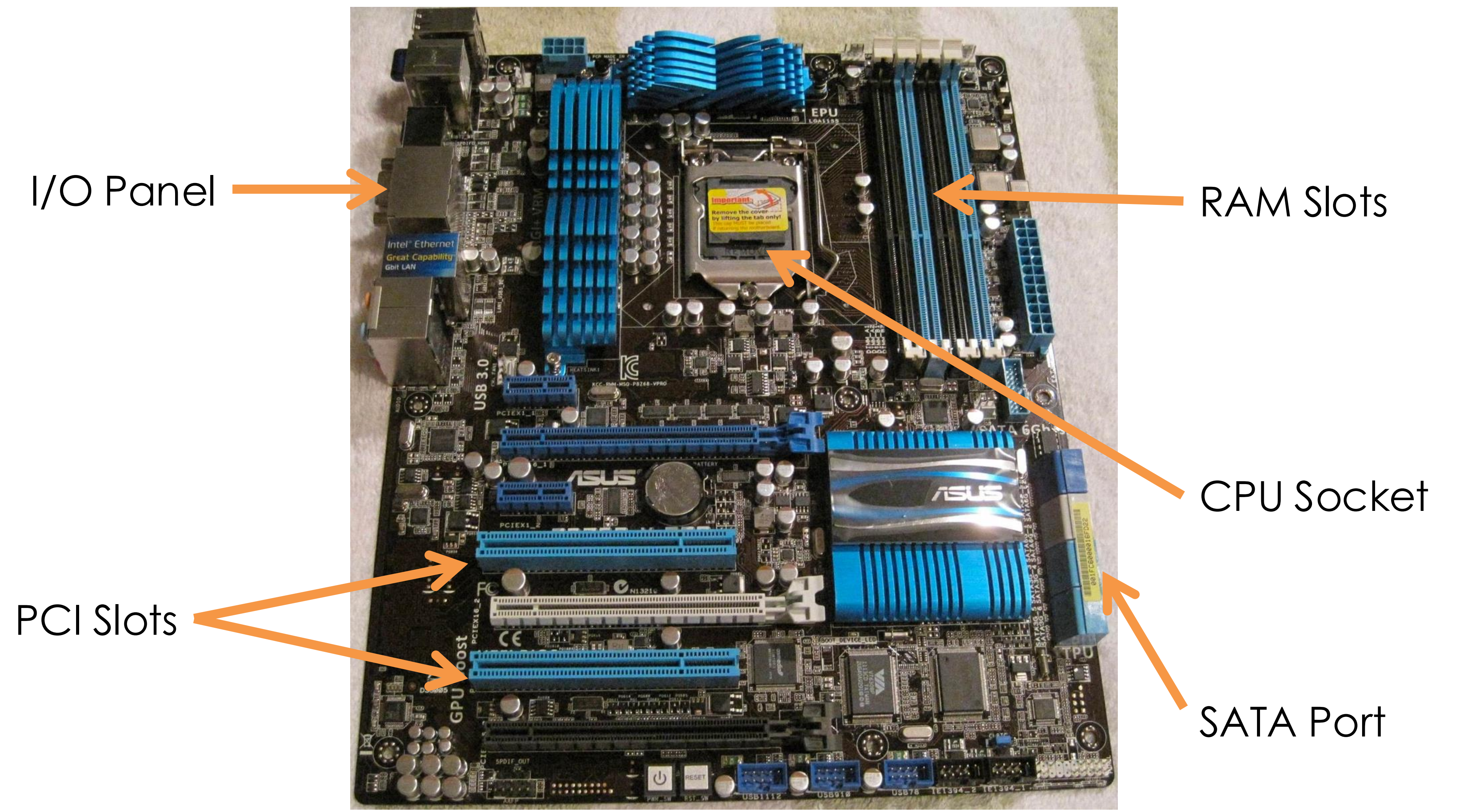
PCI Slots

SATA Port

Computer Components



Computer Components



Assembly Language

Assembly Language

Assembly language is a low-level programming language which uses an assembler to convert a program into machine code which can be run by the computer.

Assembly languages usually use short mnemonics as instructions and each one is specific to the computer architecture and operating system.

Assembly Language Code

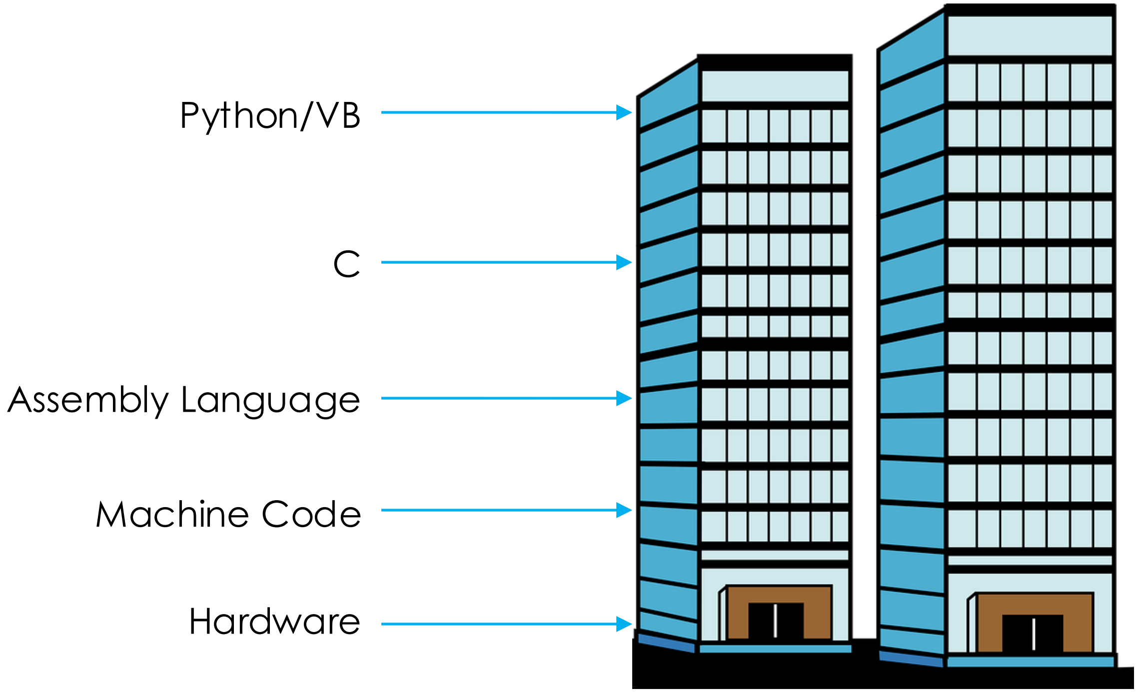
```
        INP
        STA Number
        LDA Number
        OUT
        HLT
Number  DAT
```

```
00 INP
01 STA 05
02 LDA 05
03 OUT
04 HLT
05 DAT 00
```

Little Man Computer

Assembly Language

Assembly languages are considered to be low-level because they are very close to machine languages. They are only one step removed from a computer's machine language.



Why Assembly?

Relationship between Assembly Language and Machine Code

A CPU cannot directly read source code. Different CPUs may have different architecture and each different architecture has its own machine language.

This prevents direct source code to machine code translation – we need to use an assembly language to assemble the code which bridges the gap.

For example, a piece of Python code assembled to run on a 64 bit Windows machine will not have the same instruction set as the Python code assembled to run on a 32 bit Linux machine.

Python → Assembly

Simple program in Python:

```
def main():
    for i in range(10):
        print(i)
```

This can be compiled into the following assembly:

```
.section __TEXT, __text
#
.globl _main
_main:
        pushq   $0
        pushq   %rbp
        movq    %rsp, %rbp
        movq    $0, 8(%rbp)
main_1_while:
        movq    $10, %rdx
        movq    8(%rbp), %rax
        cmpq    %rdx, %rax
        movq    $0, %rax
        jnl     main_3_less
        incq    %rax
```

```
main_3_less:
        cmpq    $0, %rax
        jz      main_2_break
        pushq   8(%rbp)
        call    print
        addq    $8, %rsp
        movq    $1, %rdx
        movq    8(%rbp), %rax
        addq    %rdx, %rax
        movq    %rax, 8(%rbp)
        jmp     main_1_while
main_2_break:
        movl    $0, %edi
        movl    $0x2000001, %eax
        syscall
```

```
#
putc:
        pushq   %rbp
        movq    %rsp, %rbp
        movl    $0x2000004, %eax
        movl    $1, %edi
        movq    %rbp, %rsi
        addq    $16, %rsi
        movq    $1, %rdx
        syscall
        popq    %rbp
        ret
```

Assembly Language

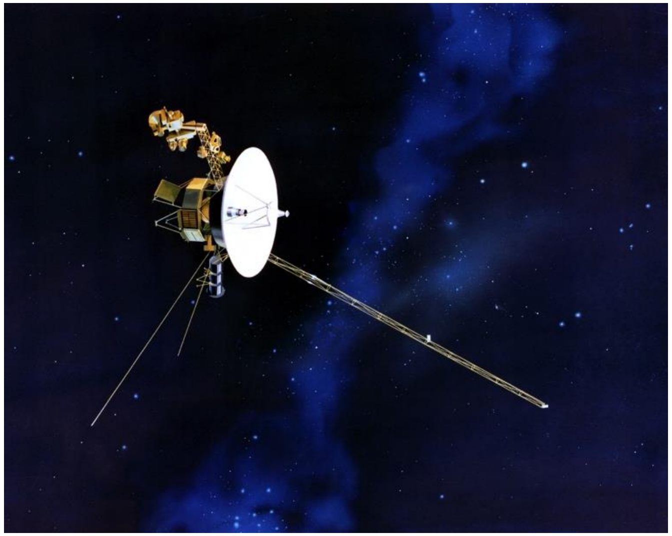
If we wrote the same code in **LMC Assembly language**, it would look like this.

```
loop  LDA value  // load value
      OUT        // output value
      ADD one    // add one to value and store
      STA value
      LDA max    // load how many times we need to loop
      SUB value  // subtract the current value
      BRP loop   // if this is positive keep looping
      HLT        // halt
value DAT 0
max   DAT 9
one   DAT 1
```

We have **10 lines** of LMC Assembly language code instead of the **30** we got from converting Python to Assembly.

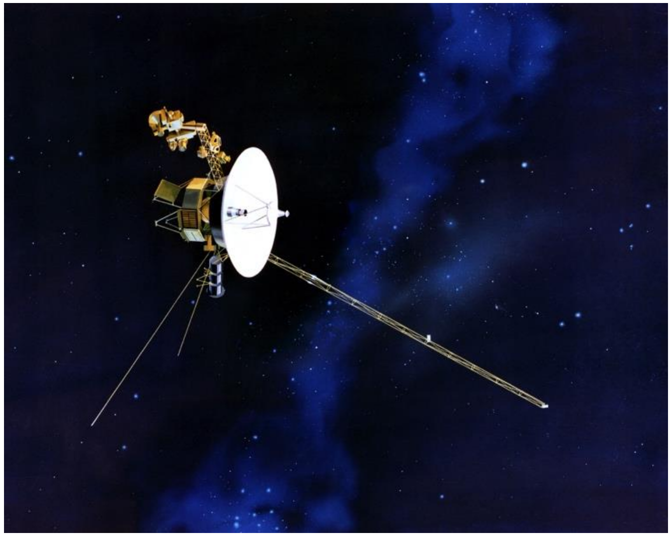
Why Are Assembly Languages Used?

Low-level languages are especially useful when speed of execution is critical or when writing software which interfaces directly with the hardware, e.g. device drivers.



Why Are Assembly Languages Used?

Example: The Voyager space probe launched in 1977 (now outside our solar system) is programmed using an old assembly language. NASA are struggling to find anyone who still has a working knowledge of the language to keep it going!

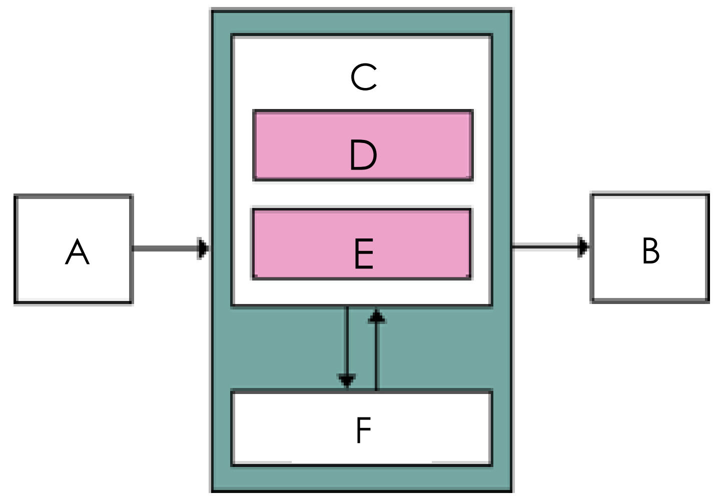


Computer Architecture

Computer Architecture

Just like architecture of a building, computer architecture is the way that a computer is designed to function in terms of hardware.

The most common architecture is known as von Neumann architecture. This architecture is made up of:



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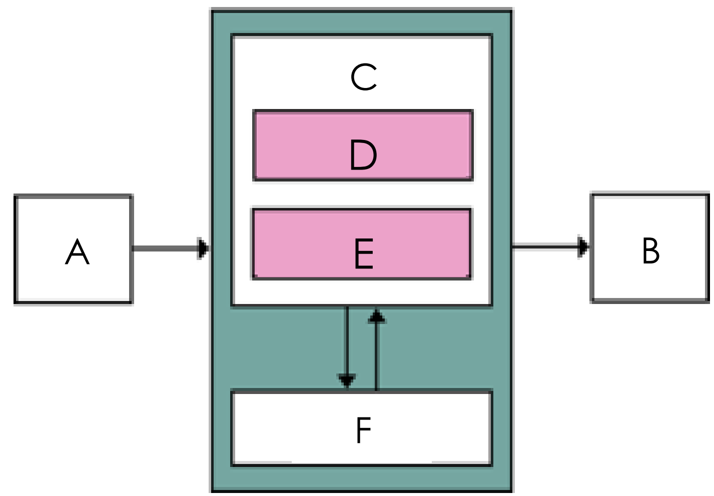

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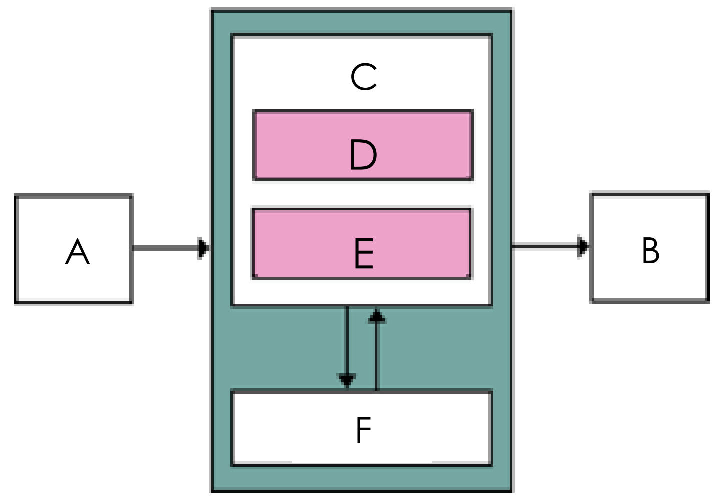

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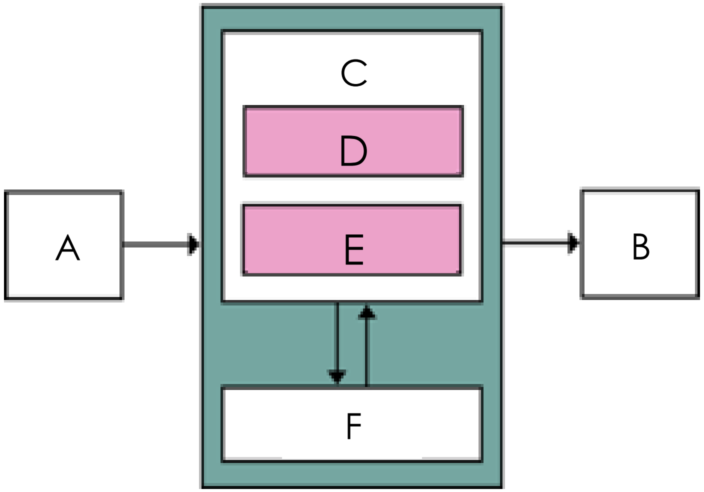

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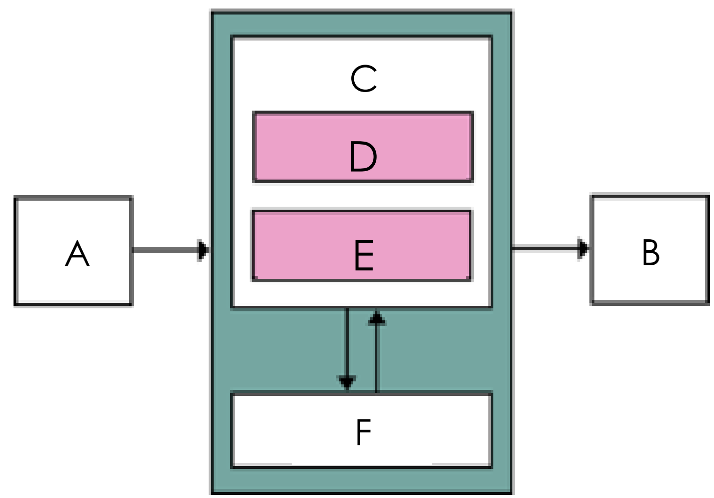
- Input device – Keyboard, mouse



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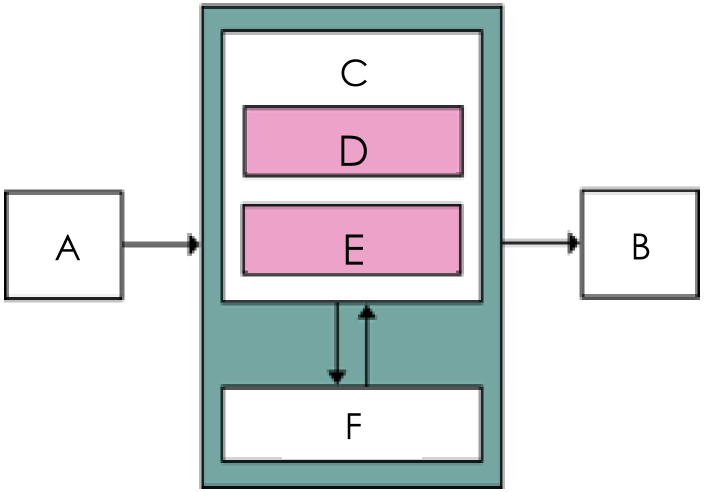

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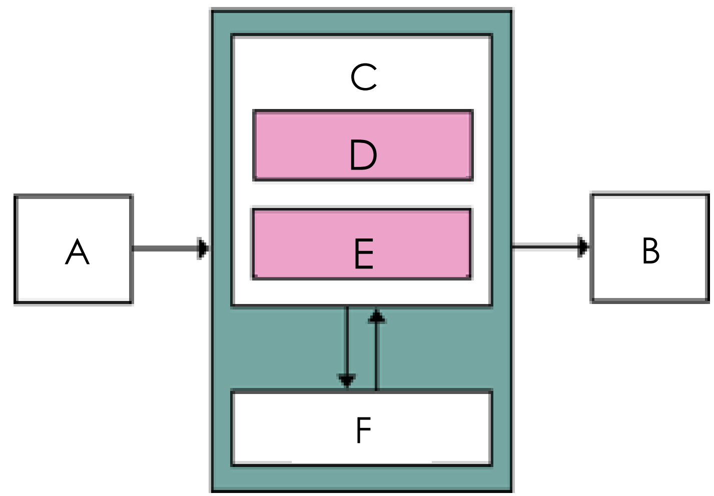
Activity: von Neumann Architecture



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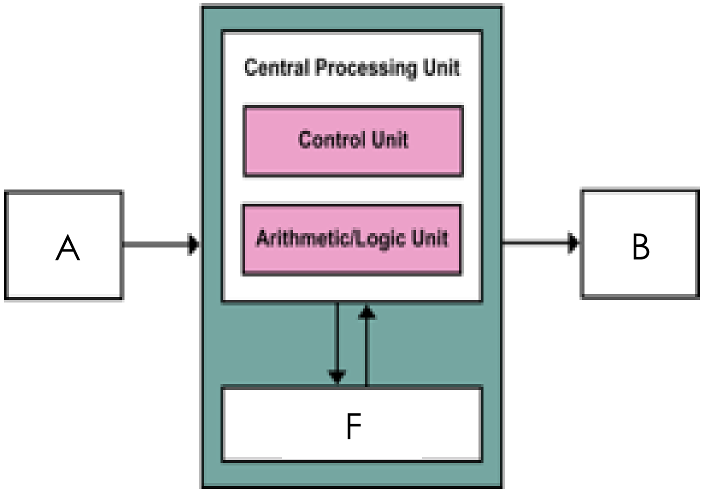

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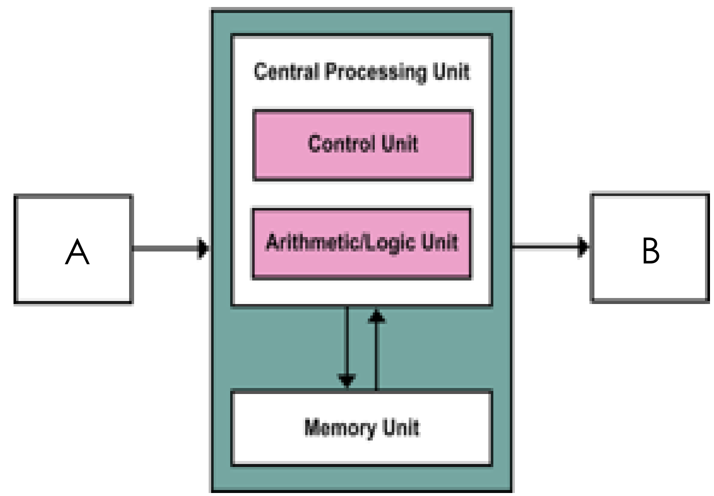
Computer Architecture

Activity: von Neumann Architecture



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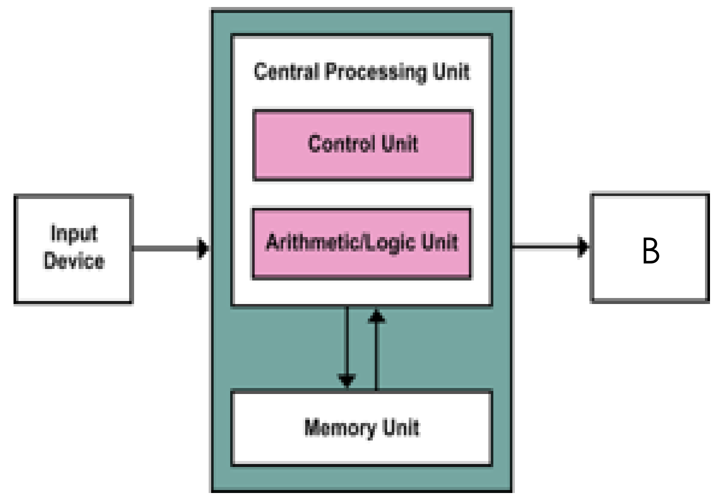

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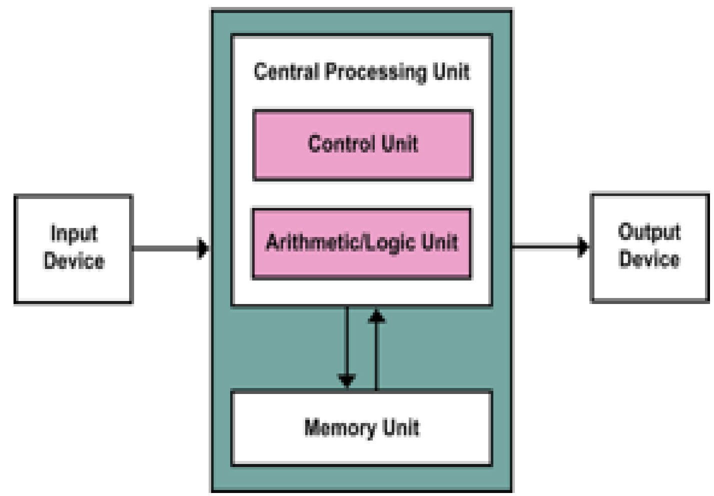
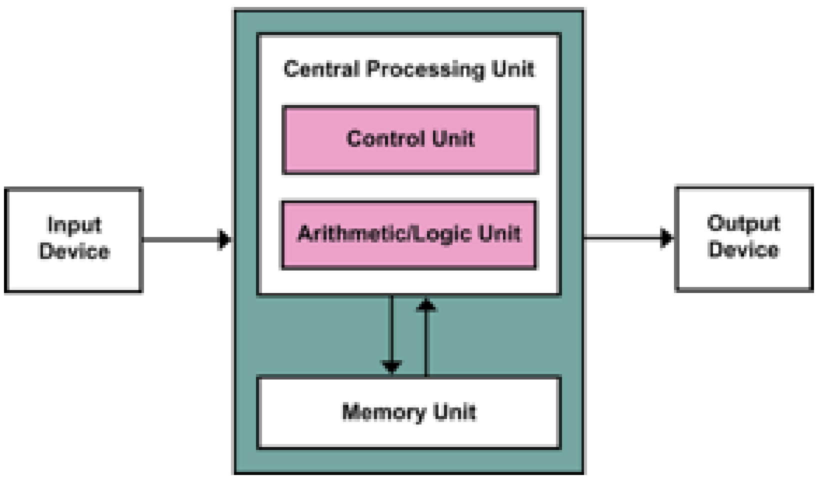


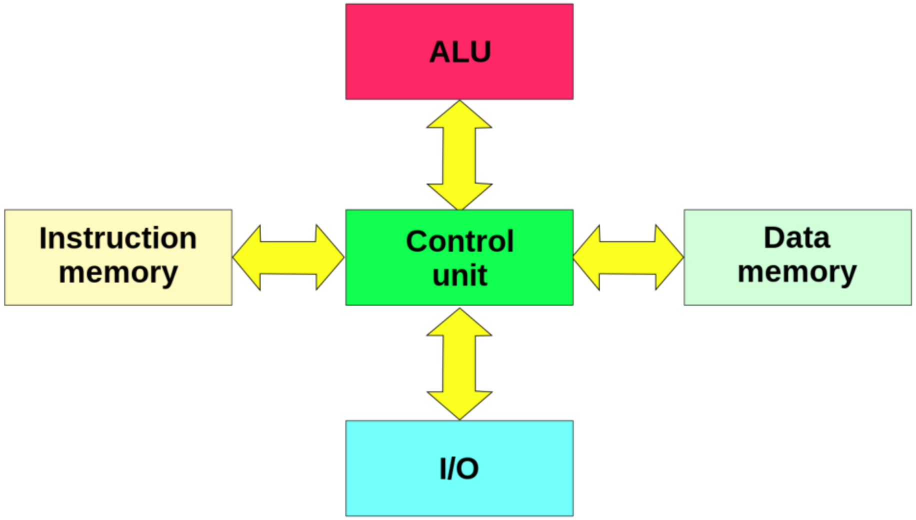
von Neumann vs. Harvard

von Neumann Architecture



This stores both instructions and data within the same memory addresses and uses the same bus for both.

Harvard Architecture



This has separate memory addresses for instructions and data meaning it can run a program and access data simultaneously.

von Neumann vs. Harvard

	von Neumann	Harvard
Flexibility		
Speed		
Cost		
Examples		

von Neumann vs. Harvard

	von Neumann	Harvard
Flexibility	High level of flexibility as the memory is shared between instructions and data so the amount assigned to each can fluctuate depending on the task.	
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Examples	Typically used in general purpose computers that will be used for many different purposes.	

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Cost	Simpler control unit design, and development of one bus is cheaper and faster.	Control unit for two buses is more complicated which adds to the development cost.
Examples	Typically used in general purpose computers that will be used for many different purposes.	Typically used in embedded systems that only perform few functions like washing machines, burglar alarms etc.

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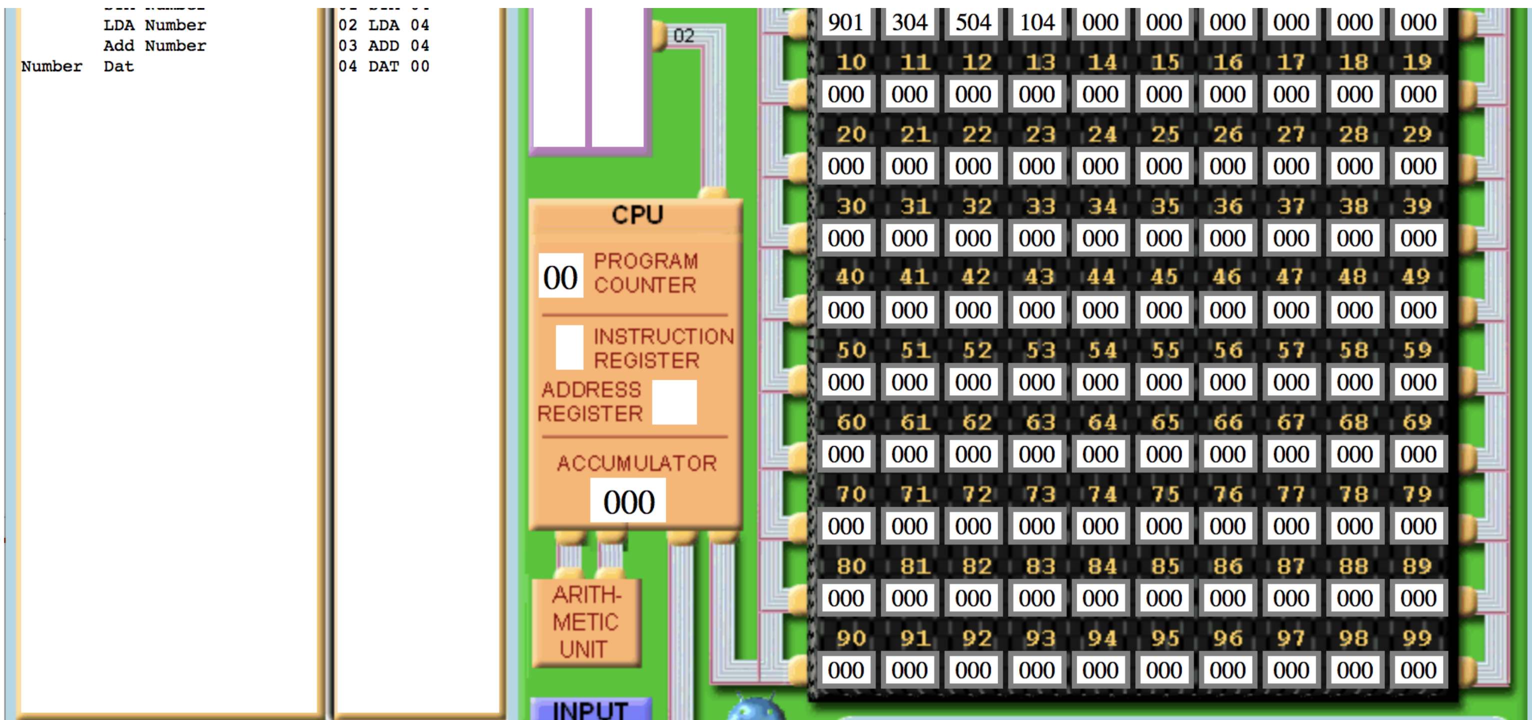
Little Man Computer (LMC)

Little Man Computer (LMC)

Little Man Computer (LMC) is a simulator that mimics von Neumann architecture.



LMC – Fetch-Decode-Execute

Everything in a computer's memory is data.

Although programs may seem different from data, they are treated in exactly the same way: the computer executes a program, instruction by instruction.

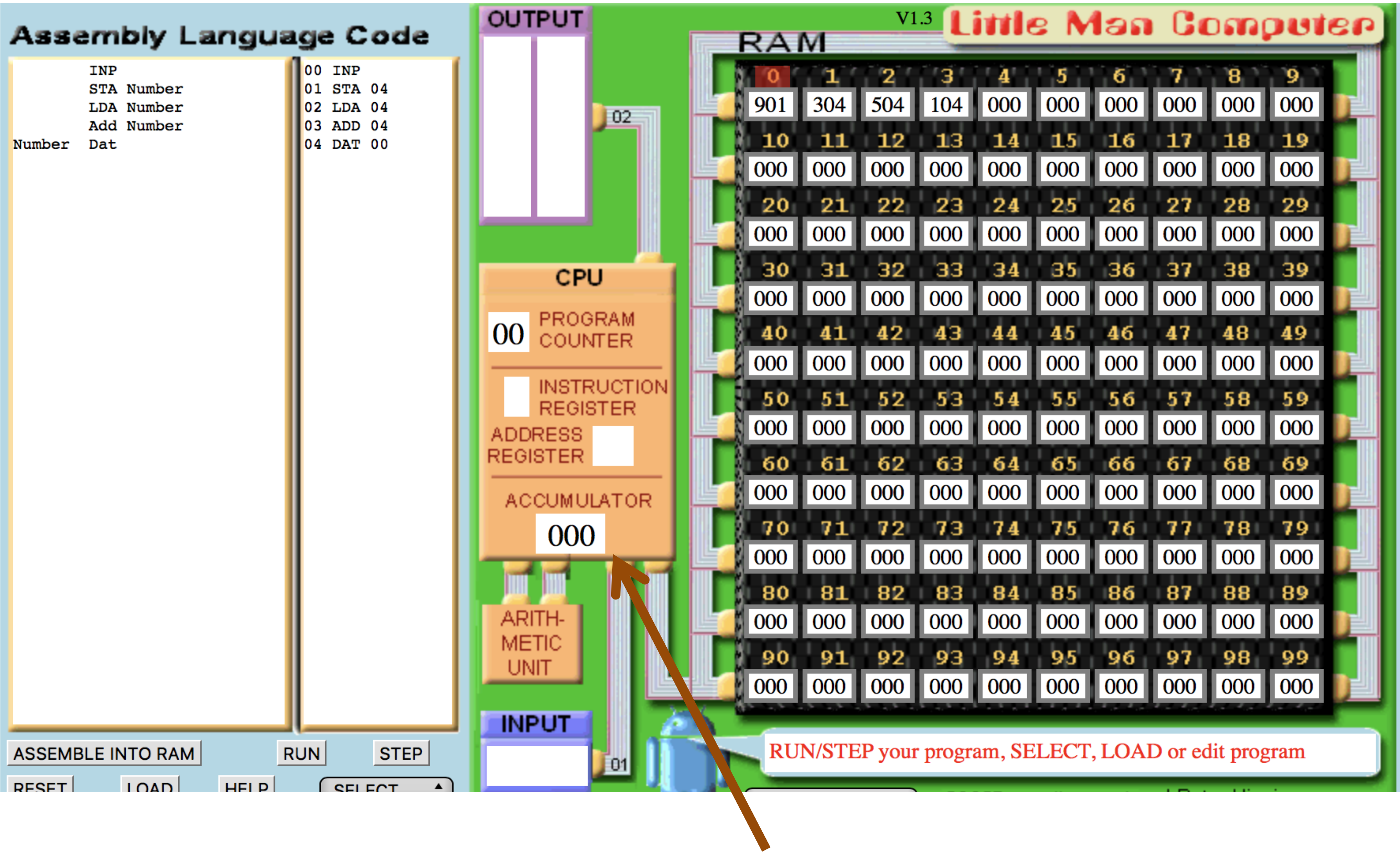
These instructions are the 'data' of the fundamental program cycle:

1. **fetch** the next instruction
2. **decode** it
3. **execute** it

Then the next program cycle starts which will process the next instruction. Even the location of the next instruction is just data.

The LMC Environment

- **Accumulator** – This is like the active memory of the simulator. The majority of our instructions will modify the contents of the Accumulator.



Accumulator

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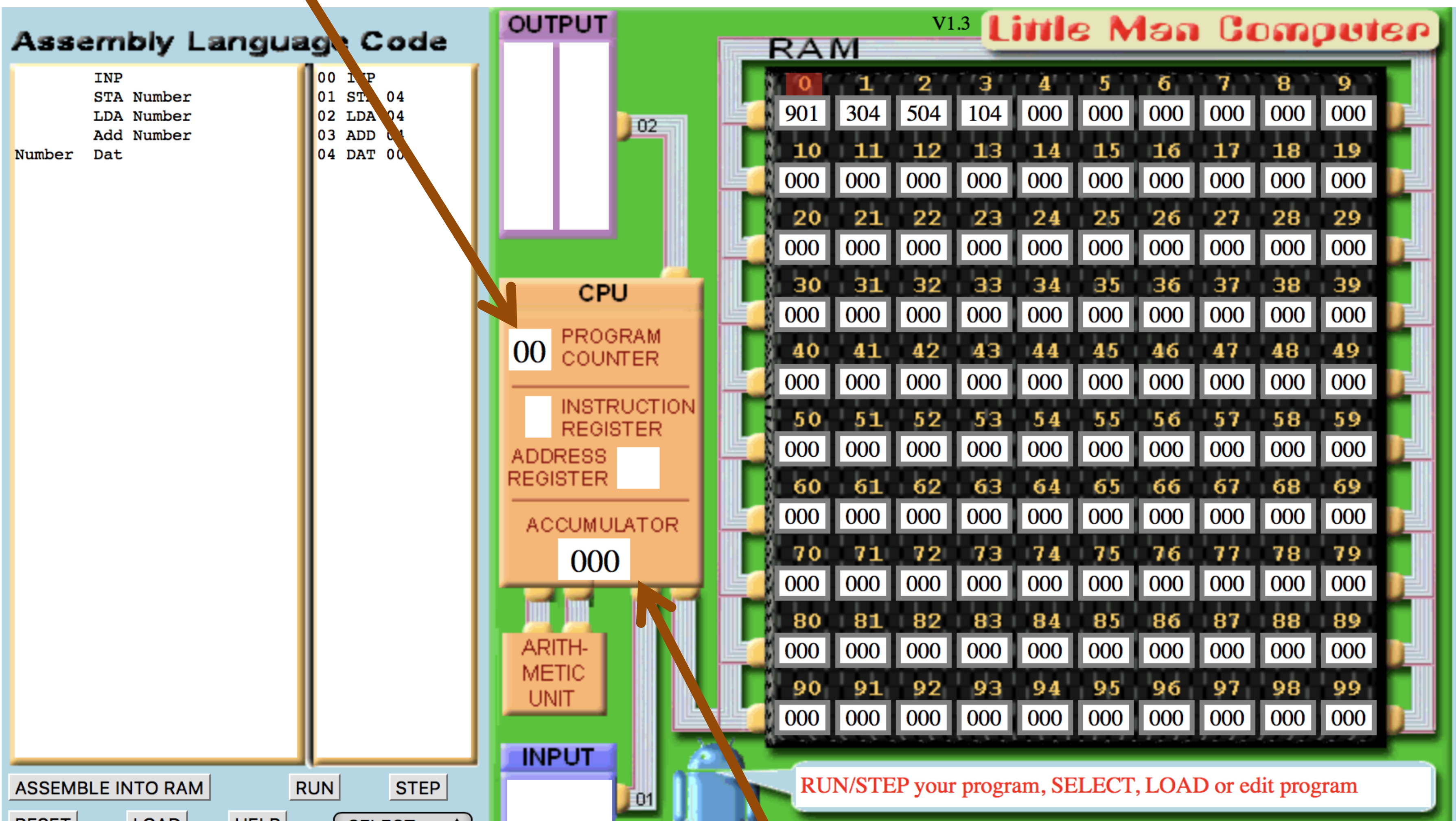
- **Program Counter** – This shows the current memory location that the processor is running.

Program Counter



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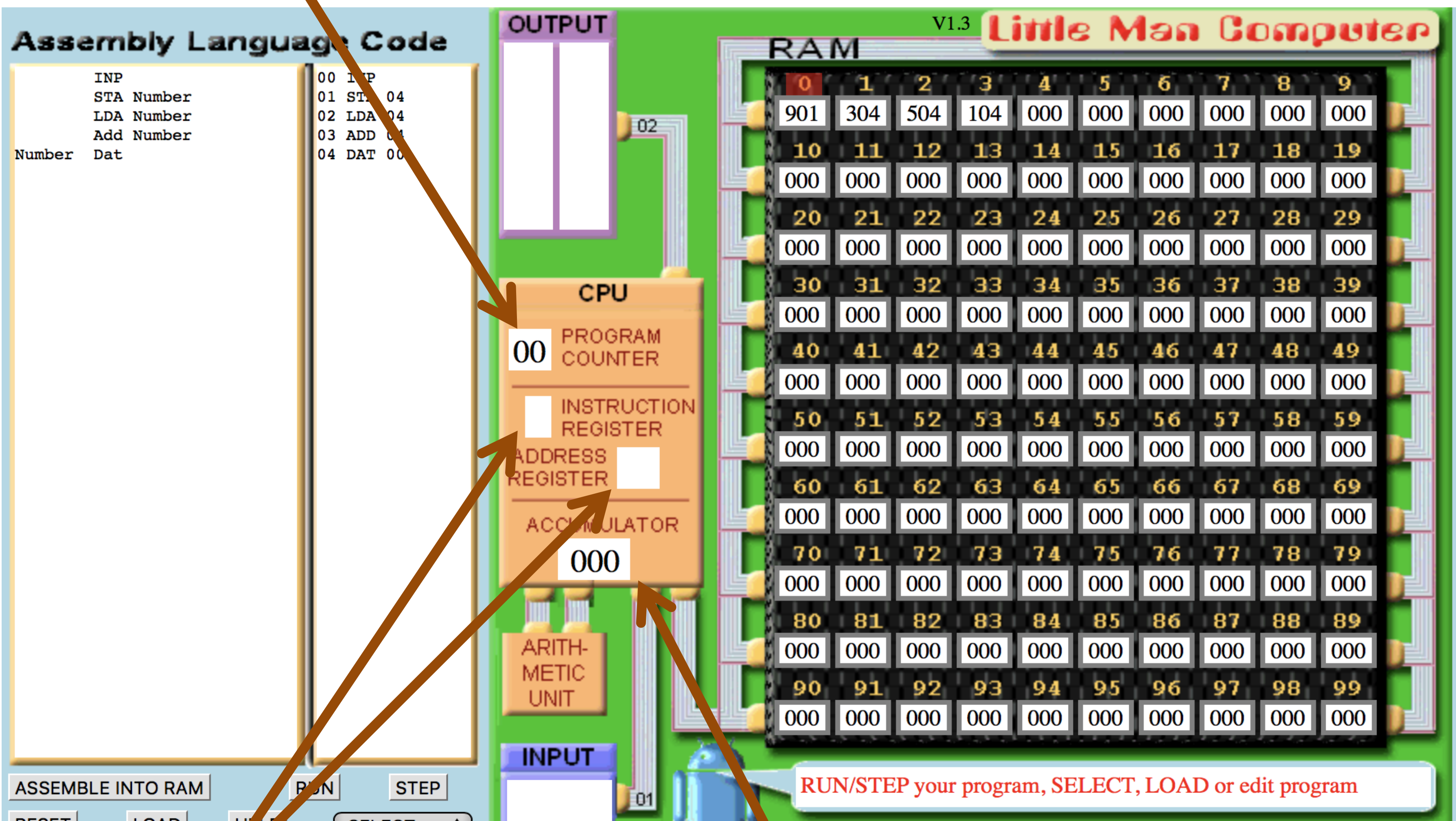
Program Counter



Instruction and Address register

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- **Program Counter** – This shows the current memory location that the processor is running.
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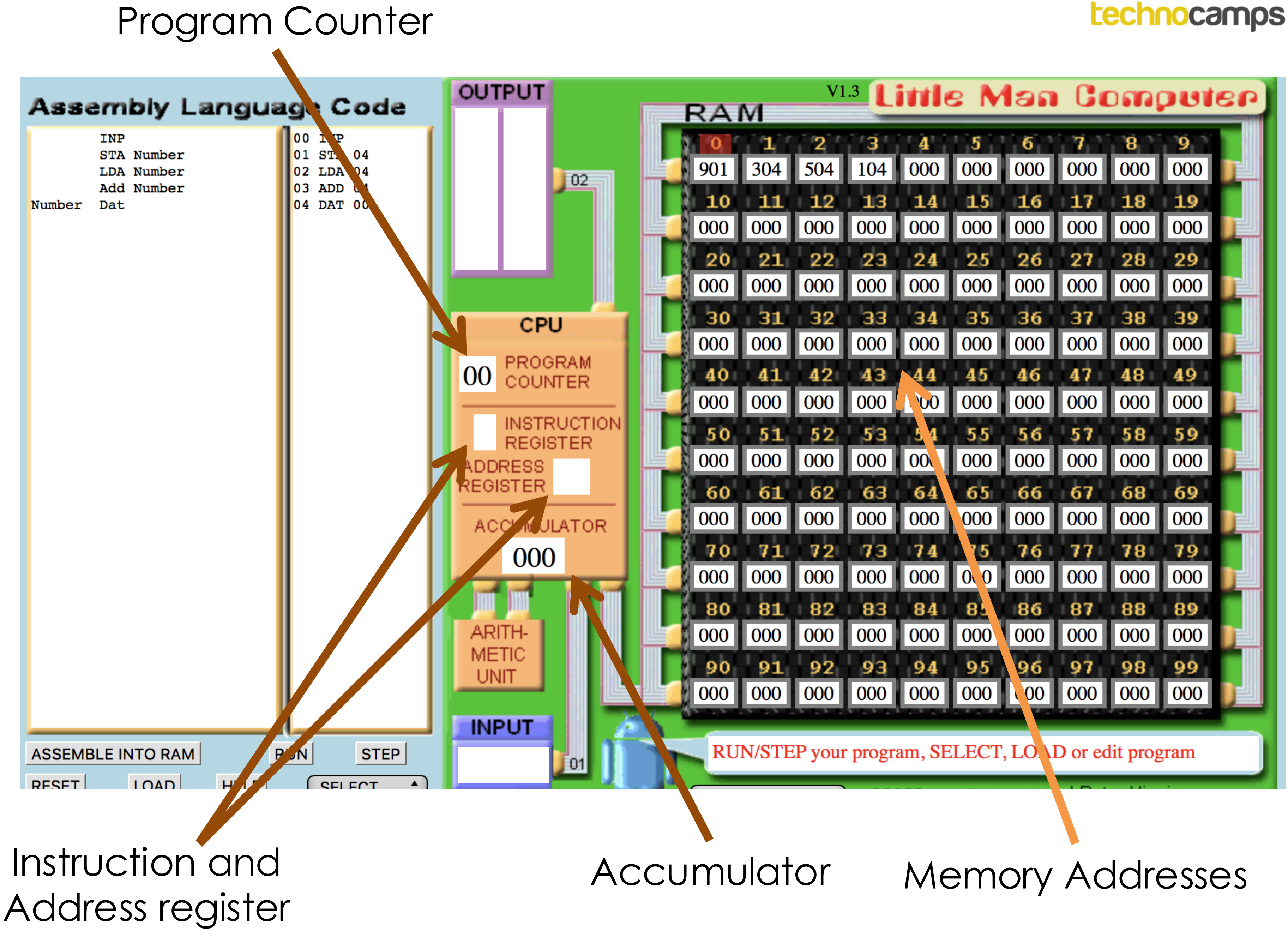
- **Memory Addresses** – These are the memory addresses which are used to store instructions and data.


Program Counter
Assembly Language Code
INP
STA Number
LDA Number
Add Number
Number Dat
00 INP
01 STA 04
02 LDA 04
03 ADD 04
04 DAT 00
OUTPUT
CPU
00
PROGRAM COUNTER
INSTRUCTION REGISTER
ADDRESS REGISTER
ACCUMULATOR
000
ARITH-METIC UNIT
INPUT
V1.3
Little Man Computer
RAM
901 304 504 104
ASSEMBLE INTO RAM
RUN
STEP
RUN/STEP your program, SELECT, LOAD or edit program
Instruction and Address register
Accumulator
Memory Addresses

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- **Input Box** – This is where user inputs are stored initially before being copied to the Accumulator.

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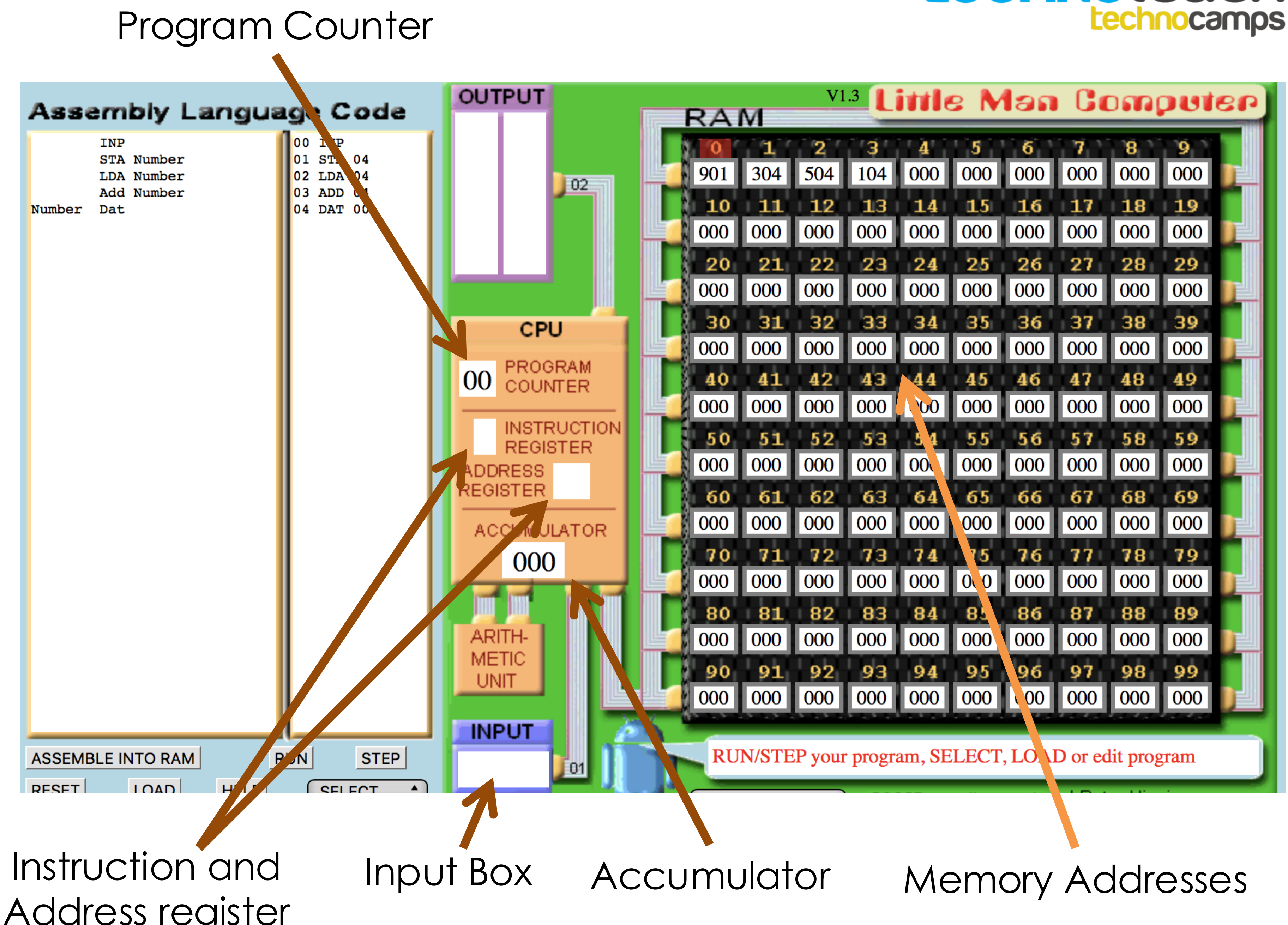
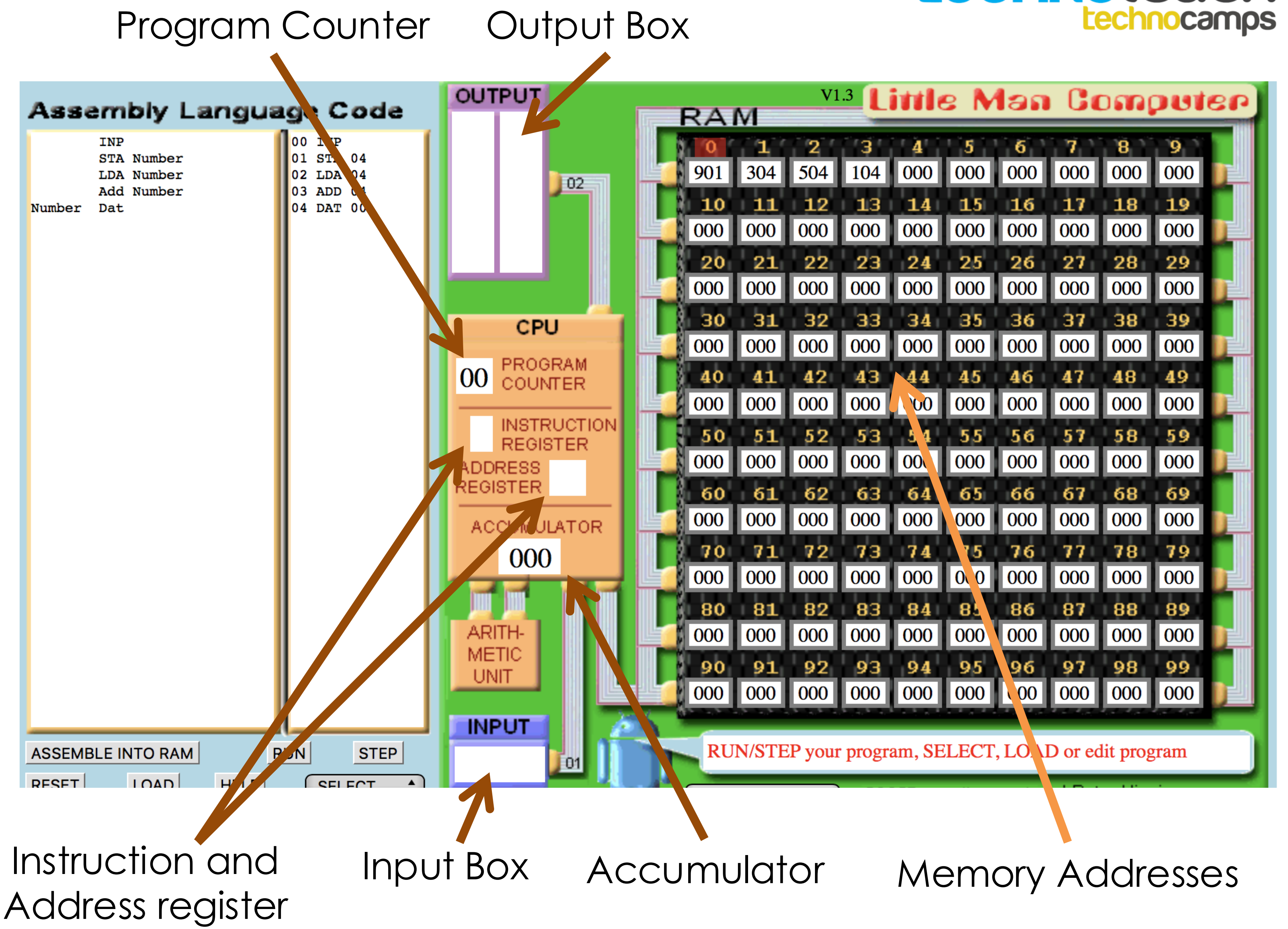
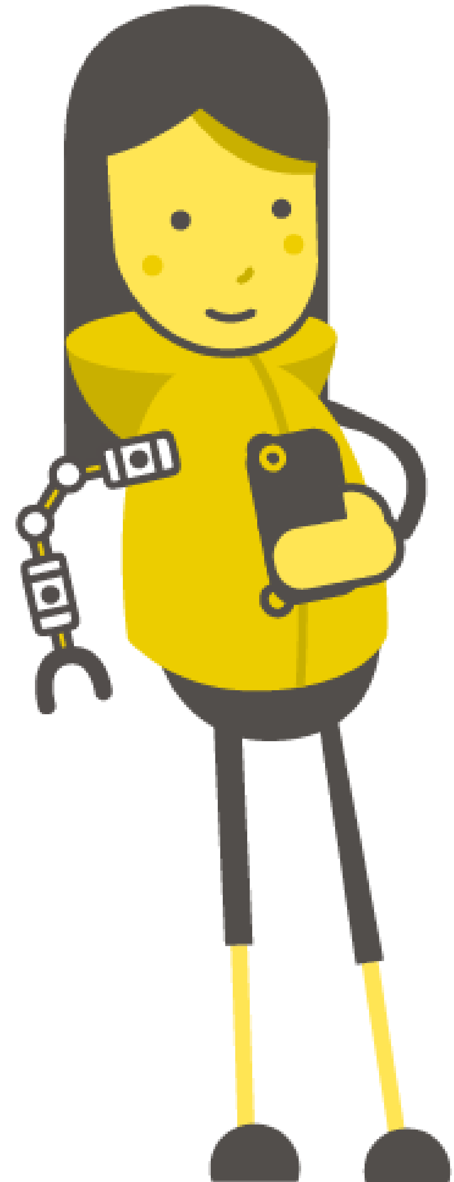


The LMC Environment

- **Accumulator** – This is like the active memory of the simulator. The majority of our instructions will modify the contents of the Accumulator.
- **Program Counter** – This shows the current memory location that the processor is running.
- **Instruction and Address register** – This shows which type of instruction is being used and which memory address it is being used on.
- **Memory Addresses** – These are the memory addresses which are used to store instructions and data.
- **Input Box** – This is where user inputs are stored initially before being copied to the Accumulator.
- **Output Box** – This is where a value is copied to from the Accumulator to display to the user.


Program Counter
Output Box
Assembly Language Code
INP
STA Number
LDA Number
Add Number
Number Dat
00 INP
01 STA 04
02 LDA 04
03 ADD 04
04 DAT 00
OUTPUT
V1.3
Little Man Computer
RAM
901
304
504
104
CPU
00
PROGRAM COUNTER
INSTRUCTION REGISTER
ADDRESS REGISTER
ACCUMULATOR
000
ARITH-METIC UNIT
INPUT
ASSEMBLE INTO RAM
RUN
STEP
RESET
LOAD
SELECT
RUN/STEP your program, SELECT, LOAD or edit program
Instruction and Address register
Input Box
Accumulator
Memory Addresses

LMC Instruction Set



Taking Input

Name: Input
Mnemonic: INP
Code: 901

Description:
The Input instruction copies the value input by the user into the Accumulator.

Next Action:
After the value has been copied, the Program Counter will move onto the next (sequential) memory location.

Providing Output

Name: Output
Mnemonic: OUT
Code: 902

Description:
The Output instruction copies the value in the Accumulator into the Output Box.

Next Action:
After the value has been copied, the Program Counter will move onto the next (sequential) memory location.

Stopping the Programming

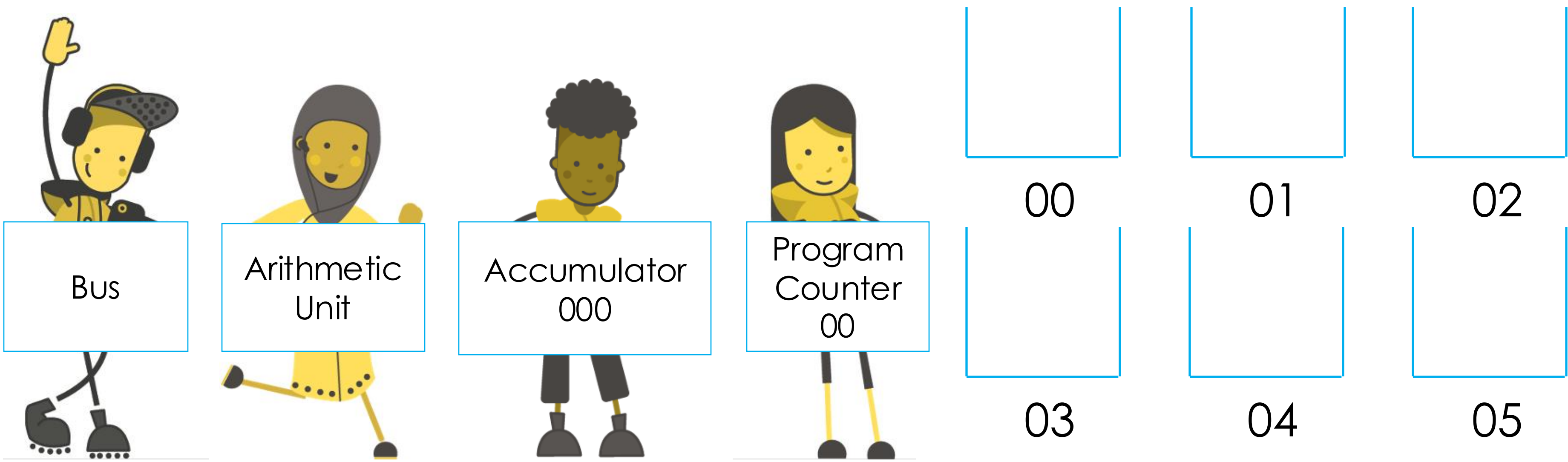
Name: Halt
Mnemonic: HLT
Code: 000

Description:
The Halt instruction does not affect any of the memory locations and stops the program.

Next Action:
The execution of the program will stop.

Activity: Visualising a Program Running

Using a few boxes and a few volunteers we can simulate running an assembly language program in the classroom. The rest of you will need to turn to the list of instructions in your workbooks.



The rest of the class are acting as the control unit, deciding what to do with the instructions and data.

Here’s the Program

Assembly Language Code

```
INP
OUT
HLT
```

```
00  INP
01  OUT
02  HLT
```

LMC Code Summary

____	INP	____	- Input
____	OUT	____	- Output
____	HLT	____	- Halt

Storing Data

Name: Store
Mnemonic: STA variable
Code: 3 _ _

Description:
The Store instruction will copy the value from the Accumulator and place it in an allocated memory location referred to by the variable name given.

Next Action:
After the value has been copied, the Program Counter will move onto the next (sequential) memory location.

Retrieving Data

Name: Load
Mnemonic: LDA variable
Code: 5 _ _

Description:
The Load instruction will copy the value stored at the memory location, given by the variable, into the Accumulator.

Next Action:
After the value has been loaded into the Accumulator, the Program Counter will move onto the next (sequential) memory location.

Data Memory Locations

Name: Data
Mnemonic: variable DAT xxx
Code: (the data)

Description:
The Data instruction will reserve a memory location to store data. This location can be referred to by the given variable name.
If you want to give the variable an initial value, replace the xxx with a value, the default is 0.

Next Action:
After the memory location has been reserved, the Program Counter will move onto the next (sequential) memory location.

Input & Print a Number

Python Code:

```
num = int (input( ))
print (num)
```

Assembly Language:

```
        INP
        STA     num
        LDA     num
        OUT
        HLT
num     DAT
```

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Activity: Running a Program

Assembly Language Code

```
        INP
        STA Number
        LDA Number
        OUT
        HLT
Number  DAT
```

```
00 INP
01 STA 05
02 LDA 05
03 OUT
04 HLT
05 DAT 00
```

00	01	02	03	04
05	06	07	08	09
10	11	12	13	14
15	16	17	18	19

Program counter

Instruction register

Address register

Accumulator

How to Write Assembly Programs

Create a program which takes in two inputs and outputs them in reverse order.

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We have to output the second input before the first. So we know we are going to have to store the first number at some point.

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INP → get the first number

STA number1 → store it away for later

How to Write Assembly Programs

Create a program which takes in two inputs and outputs them in reverse order.

Next up we need to get the second number.

INP	→	get the first number
STA number1	→	store it away for later
INP	→	get the second number

How to Write Assembly Programs

Create a program which takes in two inputs and outputs them in reverse order.

We need to output the second number before the first. We could store the second number but we don't have to.

INP	→	get the first number
STA number1	→	store it away for later
INP	→	get the second number
OUT	→	output the second number

How to Write Assembly Programs

Create a program which takes in two inputs and outputs them in reverse order.

Now we need to output the first number. But we can only output the number in the accumulator. So we need to load it first.

INP → get the first number

STA number1 → store it away for later

INP → get the second number

OUT → output the second number

LDA number1 → load the first number from the registry

OUT → output the first number

Activity: Storing and Loading

1. Create a program which takes and **stores** two inputs from the user and outputs the first input followed by the second input.

2. Create a program which takes and **stores** four inputs from the user and always outputs the third input.

3. Create a program which takes in three inputs and outputs them in reverse order.

LMC Code Summary

```
___    INP   ___   // Input
___    OUT   ___   // Output
___    HLT   ___   // Halt
___    STA   var   // Store
___    LDA   var   // Load
var    DAT   xxx   // Data (Default for xxx is 0)
```

2. Create a program which takes and **stores** four inputs from the user and always outputs the third input.

3. Create a program which takes in three inputs and outputs them in reverse order.

Addition

Name: Addition
Mnemonic: ADD variable
Code: 1 _ _

Description:
The Add instruction adds the value stored in the given memory location to the Accumulator.

Next Action:
After the value has been loaded into the Accumulator, the Program Counter will move onto the next (sequential) memory location.

Subtraction

Name: Subtraction
Mnemonic: SUB variable
Code: 2 _ _

Description:
The Subtraction instruction subtracts the value stored in the given memory location away from the Accumulator.

Next Action:
After the value has been loaded into the Accumulator, the Program Counter will move onto the next (sequential) memory location.

Addition and Subtraction (1)

Using a pen and paper write LMC programs to solve the problems.

1. Create a program which takes in and stores two inputs from the user and outputs the sum of them.

2. Create a program which takes in three numbers and stores them and then outputs the sum of the first two numbers with the third subtracted.

When you think you are finished, go to your computer and test it.

Addition and Subtraction (2)

In small groups, try and solve the following problems.

1. Create a program which takes in a number, doubles it and outputs the result.

2. Create a program which takes a number and multiplies it by eight.

Challenge - Create a program which takes in a number and multiplies it by forty.

LMC Code Summary

```
        INP           // Input
        OUT           // Output
        HLT           // Halt
        STA    var    // Store
        LDA    var    // Load
var     DAT    xxx    // Data (Default for xxx is 0)
        ADD    var    // Addition
        SUB    var    // Subtraction
```

Go To (Branch Always)

Name: Branch Always
Mnemonic: BRA variable
Code: 6 _ _

Description:
Updates the Program Counter to the memory location referred to by the variable given.

Next Action:
After the memory location has been loaded into the program counter, that memory location will be executed.

Activity: Looping

1. Create a program which allows the user to input numbers indefinitely and outputs each number.

2. Create a program which allows the user to input numbers indefinitely and outputs the running total after each entry.

Go To (Branch If Zero)

Name: Branch If Zero
Mnemonic: BRZ variable
Code: 7 _ _

Description:
*Updates the Program Counter to the memory location referred to by the variable given if the value in the Accumulator is **equal** to zero.*

Next Action:
After the memory location has been loaded into the program counter, that memory location will be executed.

Go To (Branch If Zero or Positive)

Name: Branch If Zero or Positive
Mnemonic: BRP variable
Code: 8 _ _

Description:
*Updates the Program Counter to the memory location referred to by the variable given if the value in the Accumulator is **zero or positive**.*

Next Action:
After the memory location has been loaded into the program counter, that memory location will be executed.

Comparing Values in LMC

In Little Man Computer we **do not** have "**if statements**" like we have in Python for comparisons.

The only way to branch based on a condition is to do a subtraction and then branch based on whether the result is:

- 0 (BRZ)
- 0 or positive (BRP)

Comparing Values in LMC

```
          LDA two
          SUB five
          BRP outputTwo
          LDA five
          OUT
          HLT
outputTwo LDA two
          OUT
          HLT
two       DAT 2
five      DAT 5
```

Comparing Values in LMC

```
          LDA two
          SUB five
          BRP outputTwo

          LDA five
          OUT
          HLT

outputTwo LDA two
          OUT
          HLT

two       DAT 2
five      DAT 5
```

Split up into 4 sections of code

Comparing Values in LMC

```
        LDA two
        SUB five
        BRP outputTwo

        LDA five
        OUT
        HLT

outputTwo LDA two
        OUT
        HLT

two     DAT 2
five    DAT 5
```

Load 2, subtract 5 and check the result. If it is positive, jump to instruction **outputTwo**

Comparing Values in LMC

```
          LDA two
          SUB five
          BRP outputTwo
```

Load 2, subtract 5 and check the result. If it is positive, jump to instruction **outputTwo**

```
          LDA five
          OUT
          HLT
```

Otherwise, carry on, load 5 and output it before stopping the program.

```
outputTwo LDA two
          OUT
          HLT

two       DAT 2
five      DAT 5
```

Comparing Values in LMC

```
          LDA two
          SUB five
          BRP outputTwo

          LDA five
          OUT
          HLT

outputTwo LDA two
          OUT
          HLT

two       DAT 2
five      DAT 5
```

Load 2, subtract 5 and check the result. If it is positive, jump to instruction **outputTwo**

Otherwise, carry on, load 5 and output it before stopping the program.

If it was positive, load 2 and output it before stopping the program.

Activity: Conditional Branching

1. Create a program which allows the user to input two numbers and outputs the smallest number. Hint: if you do a - b and the number is positive, then a is bigger than b.

2. Create a program which allows the user to repeatedly input two numbers and checks if they're equal. Only output the number if they are equal.

3. Create a program that repeatedly takes in inputs and only outputs them if they are zero.

4. Similar to 3, create a program which outputs everything except zeroes.

Challenge - Create a program which allows the user to input two numbers and outputs the multiplication of the two numbers.

LMC Code Summary

```
        INP            // Input
        OUT            // Output
        HLT            // Halt
        STA    var     // Store
        LDA    var     // Load
var     DAT    xxx     // Data (Default for xxx is 0)
        ADD    var     // Addition
        SUB    var     // Subtraction
        BRA    var     // Branch Always
        BRZ    var     // Branch If Zero
        BRP    var     // Branch If Positive
```

Sequences (Mathematics GCSE)

In order to calculate the equation for a given sequence of numbers we must first look at the difference between them e.g.

Index term: 1 2 3 4 5 …

Number: 3 , 5 , 7 , 9 , 11 …

Sequences (Mathematics GCSE)

In order to calculate the equation for a given sequence of numbers we must first look at the difference between them e.g.

Index term: 1 2 3 4 5 …

+2

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Sequences (Mathematics GCSE)

In order to calculate the equation for a given sequence of numbers we must first look at the difference between them e.g.

Index term: 1 2 3 4 5 …

+2 +2 +2 +2

Number: 3 , 5 , 7 , 9 , 11 …

The difference between each number is +2.

So the number in front of the nth term in our equation must be 2 i.e. **2n**

The final step is to check if we need to add or subtract from **2n**.

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Sequences (Mathematics GCSE)

In order to calculate the equation for a given sequence of numbers we must first look at the difference between them e.g.

Index term: 1 2 3 4 5 …

+2 +2 +2 +2

Number: 3 , 5 , 7 , 9 , 11 …

If we try inserting the index term into our nth term equation **2n** does the answer match up correctly?

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Number: 3 , 5 , 7 , 9 , 11 …

If we try inserting the index term into our nth term equation **2n** does the answer match up correctly? 2 x 1 = 2

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In order to calculate the equation for a given sequence of numbers we must first look at the difference between them e.g.

Index term:	1 2 3 4 5 …
	+2 +2 +2 +2
Number:	3 , 5 , 7 , 9 , 11 …

If we try inserting the index term into our nth term equation **2n** does the answer match up correctly? 2 x 1 = 2

What should we add to correct this?

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In order to calculate the equation for a given sequence of numbers we must first look at the difference between them e.g.

Index term: 1 2 3 4 5 …

+2 +2 +2 +2

Number: 3 , 5 , 7 , 9 , 11 …

If we try inserting the index term into our nth term equation **2n** does the answer match up correctly? 2 x 1 = 2

What should we add to correct this? **+1**

Sequences (Mathematics GCSE)

In order to calculate the equation for a given sequence of numbers we must first look at the difference between them e.g.

Index term: 1 2 3 4 5 …

+2 +2 +2 +2

Number: 3 , 5 , 7 , 9 , 11 …

If we try inserting the index term into our nth term equation **2n** does the answer match up correctly? 2 x 1 = 2

What should we add to correct this? **+1**

Therefore our equation is: **2n + 1**

Another Example

The first 5 terms of a sequence are:

-3, -1, 1, 3, 5

What is the difference between each term?

What is the equation so far?

Do we need to add/subtract something to get the right values?

What is the correct equation?

Another Example

The first 5 terms of a sequence are:

-3, -1, 1, 3, 5

What is the difference between each term? +2

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Another Example

The first 5 terms of a sequence are:

-3, -1, 1, 3, 5

What is the difference between each term? +2

What is the equation so far? 2n

Do we need to add/subtract something to get the right values? -5

What is the correct equation?

Another Example

The first 5 terms of a sequence are:

-3, -1, 1, 3, 5

What is the difference between each term? +2

What is the equation so far? 2n

Do we need to add/subtract something to get the right values? -5

What is the correct equation? 2n - 5

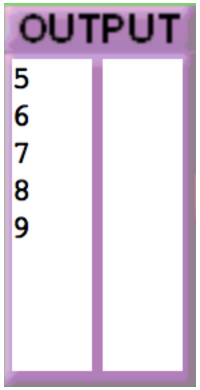
Activity: Sequences

For the following sequences:

a. Write out the nth term equation.
b. Calculate the 20th term in the sequence

1. 7, 8, 9, 10, 11 …
2. 3, 6, 9, 12, 15 …
3. 12, 17, 22, 27, 32 …
4. -6, -2, 2, 6, 10 …
5. 3, -3, -9, -15, -21 …

6. a. Write out the first 5 terms of the sequence given by 3n - 7.
   b. Calculate the 15th term of the sequence.



Activity: LMC Example

Now we are going to implement this nth term equation in LMC to produce the first 5 terms in the sequence: 5, 6, 7, 8, 9.

Using the space in your workbooks discuss with a partner and try to write down the steps you would need to implement it. Think about:

- What is the nth term equation?
- Would you need to use a loop?
- What other variables would you need?
- You will need to be adding or subtracting by 1, how could you implement this?

The First Value

To get the first result we need to load the first index term = 1 , add 4 to it and then output it.

We always add 4 in our nth term equation so should store 4 as a variable called number2.

We also need to define a variable so we know which index term we are inserting into our equation.

Load 1 and add 4 to it. Then Output the Value 5.

```
            LDA term
            ADD number2
            OUT
StopProgram HLT
term        DAT 1
number2     DAT 4
```

Stop the program. (StopProgram is a reference to the Halt which will be useful later).

Define Variables: term = 1
number2 = 4

Looping for More Values

Now we need to add one to the index term variable before we calculate the next number in our sequence.

To do this we define a variable called one which we add to the index term variable.

We use a loop to repeat the previous calculations and output each new number in the sequence.

```
00            LDA term
01            ADD number2
02            OUT
03            LDA term
04            ADD one
05            STA term
06            BRA 00
07 StopProgram HLT
08 term       DAT 1
09 one        DAT 1
10 number2    DAT 4
```

Loop back to the first line (00) Always.

Increase the current term by one and store it again.

Only Outputting the First 5 Values

If we want to stop the loop after 5 values have been output we need to compare our term variable to a limit. Once our term reaches the same value as the limit, we halt the program.

Check if the term and limit are the same, if so jump to the HLT instruction.

```
            LDA term          00
            ADD number2       01
            OUT               02
            LDA term          03
            ADD one           04
            STA term          05
            SUB limit         06
            BRZ StopProgram   07
            BRA 00            08
StopProgram HLT               09
term        DAT 1             10
one         DAT 1             11
number2     DAT 4             12
limit       DAT 6             13
```

Note: The variable limit is set to 6. Is this correct?

Yes, we increment the loop counter before checking how many times we have looped.

Activity: Creating Your Own Sequences

You can use this code as a starting point for creating your own sequences. What would we change to make the sequence n + 8 for example?

In your workbooks, answer the questions and try running the code in LMC to see if you're correct.

$n - 7$

$2n + 4$

$2n - 6$

$3n + 8$

$8n - 3$

```
            LDA term
            ADD number2
            OUT
            LDA term
            ADD one
            STA term
            SUB limit
            BRZ StopProgram
            BRA 00
StopProgram HLT
term        DAT 1
one         DAT 1
number2     DAT 4
limit       DAT 6
```

Activity: Advanced LMC

1. Create a program which takes in inputs and outputs the positive value, i.e. if it's negative, you output the positive, -3 would output 3.
2. Create a program which takes an input, outputs that value and then counts down and outputs every value until it reaches 0 (or counts up to 0 if value is negative).
3. Create a program which takes two inputs and checks if they have the same sign (both positive or both negative). If they have the same sign output a zero, otherwise output a 1.
4. Create a program which takes two inputs and returns the remainder if you divided the first by the second. (Don't worry about negative numbers, but dividing zero by a number and diving a number by zero should be considered.)

Activity: Very Advanced LMC

Create a program which takes in an input and outputs all of the numbers in the Fibonacci sequence up to that input number. The Fibonacci sequence is 1, 1, 2, 3, 5, 8, 13, 21
You can set one variable to 1 at the beginning. No cheating!

Note the Fibonacci sequence is made by adding the previous number to the current one, starting with 1:

1
0+1=1
1+1=2
2+1=3
3+2=5