CS/ECE 252: INTRODUCTION TO COMPUTER ENGINEERING

UNIVERSITY OF WISCONSIN—MADISON

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Midterm Examination 4

In Class (50 minutes)

Wednesday, May 09, 2014

Weight: 17.5%

NO: BOOK(S), NOTE(S), OR CALCULATORS OF ANY SORT.

The exam has **nine** pages. You **must turn in the pages 1-7**. Use the blank sides of the exam for scratch work.

Circle your final answers. Plan your time carefully since some problems are longer than others.

Note:

- The Instruction set is provided on Page 9
- TRAP codes and Assembler directives are provided on Page 10

LAST NAME: _____

FIRST NAME: _____

ID# _____

Problem	Maximum Points	Points Earned
1		
2		
3		
4		
5		
Total	30	

Problem 1: Short answer type questions (7 Points)

a) (1 Point) Mention what problem could come up if DSR is not checked before writing into DDR.

You could overwrite the previous data even before it is displayed.

b) (2 Points) What is the difference between polling and interrupt based I/O ? Briefly explain a scenario where you would prefer interrupt based I/O over polling based I/O?

In Polling based I/O, the program polls checks continuously for the status of the data. In an interrupt based I/O, an interrupt will be generated to signal the program of the completion of work.
If the I/O device takes a lot of time to execute the command, then polling consumes a lot of cycles. In these cases, interrupt driven I/O is preferred

c) (2 Points) Briefly mention what happens during linking and loading phases of a program.

During the Linking phase, the symbols between different object files which are linked together gets resolved.
During the loading phase, the executable image is copied onto the memory

d) (2 Points) What will be the value in R2 if you execute the following program (ie, when you reach the HALT instruction) ?

```
      .ORIG x3000
       AND R0, R0, #0
       ADD R0, R0, #7
       STI R0, DATA1
       LD R2, DATA2
       HALT

DATA1 .FILL x3006
DATA2 .FILL x3
```

Answer: 7

Problem 2: Assembly Errors (2 Points)

Identify 2 assembly errors in the following program:

```
          .ORIG x3001
          AND R5, R5, ZERO
          LD R5, FOOBAR
NEXT      ADD R5, R5, #1
          BRz NEXT
          LDR R4, R2, #0
          ST R4, FOOBAR
NEXT      HALT

ZERO      .FILL     #0
FOOBAR    .STRINGZ  "YAY!! LAST EXAM"
          .END
```

a. double declaration of NEXT
b. AND with ZERO (address)

Problem 3: Traps and Subroutines (6 Points)

Suppose we want to write a new TRAP subroutine, **TRAP x01**. This subroutine takes two inputs from the caller of the subroutine through registers R2 and R1. R2 has the memory address of the first character of a string and R1 has the number of characters to be printed. The subroutine then prints R1 number of characters from the starting of the string (whose address is located in R2). Fill in the missing blanks to complete this subroutine code.

Assume that we are implementing callee save subroutine. Save only those registers that are needed.

Assume the trap vector table (also known as system control block) is as shown below:

Address	Value
x0000	x3000
x0001	x4000
x0002	x5000

```
.ORIG  __x4000_______

       ST  __R0__,   SAVEREG_LOCATION1
       ST  __R1__,   SAVEREG_LOCATION2
       ST  __R2_,    SAVEREG_LOCATION3
       ST  __R7__,   SAVEREG_LOCATION4


LOOP   LDR R0, R2, #0          ; Load the character to be printed
       OUT                     ; Print the extracted character
       ADD R2, R2, #1          ; Point R2 to the next character
       ADD R1, R1, #-1         ; Set the condition flags if this is the last character
       BRp LOOP                ; If this is not the last character, branch to LOOP

       LD  _R0___,   SAVEREG_LOCATION1
       LD  _R1___,   SAVEREG_LOCATION2
       LD  _R2__,    SAVEREG_LOCATION3
       LD  _R7_,     SAVEREG_LOCATION4

       RET

SAVEREG_LOCATION1  .BLKW 1
SAVEREG_LOCATION2  .BLKW 1
SAVEREG_LOCATION3  .BLKW 1
SAVEREG_LOCATION4  .BLKW 1
```

Problem 4: I/O (4 Points)

For the assembly program, assume all the registers (R0 - R7) are initialized to the value of zero.

```
          .ORIG x3000
           LD  R1, NEG
           LD  R2, SET
ILOOP      LDI R3, KBSR
           BRzp ILOOP
           LDI R4, KBDR
           STI R2, KBSR
OLOOP      LDI R2, DSR
           BRzp OLOOP
           ADD R0, R4, #0
           STI R0, DDR
           ADD R5, R5, 1
           ADD R6, R5, R1
           BRnp OLOOP
           HALT

NEG       .FILL xFFFB
SET       .FILL x4000
DSR       .FILL xFE04   ; Address of DSR
DDR       .FILL xFE06   ; Address of DDR
KBSR      .FILL xFE00   ; Address of KBSR
KBDR      .FILL xFE02   ; Address of KBDR
          .END
```

(a) (2 Points) What does the above LC-3 program do?

- Enables Keyboard interrupt
- Displays the ASCII character that the user entered 5 times back to the user.

(b) (2 Points) How is the operation of the keyboard affected by the instruction **STI R2, KBSR**?

- No impact to the program logic. It just enables the Keyboard interrupt . If we are polling for next character, there can be a error window where the same old data is used even if new character is entered.

Problem 5: Two Stage Assembly Process (10 Points)

Consider the following assembly program.

```
            .ORIG x3000
            LD R0, DATA
            LEA R1, ZERO
            STR R0,R1,#-3
            LEA R5, STR1

LOOP        LDR R0, R5, 0
            BRz END
            OUT
            ADD R5, R5, #1
            BR LOOP

END         HALT


ZERO        .FILL     #0
STR1       .STRINGZ "Wierd_Question"
ARRAY       .BLKW x5
DATA        .FILL x1B62
```

(a) (3 Points) In the first pass, the assembler creates symbol table. Fill in the symbol table created by the assembler for this program (in Problem 2(a))

Label	Address
LOOP	3004
END	3009
ZERO	300A
STR1	300B
ARRAY	301A
DATA	301F

(b) (2 Points) In the second pass, the assembler creates a binary (.obj) version of the program, using the entries from the symbol table. Write the binary code generated for the first two instructions (LEA and LD) in the table below.

Assembly code	Binary Code
LD R0, DATA	0010 000 000011110
LEA R1, ZERO	1110 001 000001000

(c) (3 Points) Complete the missing comments for this program (For loop, consider only first iteration):

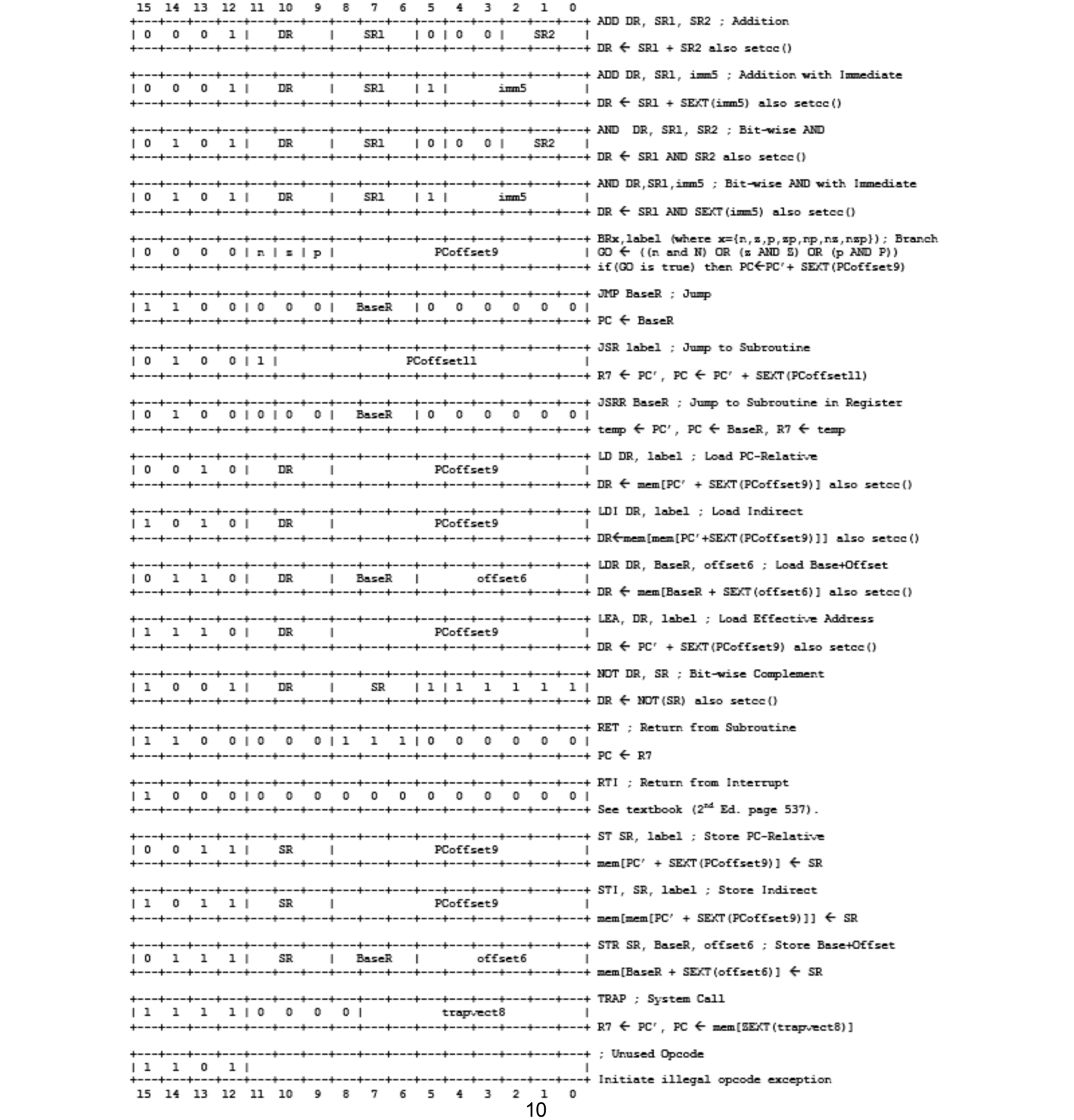
```
            .ORIG x3000
            LD R0, DATA     ; Value loaded into R0 is ___X1B62________
            LEA R1, ZERO    ; Loads __address of ZERO_____ into R1
            STR R0,R1,#-3   ; Stores value x1B62 into address _x3007___
            LEA R5, STR1    ; Loads __address of STR1______ into R5

LOOP        LDR R0, R5, 0   ; Value at R0 in the first iteration is x57
            BRz END         ; Branch to END if ZERO flag is set
            OUT             ; Print the character at __R0____
            ADD R5, R5, #1 ;
            BR LOOP          ; Branch to LOOP

END         HALT            ; HALT


ZERO       .FILL       #0
STR1       .STRINGZ "Wierd_Question"
ARRAY      .BLKW x5
DATA       .FILL x1B62
```

(d) (3 Points) What will be printed on the console if this program is run on PennSim?

WedQeto

LC-3 Instruction Set (Entered by Mark D. Hill on 03/14/2007; last update 03/15/2007)

PC': incremented PC. setcc(): set condition codes N, Z, and P. mem[A]:memory contents at address A.
SEXT(immediate): sign-extend immediate to 16 bits. SEXT(immediate): zero-extend immediate to 16 bits.



TRAP CODES

Code	Equivalent	Description
HALT	TRAP x25	Halt execution and print message to console.
IN	TRAP x23	Print prompt on console, read (and echo) one character from keybd. Character stored in R0[7:0].
OUT	TRAP x21	Write one character (in R0[7:0]) to console.
GETC	TRAP x20	Read one character from keyboard. Character stored in R0[7:0].
PUTS	TRAP x22	Write null-terminated string to console. Address of string is in R0.

ASSEMBLER DIRECTIVES

Opcode	Operand	Meaning
.ORIG	address	starting address of program
.END		end of program
.BLKW	n	allocate n words of storage
.FILL	n	allocate one word, initialize with value n
.STRINGZ	n-character string	allocate n+1 locations, initialize w/characters and null terminator