Microcomputers I – CE 320

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Announcement

- Homework exercise 5 will be uploaded on BB this week.

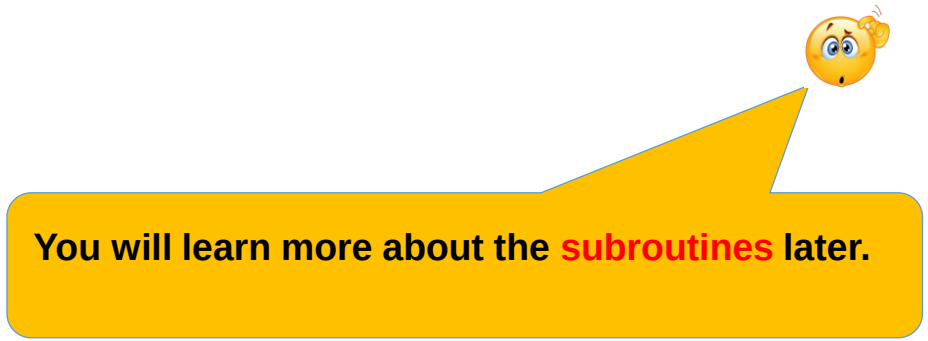
Lecture 14: The Stack

Today’s Topics

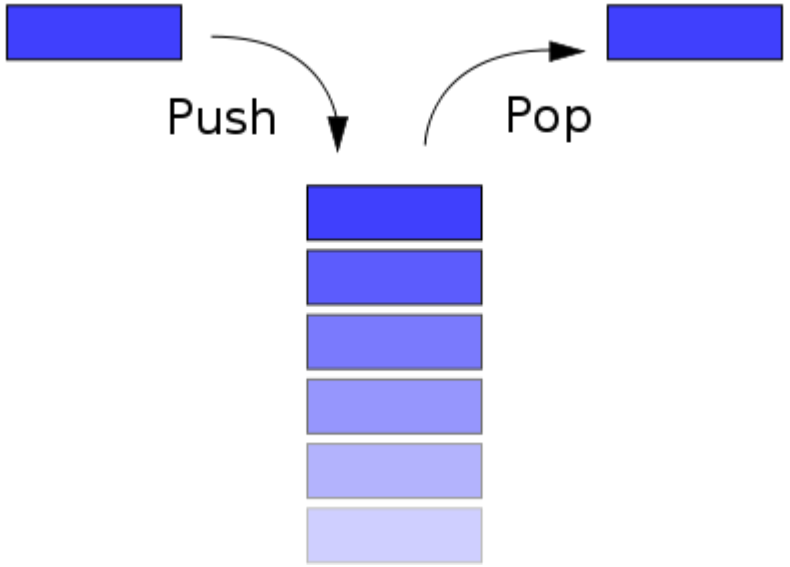
- Learn how HCS12 stack functions

What is the Stack?

Last In, First Out (LIFO)

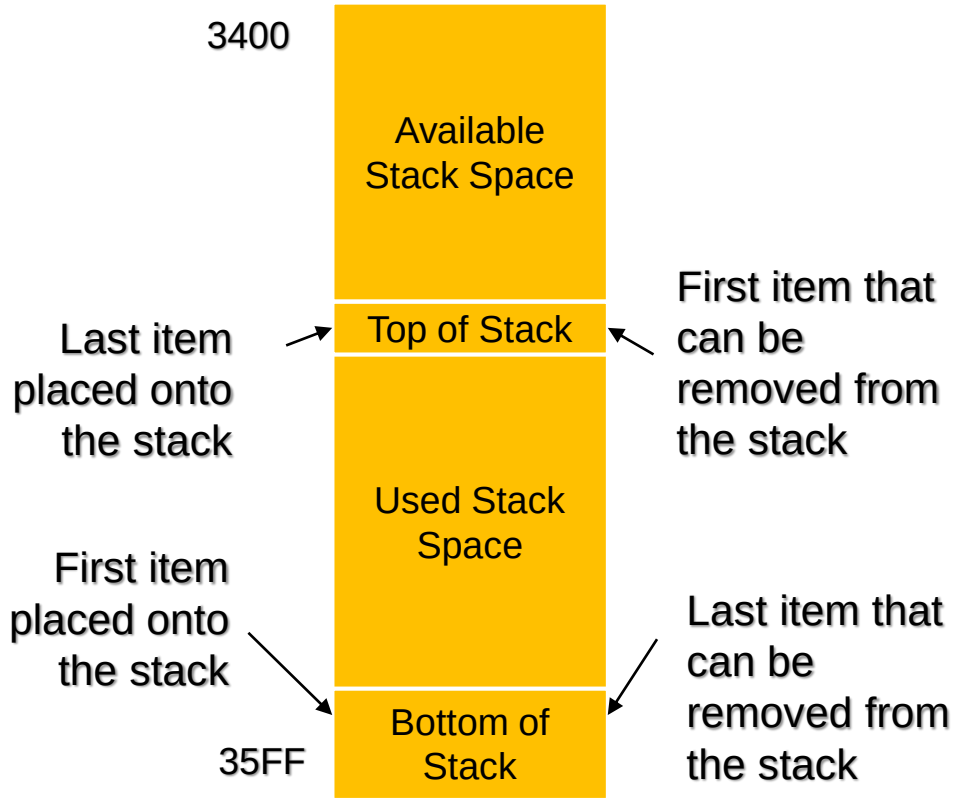


- The stack is a last-in, first-out (LIFO) data structure.
  - Elements can be accessed from only its top.
- Allows dynamic variable storage
  - Mainly used by microprocessors for calling subroutines.
- Two fundamental operations
  - Push: add to the top of the list.
  - Pop/Pull: removes an item from the top of the list.
- Think books stacked on a table
- c.f. Queue
  - First-in, first-out (FIFO) data structure



The Stack

Memory diagram of a stack



The Stack

- Physically, a stack can grow from a high address toward lower addresses or from a low address toward higher addresses.

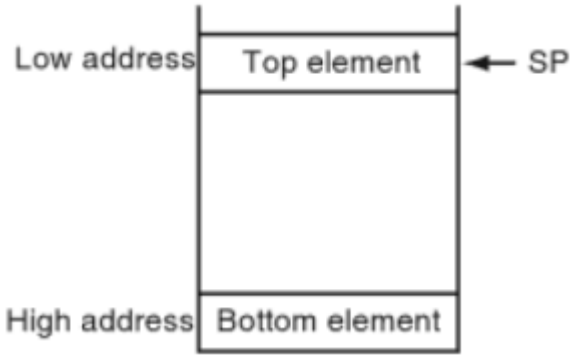


Diagram of the HCS12 stack

- Here the HCSI2 stack grows from a high address toward lower addresses and has a 16-bit stack pointer (SP) that points to the top byte of the stack.

Important Concepts about Stacks

- A section of regular RAM (stack space) that all programs agree will be used for nothing else.
  - There is typically nothing in hardware that enforces this boundary.
- Much like variable-length array that uses a portion of the available stack space.
- Standard convention is that the stack grows towards lower addresses when data is added.
- The **stack pointer register (SP)** holds the address of the top byte and moves up (*decrements*) when items are added and moves down (*increments*) when data is removed.

Important Concepts about Stacks

- Depth:
  - The number of bytes stored on the stack
- Empty:
  - If the depth is 0, we say the stack is **empty**
- Underflow
  - Removing a byte from an empty stack
- Overflow
  - The depth is larger than the available stack space

Manipulating the Stack & Stack Pointer Register

Adding/Removing an item to a stack

- PSHx
  - Push an item to the stack
  - X: A, B, CCR (C), D, X, Y
  - S register is first decremented by the number of bytes to be pushed, then the register value is copied into the newly generated “hole”.
  - No affect on CCR bits
- PULx
  - Pull or Pop an item from the stack
  - X: A, B, CCR (C), D, X, Y
  - One or two bytes at the top of the stack is/are copied into the specified register, then the S register is incremented.
  - No affect on CCR (unless PULC)
- Again, there is no separate space for the stack. The stack is just a chunk of RAM. S register holds the current position.

Manipulating the Stack & Stack Pointer Register

- LDS
  - Loads the S (also referred as SP) register
  - Supports multiple addressing modes, but we will typically use only immediate addressing
  - Typically done once at the beginning of a program to “initialize” the stack, at least for this class.

Other Useful Stack Operations …

- It is also useful at times to ***allocate space on the stack*** for variables without having the data to push onto the stack first.

- Also, we may want to ***remove a number of bytes*** without having to pull the unneeded data into registers with pull operations.

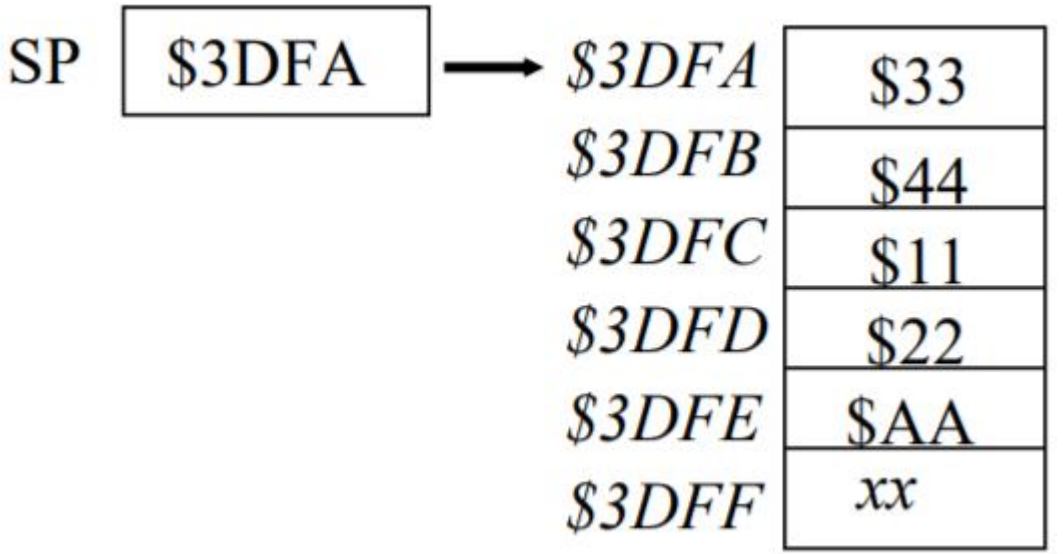
- This can be done using the ***Load Effective Address*** instruction.

- LEAS ±n, SP
  - Uses multiple addressing modes, but we will use indexed off of S almost exclusively.
  - With negative offsets, creates (allocates) space on the top of the stack.
  - With positive offsets, removes (de-allocates) data from the top of the stack.

Where is the Runtime Stack ?

- SP = address of the top element

- Before any PSH/PUL instruction, SP must be initialized.
  - LDS #$3DFF



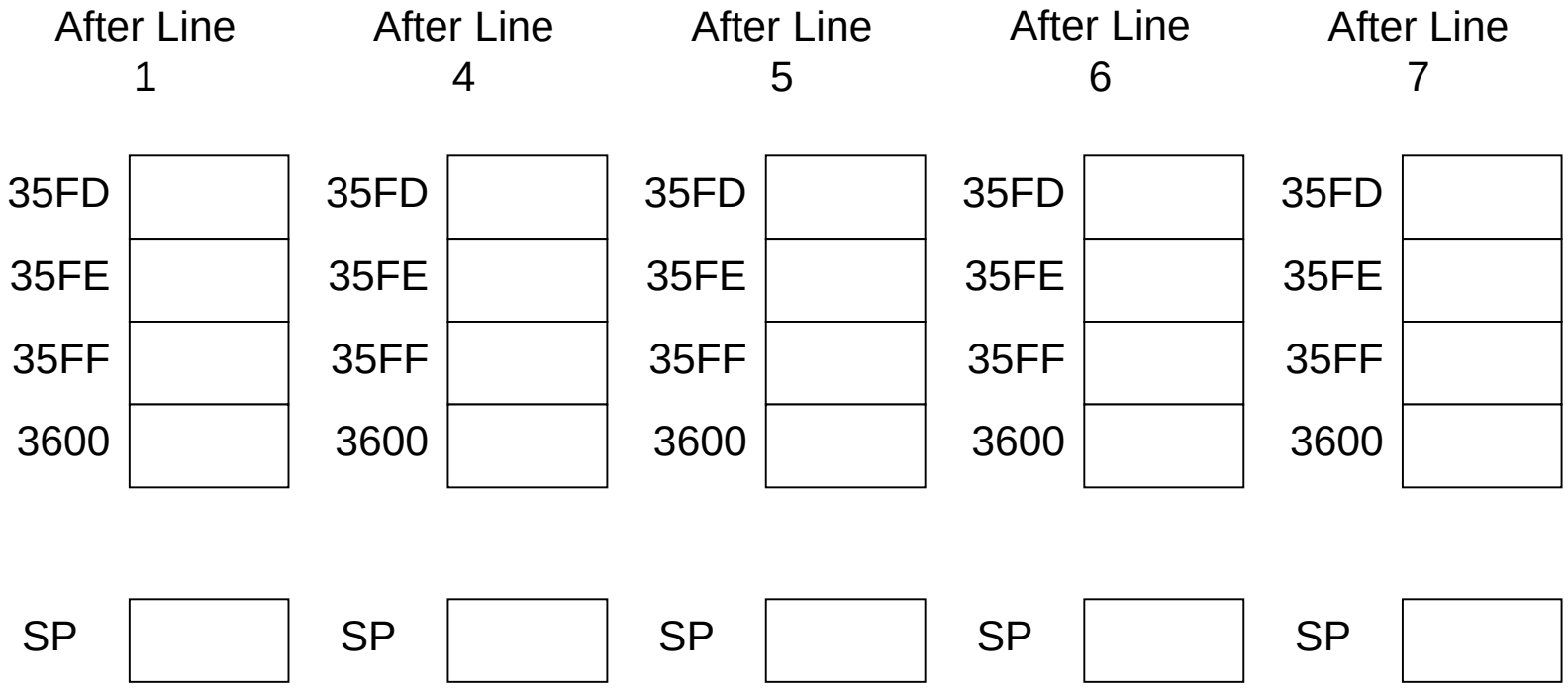
- Stack is any RAM area in main memory

- Who initializes ?
  - Simulator: Your program must use $3DFF
  - NoICE: Auto-init’s to $3DFF

Example 1

Q: Assuming that we have the following instruction sequence to be executed by the HCS12, what would be the contents of the stack after the execution of these instructions?

```
1: LDS   #$3600
2: LDAA  #$AA
3: LDAB  #$BB
4: PSHA
5: PSHB
6: PULB
7: PULA
```



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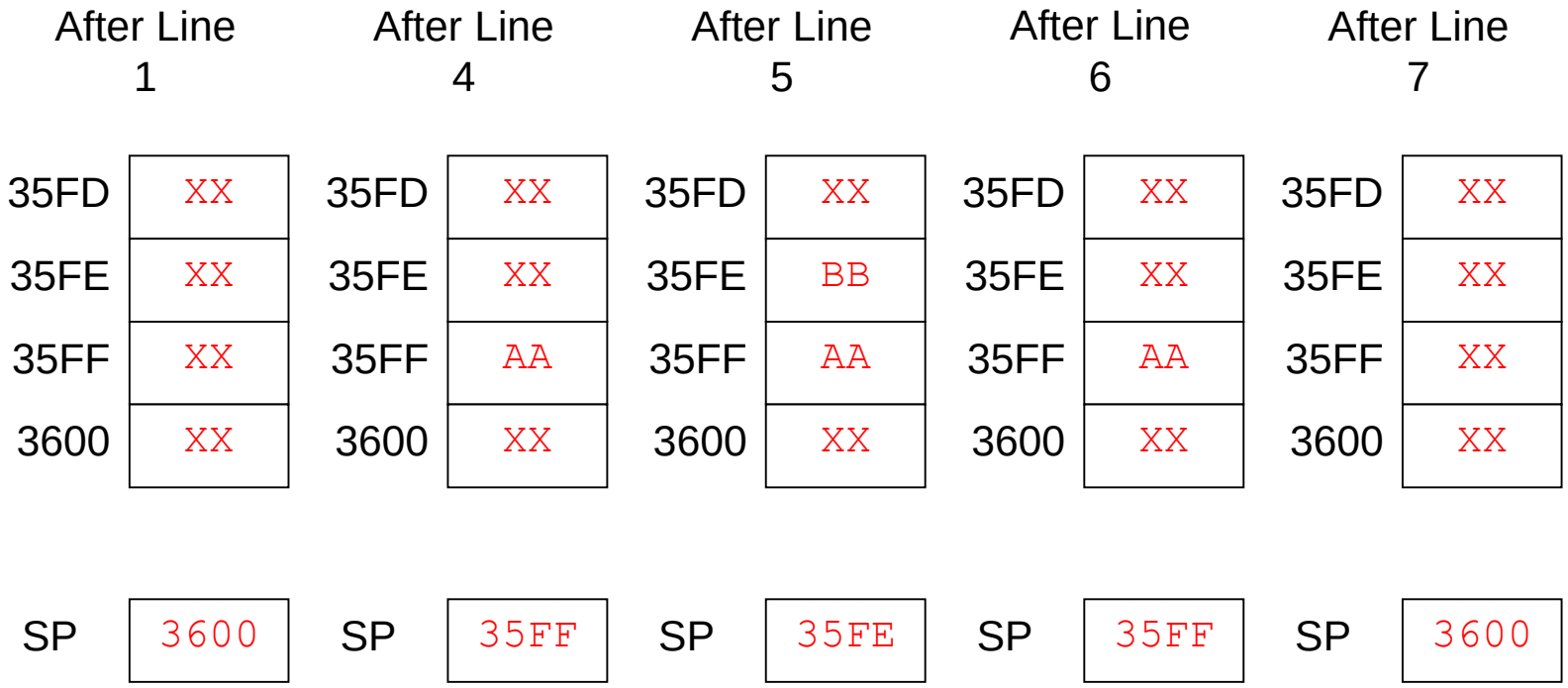
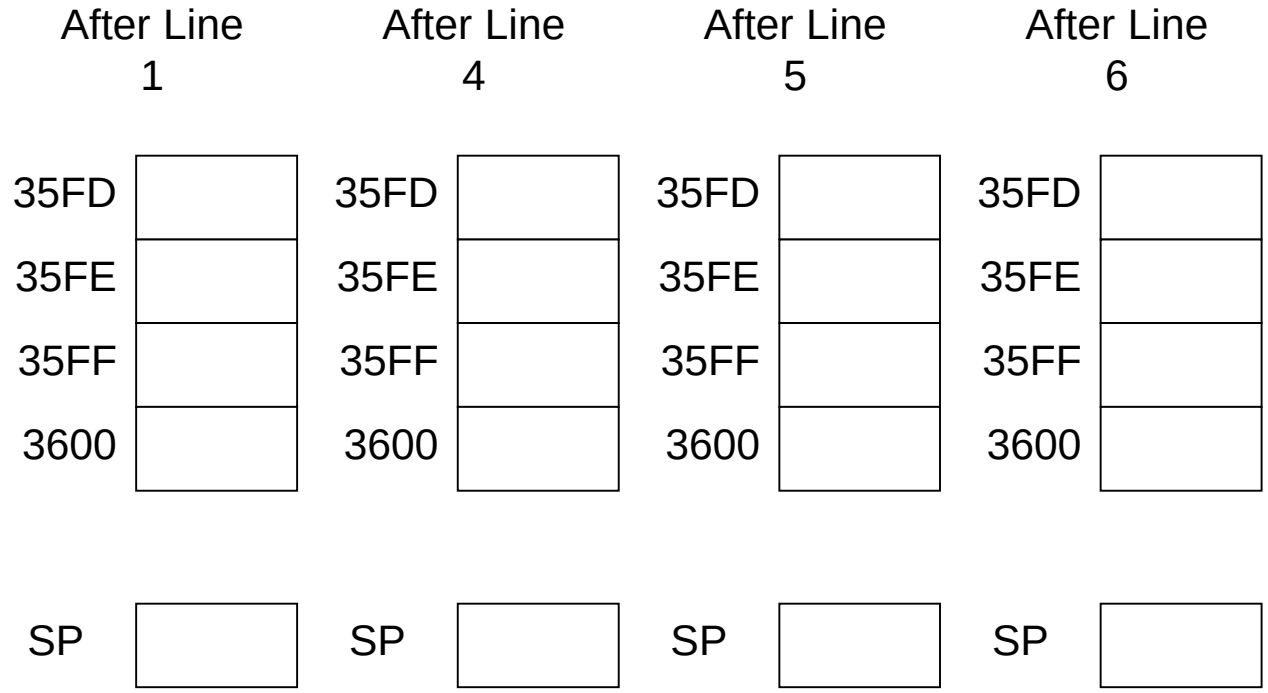


Example 2

Q: Assuming that we have the following instruction sequence to be executed by the HCS12, what would be the contents of the stack after the execution of these instructions?

```
1:      LDS     #$3600
2:      LDAA    #$AA
3:      LDAB    #$BB
4:      PSHD
5:      LDD     #$CCDD
6:      LEAS    2,SP
```



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Questions?

Wrap-up

What we've learned

- Stack

- PUSx, PULx, LDS, LEAS

What to Come

- Subroutines