Computer Organization

Assembly Procedures

Bridging the Gap

- While assembly is a very low-level programming paradigm, we can still achieve many of the complex operations that we commonly do in higher-level languages

- All you need is a core understanding of manipulating your data

Basic Procedure

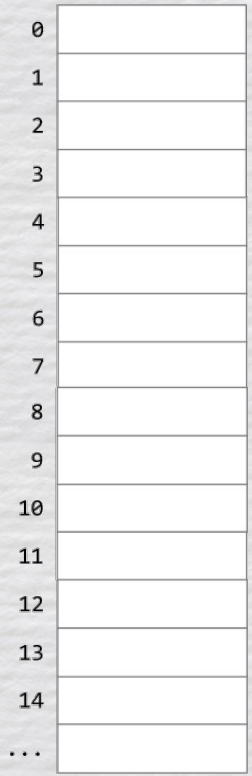
Pseudocode

```
// if R0 >= 0 then R1 = 1
// else R1 = -1
   if (R0 ≥ 0) goto POS
   R1 = -1
   goto END
POS:
   R1 = 1
END:
```

Signum.asm

```
// if R0 >= 0 then R1 = 1
// else R1 = -1
```

Memory



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POS:
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END:
```

Signum.asm

```
// if R0 >= 0 then R1 = 1
// else R1 = -1
      // if R0 >= 0 goto POS
      @R0
      D=M
      @POS
      D;JGE
```

Memory

0	@0
1	D=M
2	@
3	D;JGE
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
...	

Basic Procedure

Pseudocode

```
// if R0 >= 0 then R1 = 1
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   if (R0 ≥ 0) goto POS
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      // if R0 >= 0 goto POS
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      @POS
      D;JGE
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      M=-1
```

Memory

0	@0
1	D=M
2	@
3	D;JGE
4	@1
5	M=-1
6	
7	
8	
9	
10	
11	
12	
13	
14	
...	

Basic Procedure

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```
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      @R0
      D=M
      @POS
      D;JGE
      // R1 = -1
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      M=-1
      // goto END
      @END
      0;JMP
```

Memory

0	@0
1	D=M
2	@
3	D;JGE
4	@1
5	M=-1
6	@
7	0;JMP
8	
9	
10	
11	
12	
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...	

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```
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// else R1 = -1
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POS:
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// if R0 >= 0 then R1 = 1
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      // if R0 >= 0 goto POS
      @R0
      D=M
      @POS
      D;JGE
      // R1 = -1
      @R1
      M=-1
      // goto END
      @END
      0;JMP
(POS)
```

Memory

0	@0
1	D=M
2	@8
3	D;JGE
4	@1
5	M=-1
6	@
7	0;JMP
8	
9	
10	
11	
12	
13	
14	
...	

Basic Procedure

Pseudocode

```
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// else R1 = -1
   if (R0 ≥ 0) goto POS
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POS:
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END:
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      @POS
      D;JGE
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      M=-1
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      @END
      0;JMP
(POS)
      // R1 = 1
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```

Memory

0	@0
1	D=M
2	@8
3	D;JGE
4	@1
5	M=-1
6	@
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8	@1
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(POS)
      // R1 = 1
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      M=1
(END)
```

Memory

0	@0
1	D=M
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3	D;JGE
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      @END
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(POS)
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      @R1
      M=1
(END)
      @END
      0;JMP
```

Memory

0	@0
1	D=M
2	@8
3	D;JGE
4	@1
5	M=-1
6	@10
7	0;JMP
8	@1
9	M=1
10	@10
11	0;JMP
12	0100100110011011
13	1110010011111111
14	0101011100110111
...	

- We implement an infinite loop after our procedure to ensure that we do not continue executing any instructions that might be left over in memory

Iterative Procedure

Pseudocode

```
// Program: Sum1ToN (R0 represents N)
// Computes R1 = 1 + 2 + 3 + ... + R0
// Usage: put a value >= 1 in R0
   i = 1
   sum = 0
LOOP:
   if (i > R0) goto STOP
   sum = sum + i
   i = i + 1
   goto LOOP
STOP:
   R1 = sum
```

Hack assembly

```
// Program: Sum1ToN (R0 represents N)
// Computes R1 = 1 + 2 + 3 + ... + R0
// Usage: put a value >= 1 in R0
```

(code continues here)

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```

(code continues here)

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(code continues here)

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(LOOP)
```

(code continues here)

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// Usage: put a value >= 1 in R0
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   @i
   M=1
   // sum = 0
   @sum
   M=0
(LOOP)
   // if (i > R0) goto STOP
   @i
   D=M
   @R0
   D=D-M
   @STOP
   D;JGT
```

(code continues here)

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   D=D+M
   @sum
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```

(code continues here)

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   D=D-M
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   @sum
   D=M
   @i
   D=D+M
   @sum
   M=D
   // i = i + 1
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   @sum
   D=M
   @i
   D=D+M
   @sum
   M=D
   // i = i + 1
   @i
   M=M+1
   // goto LOOP
   @LOOP
   0;JMP
```

(code continues here)

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   @i
   D=M
   @R0
   D=D-M
   @STOP
   D;JGT
   // sum = sum + i
   @sum
   D=M
   @i
   D=D+M
   @sum
   M=D
   // i = i + 1
   @i
   M=M+1
   // goto LOOP
   @LOOP
   0;JMP
```

(code continues here)

```
(STOP)
```

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   D=D-M
   @STOP
   D;JGT
   // sum = sum + i
   @sum
   D=M
   @i
   D=D+M
   @sum
   M=D
   // i = i + 1
   @i
   M=M+1
   // goto LOOP
   @LOOP
   0;JMP
```

(code continues here)

```
(STOP)
   // R1 = sum
   @sum
   D=M
   @R1
   M=D
```

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   @sum
   M=0
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   // if (i > R0) goto STOP
   @i
   D=M
   @R0
   D=D-M
   @STOP
   D;JGT
   // sum = sum + i
   @sum
   D=M
   @i
   D=D+M
   @sum
   M=D
   // i = i + 1
   @i
   M=M+1
   // goto LOOP
   @LOOP
   0;JMP
```

(code continues here)

```
(STOP)
   // R1 = sum
   @sum
   D=M
   @R1
   M=D
   // infinite loop
(END)
   @END
   0;JMP
```