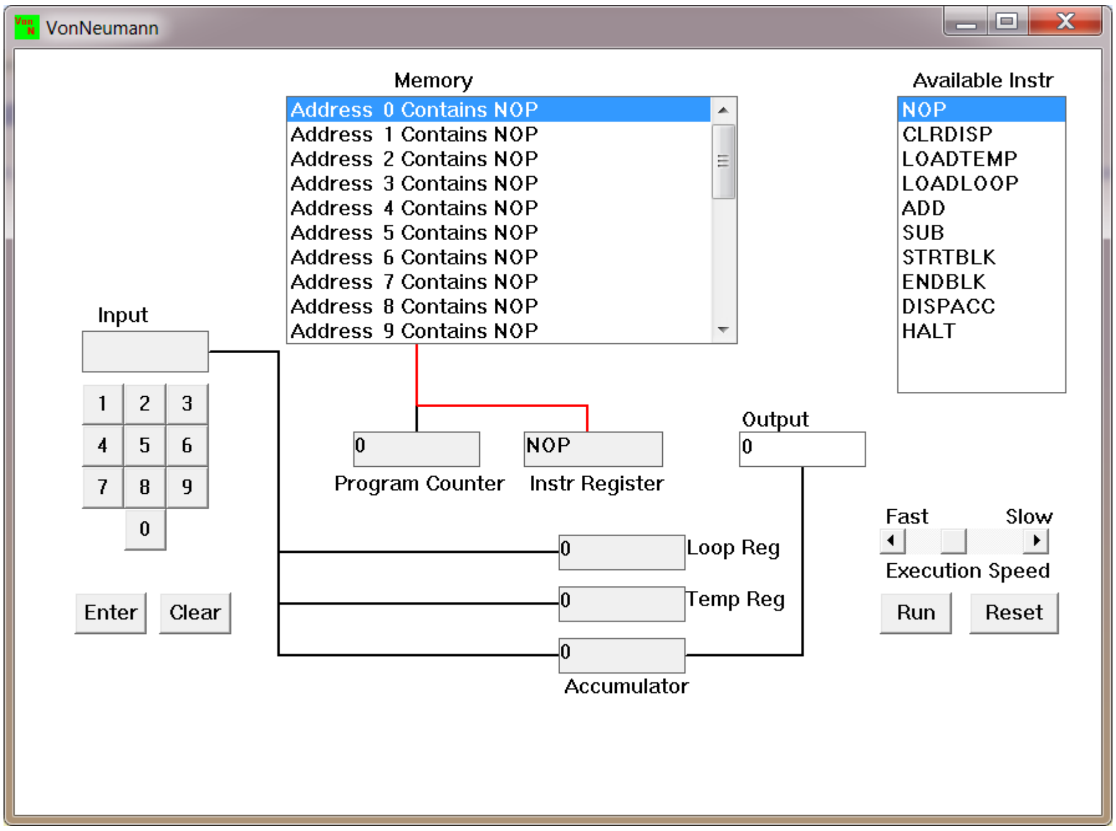
4CS015 Fundamentals of Computing – Workshop #6 (Task #3)

This is a marked workshop. It forms the second part of your portfolio. You will need to complete the workshop and then submit a copy of this document with a title that follows the following format (“DENNETT_1234567_wsp6.docx”), via CANVAS, by the deadline. The Von Neumann Simulator can be found on canvas

Workshop tasks:

1. Von Neumann Simulator. This program simulates a very simple computer with the von Neumann architecture.

    a. Download the von Neumann Simulator (VonNeumann.exe) program from WOLF in the Week 5 folder. Save it in your Documents folder and run it. You will see a window similar to this:



The simulator has a small program memory area which is available for programming. To enter your program instructions simply click on the “Available” instruction on the list on the right and then click on the “Memory” location you wish to put it in.

This simulator understands only the following ten instructions:

NOP	No Operation, i.e. do nothing.
LOADTEMP	Get a number from the keypad, completed by the Enter key, into the Temporary Register.
LOADLOOP	Get a number from the keypad, completed by the Enter key, into the Loop Register.
CLRDISP	Clear the Display.
ADD	Add the Temporary Register to the Accumulator
SUB	Subtract the Temporary Register from the Accumulator
DISPACC	Display the contents of the Accumulator
STRTBLK	Start of Loop Block
ENDBLK	End of Loop Block
HALT	Halt. Stop Program

b. Load the following program into the memory:

```
LOADTEMP
ADD
DISPACC
HALT
```

To do this, first click on the "LOADTEMP" in the list of instructions on the right of simulator window. Then click on Memory location with "Address 0 Contains NOP". This will then change into "Address 0 Contains LOADTEMP". Repeat the process with "Address 1" and so on until the whole program is loaded.

c. Run the program by clicking on the "Run" button. The simulator would highlight the Address 0 location and then pause. It is executing the instruction "LOADTEMP" which requires you to input a number into the keypad.
Click 2 or 3 numbers on the keypad and then click the "Enter" button. The simulator will then resume running the program and execute the instruction "ADD". This adds the number that you just entered, to the zero in the accumulator.
The next instruction is "DISPACC" which stands for "Display Accumulator", and it does exactly that. After than the simulator stops running the program when it executes the instruction "HALT".

NOTE: Remember to Write down your code along with the screenshots of your code

d. Load the following program into the simulator:

```
LOADTEMP
ADD
LOADTEMP
SUB
DISPACC
HALT
```

What do you think it does? Explain. Write your answer below (10 marks)

```
LOADTEMP→7
ADD
LOADTEMP→3
SUB
DISPACC→4
HALT
```

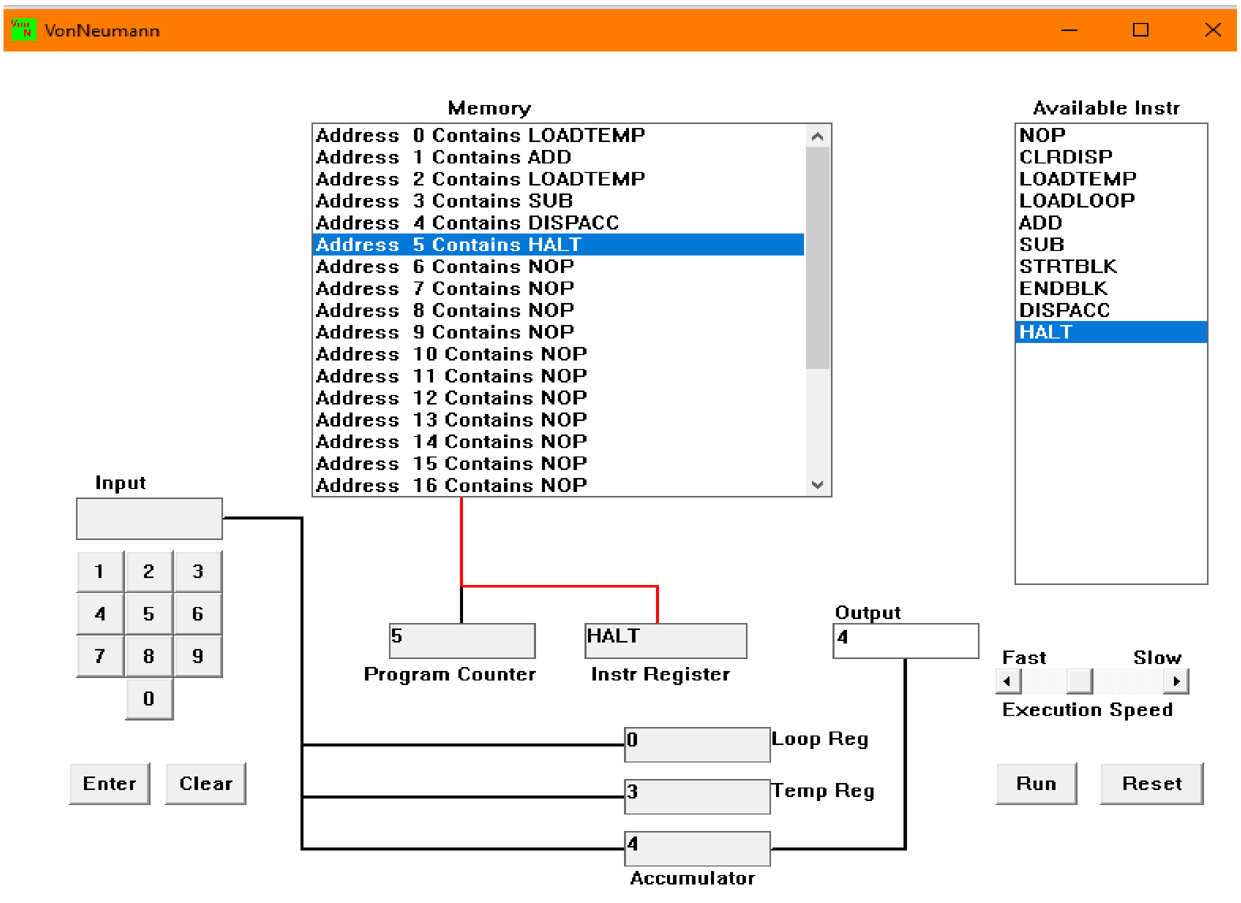
LOADTEMP gets the number put in the Input and loads it into the Temporary Register. ADD then adds the number of the Input of Temporary Register to the zero in the Accumulator. LOADTEMP again takes another number from the Input and loads it into the Temporary Register replacing the earlier input. SUB then subtracts the number in the Temporary Register with the number in the Accumulator. DISPACC then displays the Accumulator value in the Output. And with HALT the program stops.

Initial value of Accumulator = 0

7 + 0 = 7

7 - 3 = 4

Output = 4



```
Address  0 Contains LOADTEMP
Address  1 Contains ADD
Address  2 Contains LOADTEMP
Address  3 Contains SUB
Address  4 Contains DISPACC
Address  5 Contains HALT
Address  6 Contains NOP
Address  7 Contains NOP
Address  8 Contains NOP
Address  9 Contains NOP
Address  10 Contains NOP
Address  11 Contains NOP
Address  12 Contains NOP
Address  13 Contains NOP
Address  14 Contains NOP
Address  15 Contains NOP
Address  16 Contains NOP
```

```
NOP
CLRDISP
LOADTEMP
LOADLOOP
ADD
SUB
STRTBLK
ENDBLK
DISPACC
HALT
```

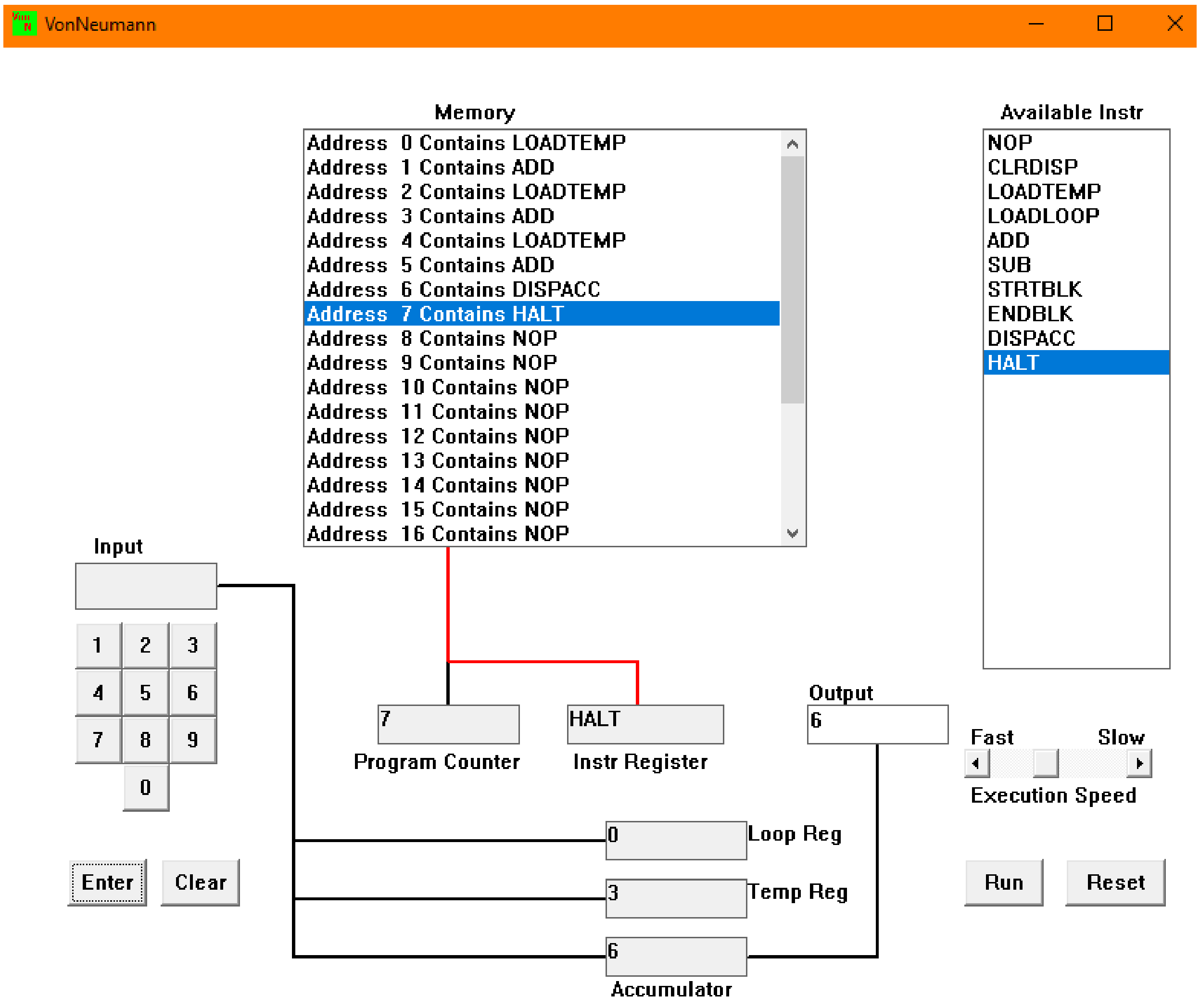
Program Counter: 5
Instr Register: HALT
Output: 4
Loop Reg: 0
Temp Reg: 3
Accumulator: 4

e. Write a program to add 3 numbers together. List your program below and explain the code (10 marks)

LOADTEMP→1
ADD
LOADTEMP→2
ADD
LOADTEMP→3
ADD
DISPACC→6
HALT

LOADTEMP gets the number put in the Input and loads it into the Temporary Register. ADD then adds the number of the Input of Temporary Register to the zero in the Accumulator. LOADTEMP again takes another number from the Input and loads it into the Temporary Register replacing the earlier input. ADD then again adds the number in the Temporary Register with the number in the Accumulator. Finally, LOADTEMP again takes another number from the Input and loads it into the Temporary Register replacing the earlier input. And the final ADD adds the number in the Temporary Register with the Accumulator. DISPACC then displays the Accumulator value in the Output. And with HALT the program stops.

Initial value of Accumulator = 0
0 + 1 = 1
1 + 2 = 3
3 + 3 = 6
Output = 6


VonNeumann

Memory

```
Address  0 Contains LOADTEMP
Address  1 Contains ADD
Address  2 Contains LOADTEMP
Address  3 Contains ADD
Address  4 Contains LOADTEMP
Address  5 Contains ADD
Address  6 Contains DISPACC
Address  7 Contains HALT
Address  8 Contains NOP
Address  9 Contains NOP
Address  10 Contains NOP
Address  11 Contains NOP
Address  12 Contains NOP
Address  13 Contains NOP
Address  14 Contains NOP
Address  15 Contains NOP
Address  16 Contains NOP
```

Available Instr

```
NOP
CLRDISP
LOADTEMP
LOADLOOP
ADD
SUB
STRTBLK
ENDBLK
DISPACC
HALT
```

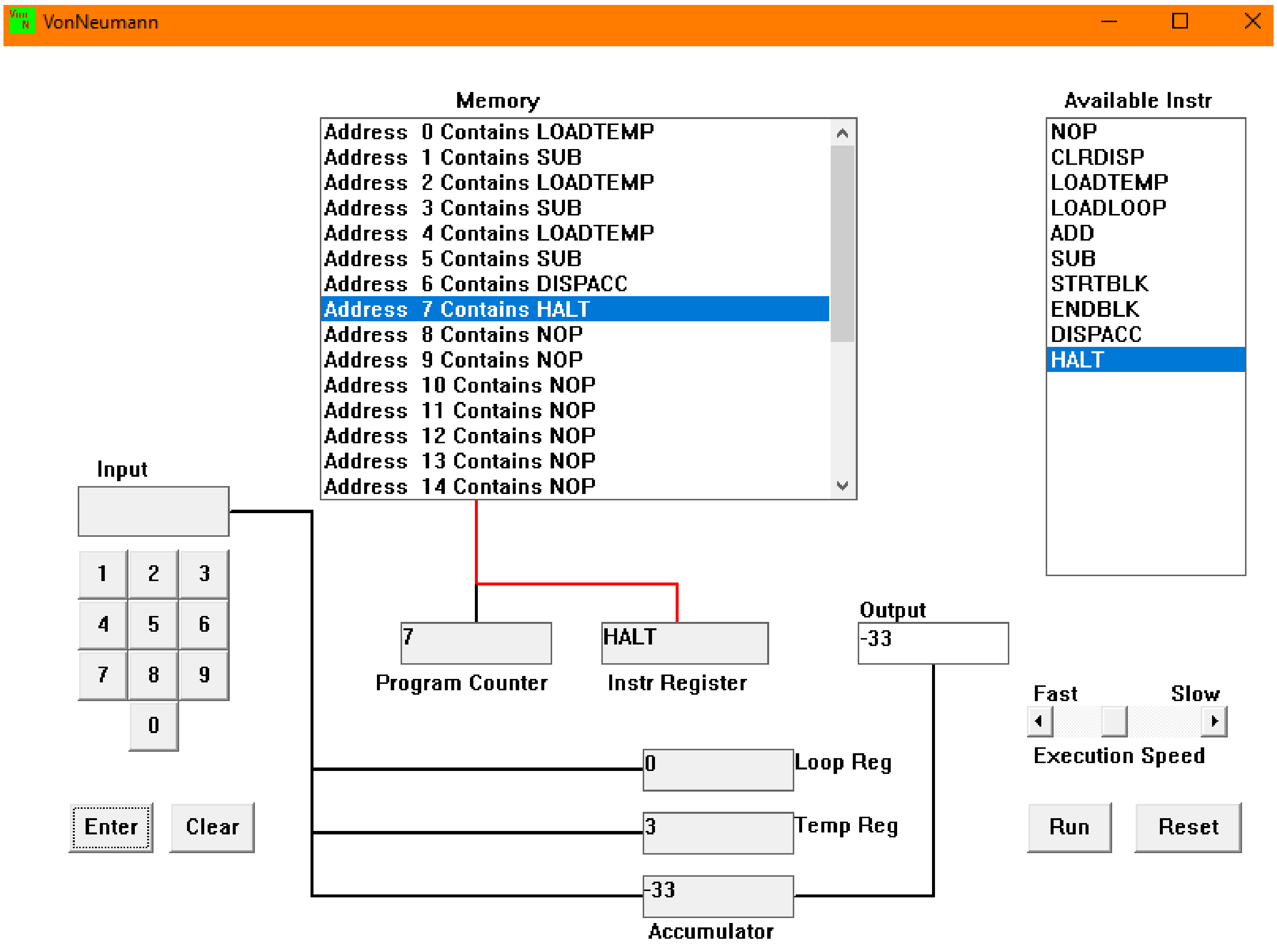
Program Counter: 7
Instr Register: HALT
Output: 6
Loop Reg: 0
Temp Reg: 3
Accumulator: 6

f. Write a program to simplify: – 25 - (5 + 3). List your program below. (10 marks)

LOADTEMP→25
SUB
LOADTEMP→5
SUB
LOADTEMP→3
SUB
DISPACC→-33
HALT

LOADTEMP gets the number put in the Input and loads it into the Temporary Register. SUB then subtracts the number of the Input of Temporary Register with that to the zero in the Accumulator. LOADTEMP again takes another number from the Input and loads it into the Temporary Register replacing the earlier input. SUB then again subtracts the number in the Temporary Register with the number in the Accumulator. Finally, LOADTEMP again takes another number from the Input and loads it into the Temporary Register replacing the earlier input. And the final SUB subtracts the number in the Temporary Register with the Accumulator. DISPACC then displays the Accumulator value in the Output. And with HALT the program stops.

Initial value of Accumulator = 0
0 - 25 = -25
-25 - 5 = -30
-30 - 3 = -33
Output = -33



Memory

```
Address  0 Contains LOADTEMP
Address  1 Contains SUB
Address  2 Contains LOADTEMP
Address  3 Contains SUB
Address  4 Contains LOADTEMP
Address  5 Contains SUB
Address  6 Contains DISPACC
Address  7 Contains HALT
Address  8 Contains NOP
Address  9 Contains NOP
Address  10 Contains NOP
Address  11 Contains NOP
Address  12 Contains NOP
Address  13 Contains NOP
Address  14 Contains NOP
```

Available Instr

```
NOP
CLRDISP
LOADTEMP
LOADLOOP
ADD
SUB
STRTBLK
ENDBLK
DISPACC
HALT
```

Program Counter: 7
Instr Register: HALT
Output: -33
Loop Reg: 0
Temp Reg: 3
Accumulator: -33

g. Load the following program into the simulator:

```
LOADTEMP
ADD
LOADLOOP
STRTBLK
ADD
DISPACC
ENDBLK
HALT
```

Run it and when it reaches the LOADTEMP instruction, enter 5 on the keypad and click the "Enter" button. When it reaches the LOADLOOP instruction, enter 6. What do you think the program does? Write your answer below in the form of an equation (10 marks)

```
LOADTEMP→5
ADD
LOADLOOP→6
STRTBLK
ADD
DISPACC→35
ENDBLK
HALT
```

LOADTEMP gets the number put in the Input and loads it into the Temporary Register. ADD then adds the number of the Input of Temporary Register to the zero in the Accumulator. LOADLOOP gets the number put in the Input and loads it into the Loop Register. STRTBLK starts the loop. ADD instruction inside of the loop keeps on adding the initial Input with the Accumulator until the Loop Register value drops to zero. ENDBLCK then ends the loop block once the Loop Register is zero. DISPACC then displays the Accumulator value in the Output. And with HALT the program stops.

Initial value of Accumulator = 0

0 + 5 = 5

Loop Starts (6 times):

5 + 5 = 10

10 + 5 = 15

15 + 5 = 20

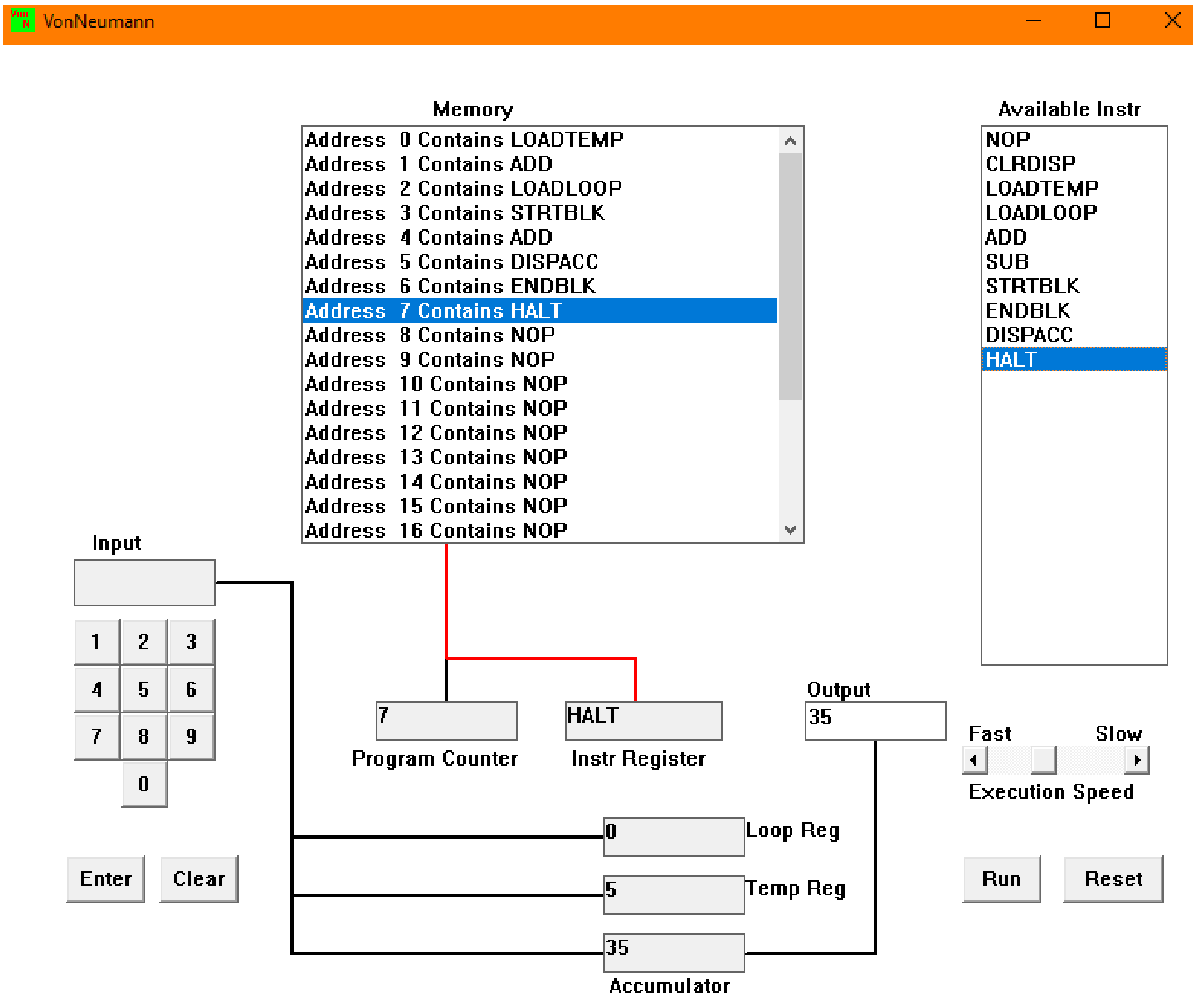
20 + 5 = 25

25 + 5 = 30

30 + 5 = 35

Loop Ends!

Output = 35



```
Address  0 Contains LOADTEMP
Address  1 Contains ADD
Address  2 Contains LOADLOOP
Address  3 Contains STRTBLK
Address  4 Contains ADD
Address  5 Contains DISPACC
Address  6 Contains ENDBLK
Address  7 Contains HALT
Address  8 Contains NOP
Address  9 Contains NOP
Address  10 Contains NOP
Address  11 Contains NOP
Address  12 Contains NOP
Address  13 Contains NOP
Address  14 Contains NOP
Address  15 Contains NOP
Address  16 Contains NOP
```

```
NOP
CLRDISP
LOADTEMP
LOADLOOP
ADD
SUB
STRTBLK
ENDBLK
DISPACC
HALT
```

Program Counter: 7
Instr Register: HALT
Output: 35
Loop Reg: 0
Temp Reg: 5
Accumulator: 35

h. Write a program that will let you add 5, or 10 or 20 numbers together. List your program below and explain how it works (25 marks)

LOADLOOP→5

STRTBLK

LOADTEMP→1, 2, 3, 4, 5

ADD

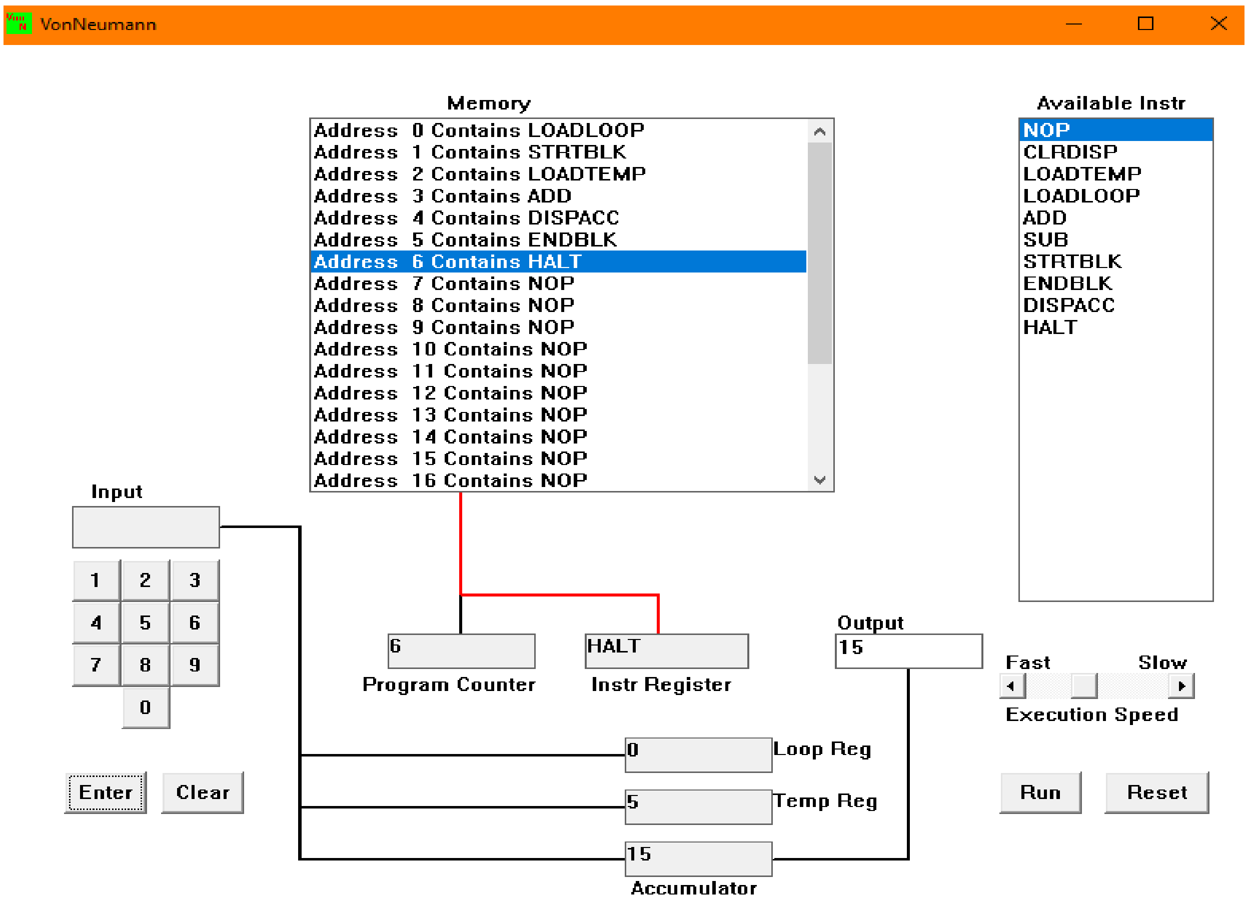
DISPACC→15

ENDBLK

HALT

LOADLOOP gets the number put in the Input and loads it into the Loop Register. STRTBLK starts the loop. LOADTEMP gets the number put in the Input and loads it into the Temporary Register. ADD then adds the number of the Input of Temporary Register to the zero in the Accumulator. DISPACC then displays the Accumulator value in the Output. ENDBLCK then ends the loop block. The input in the Loop Register decreases by one and the loop re-iterates till the Loop Register's value becomes zero. ENDBLCK then ends the loop once the Loop Register is zero. And with HALT the program stops.

Number of times to loop = 5
Initial value of Accumulator = 0
Loop Starts:
0 + 1 = 1
1 + 2 = 3
3 + 3 = 6
6 + 4 = 10
10 + 5 = 15
Loop Ends!
Output = 15



```
Address  0 Contains LOADLOOP
Address  1 Contains STRTBLK
Address  2 Contains LOADTEMP
Address  3 Contains ADD
Address  4 Contains DISPACC
Address  5 Contains ENDBLK
Address  6 Contains HALT
Address  7 Contains NOP
Address  8 Contains NOP
Address  9 Contains NOP
Address  10 Contains NOP
Address  11 Contains NOP
Address  12 Contains NOP
Address  13 Contains NOP
Address  14 Contains NOP
Address  15 Contains NOP
Address  16 Contains NOP
```

Available Instr: NOP, CLRDISP, LOADTEMP, LOADLOOP, ADD, SUB, STRTBLK, ENDBLK, DISPACC, HALT

Program Counter: 6
Instr Register: HALT
Output: 15
Loop Reg: 0
Temp Reg: 5
Accumulator: 15

i. Write a program that will let you multiply 3 numbers together. List your program below and explain how it works. (35 marks)

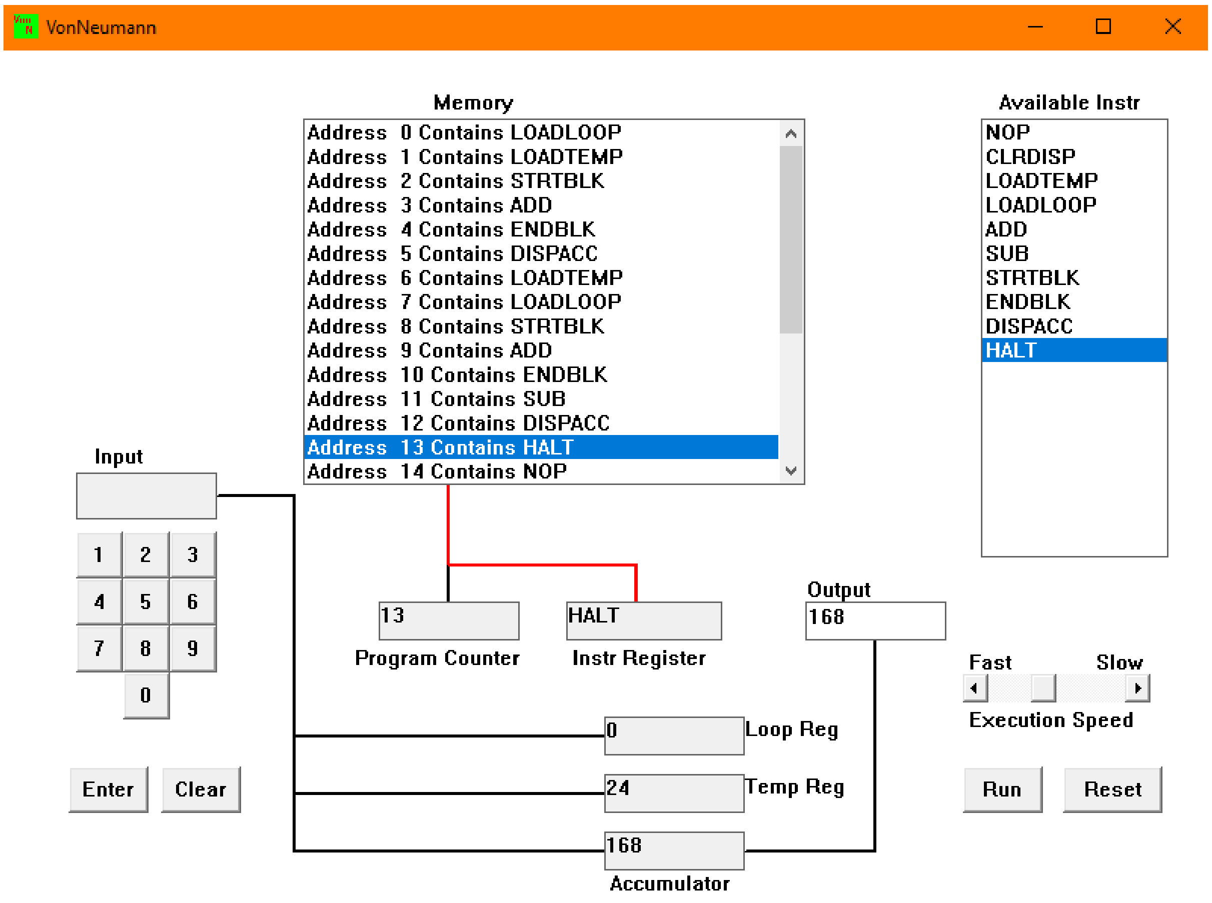
E.g.: (4×6×7)

```
LOADLOOP→4
LOADTEMP→6
STRTBLK
ADD
ENDBLK
DISPACC
LOADTEMP→24 (As 4 * 6 = 24)
LOADLOOP→7
STRTBLK
ADD
ENDBLK
SUB
DISPACC→168
HALT
```

LOADLOOP gets the number put in the Input and loads it into the Loop Register. LOADTEMP gets the number put in the Input and loads it into the Temporary Register. STRTBLK starts the loop. ADD then adds the number of the Input of Temporary Register to the zero in the Accumulator. ADD instruction inside of the loop keeps on adding the initial Input with the Accumulator until the Loop Register value drops to zero. ENDBLCK then ends the loop block once the Loop Register is zero. ENDBLCK then ends the loop block. DISPACC then displays the Accumulator value in the Output. This Output is the multiplication of two Inputs. Now, LOADTEMP gets another number put in the Input and loads it into the Temporary Register. Again, LOADLOOP gets the number put in the Input and loads it into the Loop Register and the ADD instruction keeps on adding the initial Input with the Accumulator until the Loop Register value drops to zero then once it reaches zero ENDBLK instruction is run and the loop is ended. SUB then subtracts the third input from the Accumulator. Finally, DISPACC displays the Output and HALT ends the program.

Number of times to loop = 4
Initial value of Accumulator = 0
Input = 6
Loop Starts:
0 + 6 = 6
6 + 6 = 12
12 + 6 = 18
18 + 6 = 24
Loop Ends!
Output = 24 (This is the multiplication of first two inputs)

Input = 24 (As 4 * 6 = 24; Because the Accumulator already has 24 stored, we need to subtract it from the final output)
Number of times to loop = 7
Value of Accumulator = 24
Loop Starts:
24 + 24 = 48
48 + 24 = 72
72 + 24 = 96
96 + 24 = 120
120 + 24 = 144
144 + 24 = 168
168 + 24 = 192
Loop Ends!
SUB = 192 – 24 = 168
Output = 168


VonNeumann

Memory

```
Address  0 Contains LOADLOOP
Address  1 Contains LOADTEMP
Address  2 Contains STRTBLK
Address  3 Contains ADD
Address  4 Contains ENDBLK
Address  5 Contains DISPACC
Address  6 Contains LOADTEMP
Address  7 Contains LOADLOOP
Address  8 Contains STRTBLK
Address  9 Contains ADD
Address  10 Contains ENDBLK
Address  11 Contains SUB
Address  12 Contains DISPACC
Address  13 Contains HALT
Address  14 Contains NOP
```

Available Instr

```
NOP
CLRDISP
LOADTEMP
LOADLOOP
ADD
SUB
STRTBLK
ENDBLK
DISPACC
HALT
```

Program Counter: 13
Instr Register: HALT
Output: 168
Loop Reg: 0
Temp Reg: 24
Accumulator: 168