HKN ECE 220: Spring 2015 Midterm 1

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ECE ILLINOIS

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Pseudo-Ops

- .ORIG x3000 ;;the first instruction should be at x3000
- .END ;;indicate this is the end of the program
- .FILL #-3 ;;#-3, #5, #0, xFFC0, xABCD, etc.
- .BLKW#3 ;;how many memory location you want to put
- .STRINGZ "Hello, World!" ;;Null-terminated
- TRAP x25 ;;same as HALT

Examples

- How to clear R0?
- AND R0, R0, #0

- How to do R0 ← R1?
- ADD R0, R1, #0   ;;remember: -16 <= immediate value and <= 15

- How to get –R0?
- NOT R0, R0
- ADD R0, R0, #1

Tips

- .asm→ (PASS 1) → symbol table → (PASS2) → .obj (the excutable)
- Use LABELS
- Use semicolon to comment
- BR = BRnzp
- Set breakpoint when debugging
- Draw a flow chart if necessary
- Try to remember what kind of numbers are in the registers that you are using. Write them down when calculation gets complicated.
- Assign different registers to specific functionality when the task is complex (R1 for row count, R2 for column count, etc)
- Don't get frustrated, breathe and start over.

LC-3 Review: I/O

I/O Interactions

- Polling vs Interrupts
    - Polling
        - Loop indefinitely until data is available by checking status register
    - Interrupts
        - Allows program to perform other work while no data is available
        - Upon reception of interrupt, pause current code execution and execute special interrupt handling functions
        - Return to interrupted code once interrupt has been handled
        - Will be covered in depth in ECE 391!

LC-3 Review: I/O

Memory Mapped I/O

- Map I/O to specific memory addresses
    - Removes the need for dedicated I/O channels
- Accessing the mapped memory address gives access to the input or output device
    - Reading from xFE02 (KBDR) returns a char of what key was pressed on the keyboard
    - Writing ‘a’ to xFE06 (DDR) will display ‘a’ on the display
    - Check the status register (KBSR, DSR) of the respective input/output before reading or writing

LC-3 Review: Keyboard Input

Reading from the keyboard

- Poll KBSR until ready bit is set then access input data stored in lower 8 bits of KBDR

```
POLL    LDI     R1, KBSR        ; Check status register
        BRzp    POLL            ; Loop while ready bit not set
        LDI     R0, KBDR        ; Get keyboard input

KBSR    .FILL   xFE00           ; KBSR address
KBDR    .FILL   xFE02           ; KBDR address
```

LC-3 Review: Display Output

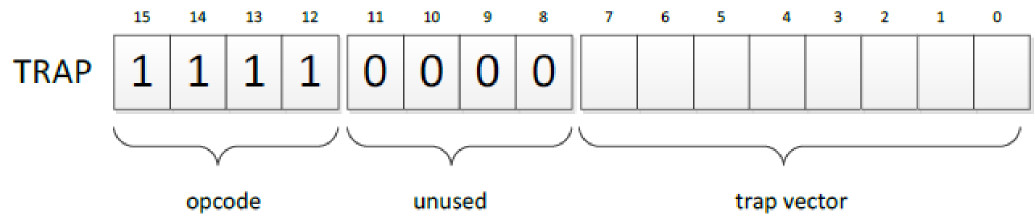
Writing to the display

- Poll DSR until ready bit is set then write display data to DDR

```
POLL    LDI     R1, DSR         ; Check status register
        BRzp    POLL            ; Loop while ready bit not set
        STI     R0, DDR         ; Write display data

DSR     .FILL   xFE04           ; DSR address
DDR     .FILL   xFE06           ; DDR address
```

TRAPS



TRAP function

- Passes control to operating system
- Programmers can use complex operations without specialized knowledge

Trap Vector	Assembler Name	Description
x20	GETC	Read single character from keyboard into R0
x21	OUT	Write character from R0 to display
x22	PUTS	Write null terminated string of characters to display starting from memory location at R0
x23	IN	Prompts for input; Reading char from keyboard and echo input to console
x24	PUTSP	Same as puts but use characters from both lower and upper 8 bits
x25	HALT	Halts program execution

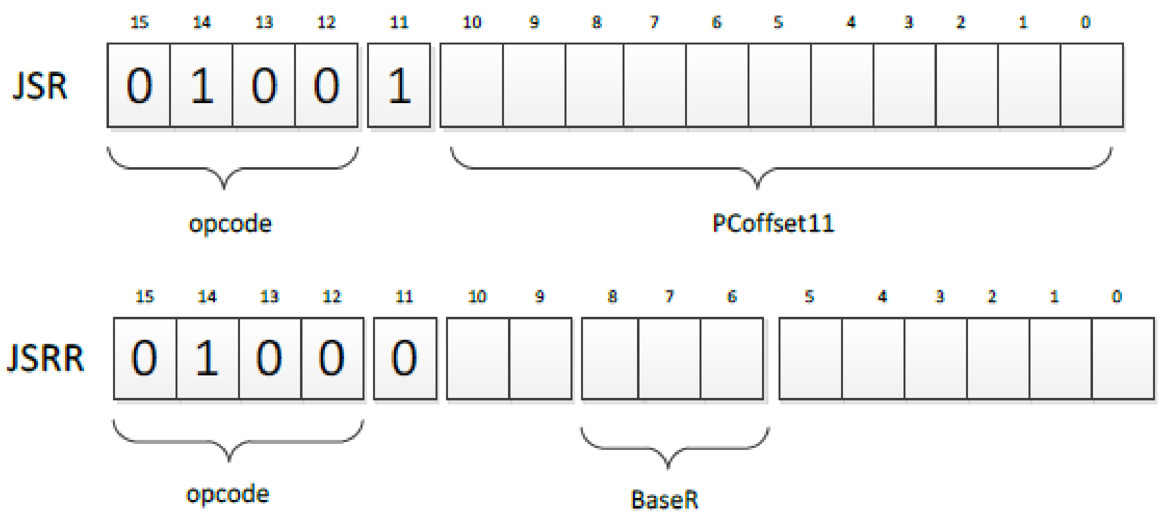
TRAPS: How they work

- TRAP function is called by the user
- The 8-bit trap vector is used as the index of the service routine's address in the trap vector table
  - - the table is stored in memory at 0x0000 – 0x00FF
- The PC is loaded with the address of the service routine
- After executing the service routine, control returns to the user program

```
MAR <- ZEXT(trapvector)
   MDR <- MEM[MAR]
         R7 <- PC
        PC <- MDR
```

Subroutines

- Similar to service routines but not part of the OS
- Useful if there is a code segment that needs to be executed multiple times
- Subroutines can be invoked by JSR or JSRR
- Return is implemented with RET instruction



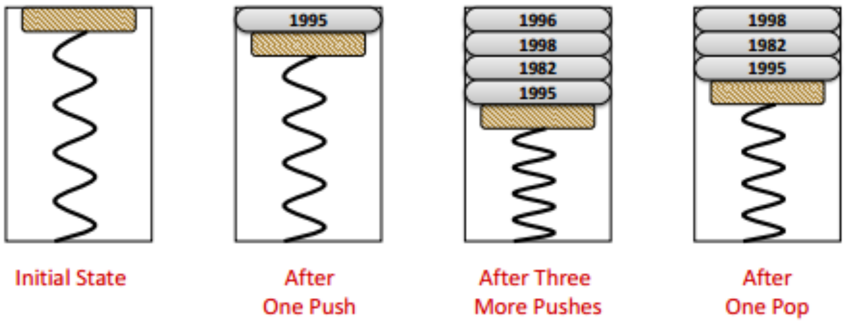

```
TEMP <- PC
If(IR[11] == 0)
        -   PC <- BaseR
Else
        -   PC <- PC + SEXT(PCoffset11)
R7 <- TEMP
```

Subroutines: Callee and Caller Save

- Subroutine will save and restore registers that it modifies except for the return values
  - The only visible change should be the return value (if any) upon return
- Caller should save registers that could be modified by the subroutine if they contain important data
  - R7 would need to be saved since JSR and JSRR overwrite its value

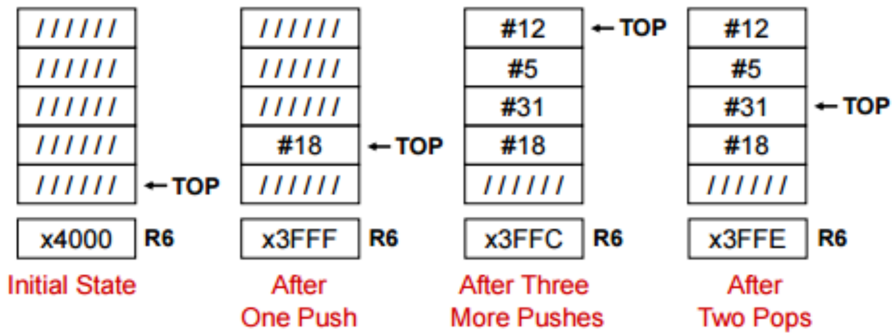
Stacks

- Last-In-First-Out (LIFO)
- Stack operations
  - Push: puts a new thing on top of the stack
  - Pop: removes whatever is on the top of the stack
  - IsEmpty: checks if the stack is empty
  - IsFull: checks if the stack is full
- Example:



Stacks(continued)

- Implementation
  - Keep elements stationary, just move the pointer
  - More efficient than moving everything



- Example: Calculator
- Questions?