Exam 1

Date: February 23, 2016

UT EID: ____________ __________

Printed Name: ____
Last, First

Your signature is your promise that you have not cheated and will not cheat on this exam, nor will you help others to cheat on this exam:

Signature:

Instructions:

- Closed book and closed notes. No books, no papers, no data sheets (other than the last two pages of this Exam)
- No devices other than pencil, pen, eraser (no calculators, no electronic devices), please turn cell phones off.
- Please be sure that your answers to all questions (and all supporting work that is required) are contained in the space (boxes) provided. Do Not write answers on back of pages
- You have 75 minutes, so allocate your time accordingly.
- Unless otherwise stated, make all I/O accesses friendly.
- Please read the entire exam before starting.

Problem 1	20	
Problem 2	10	
Problem 3	20	
Problem 4	10	
Problem 5	20	
Problem 6	20	
Total	100	

[8 points] ***Problem 1a***: Represent the following hexadecimal numbers as 8-bit binary, and determine their values as unsigned and signed decimal numbers.

Hexadecimal	**Binary**	**Unsigned decimal**	**Signed decimal**
0x7F			
0xEF			

[12 points] ***Problem 1b***: Assume that ***number*** is a 16-bit variable initialized to 0x0088. For the following code snippets indicate which branch is taken.

Code Snippet	**Destination label**
LDR R1, =number LDRB R0, [R1] CMP R0, #136 BNE next BL subroutine	
LDR R1, =number LDRSB R0, [R1] CMP R0, #100 BLT next BL subroutine	
LDR R1, =number LDRH R0, [R1] CMP R0, #120 BHI next BL subroutine	
LDR R1, =number LDRSH R0, [R1] CMP R0, #136 BGE next BL subroutine	

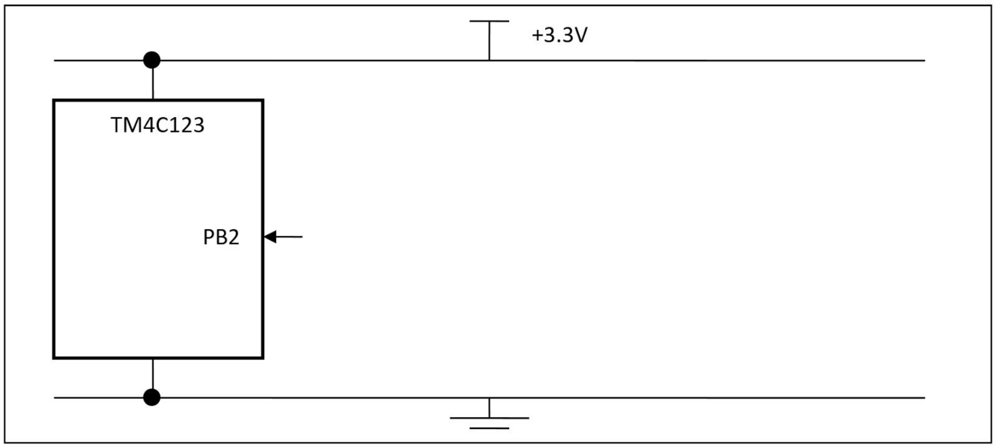
[5 points] ***Problem 2a***: Write friendly C code (function Ports_Init()) to turn the clock ON for two ports, PortA and PortE. Also configure and digital enable their pins as follows: PortA: All pins are input; PortE: pins 4,3,2,1,0 are outputs. Assume that the following device register declarations are given (only these need manipulating for initialization): `SYSCTL_RCGCGPIO_R`, `GPIO_PORTA_DIR_R`, `GPIO_PORTA_DEN_R`, `GPIO_PORTA_DATA_R`, `GPIO_PORTE_DIR_R`, `GPIO_PORTE_DEN_R`, `GPIO_PORTE_DATA_R`.

```
void Ports_Init(void) {













}
```

[5 points] ***Problem 2b***: A 319K student attempted to write code that swapped the bytes of a 16-bit unsigned Input number and wrote them into Output. So, if Input was `0xABCD` then Output after the program is run should be `0xCDAB`. His flawed solution is given below. Fix it by providing the correct solution on the right (Cite the line and the correction).

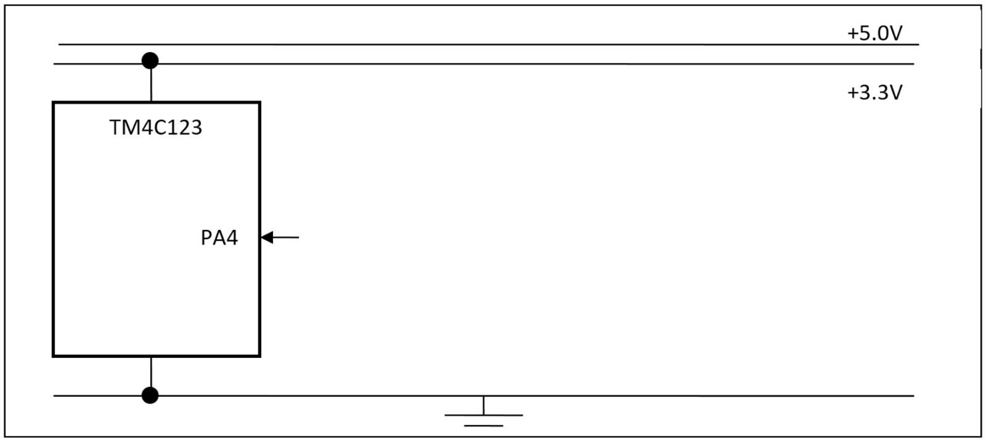
```
1:  AREA DATA, ALIGN=2
2: Input  SPACE 1
3: Output SPACE 1

4:  AREA |.text|, CODE, READONLY, ALIGN=2
5:    THUMB
6:    EXPORT  Start

7: Start
8:    LDR R0,=Input
9:    LDR R1,=Output
10:   LDR R3,[R0]
11:   LDR R4,[R0,#2]
12:   STR R4,[R1]
13:   STR R3,[R1,#2]
14:   ALIGN
15:   END
```

[10 points] ***Problem 3a***: Interface a switch through a 10 kΩ resistor to port PB2 (which has been configured as an input port) using negative logic. Show the circuit diagram with all components properly labeled. Assuming that no current can flow into and out of the port pin and the switch is ideal, find the current through the switch and the voltage across the resistor. Complete the table below .



Switch configuration	**Current through switch**	**Voltage across the resistor**
Switch open		
Switch closed		

[10 points] ***Problem 3b***: Interface an LED through a resistor to port PA4 (which has been configured as an output port) using positive logic. The LED's desired brightness needs an operating point as 3.0V, 15 mA. The V_{OL} and V_{OH} of the TM4C123 is 0.3V and 3.3V respectively. The 7406 driver has also been provided to you whose V_{OL} is 0.5V. Find the value of the resistor R that needs to be connected, and show the circuit diagram. Two supply voltages have also been provided having values 3.3V and 5V. What is the current through the LED and the voltage across the resistor? Complete the table below the figure.



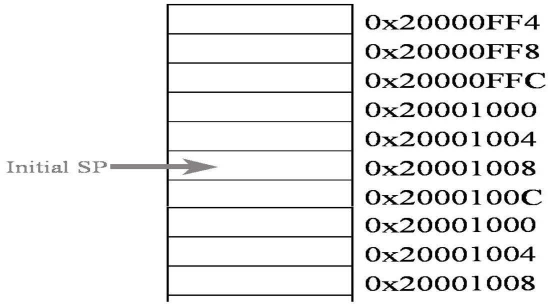
Voltage at PA4	**Current through LED**	**Voltage across the resistor**
Logic level 0		
Logic level 1		

[10 points] ***Problem 4***: Work through the assembly code below to identify the contents in the stack. Also, describe why CalleR and Callee are not AAPCS compliant.

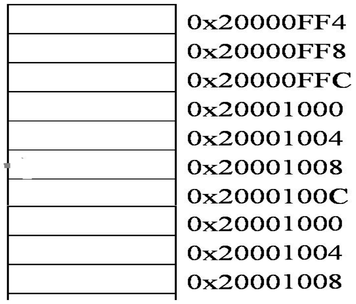
```
00000000 CalleR
00000000   MOV   R0,#1
00000004   MOV   R1,#7
00000008   MOV   R2,#2
0000000C   MOV   R3,#5
00000010   PUSH  {R3, R1, R2, R0}
       ;----A-----
00000012   BL                Callee
00000016   POP               {R5}
```

```
00000018 Callee
00000018   POP   {R2}
0000001A   MOV   R0,#3
0000001E Again
0000001E   POP   {R1}
00000020   CMP   R1,R2
00000022   BLT   Next
00000024   MOV   R2, R1
00000026 Next
00000026   SUBS  R0,#1
00000028   BNE   Again
0000002A   PUSH  {R2}
0000002C       ; ----B----
```

[5 points] ***Part (a)***: Give the state of the stack (SP and contents) at execution points **A** and **B**



At Execution Point A

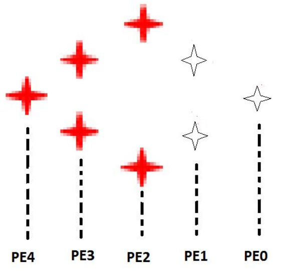


At Execution Point B

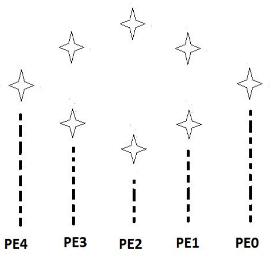
Final SP (at A):	**Final SP (at B):**

[5 points] ***Part (b)***:What makes CalleR and Callee non-compliant with AAPCS

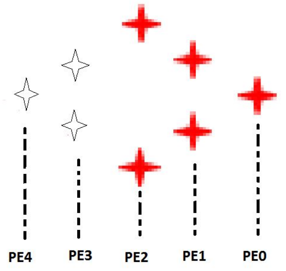
[20 points] ***Problem 5***: Write a software (in assembly) that controls the turn indicators for a bicycle. There are eight indicator LEDS that are interfaced as shown in the figure below to 5 output pins on the TM4C microcontroller. Note, PE3,2,1 control two LEDs each and PE4 and PE0 each control one LED.



Left Indication



All Off



Right Indication

An accelerometer interfaced externally to input pins PA7-PA0 gives the accelerometer reading in the x-direction. The reading is a signed number between -90 and +90. The accelerometer is mounted on the rider's helmet, so when the rider tilts her head to the left the readings are negative [-90,0) and when she tilts her head to the right the readings are positive (0,90]. You can consider any value between -20 and 20 to be false indicators of rider's intent to turn. Indication of left or right has to flash (on/off) the corresponding LEDS (see figure) at 4Hz with 50% duty cycle.

You can assume that all GPIO port initialization is already done for you and you only need to access the Data registers (GPIO_PORTE_DATA_R, GPIO_PORTA_DATA_R) for completing the software module. Your task is split into two parts.

[8 points] ***Part (b)***: Write a delay routine that delays in units of 1ms. You may assume the following: (i) the microcontroller is operating at the default clock speed of 16MHz, (ii) all add/sub/logic operations take 1 clock cycle and all conditional branches take 3 clock cycles.

```
; DelayMS - Delays for R0 ms
; Input: R0 has the number of milliseconds to delay for
; Output: None
DelayMS
```

[8 points] ***Part (b)***: Complete the main loop of the software. Your code should turn the appropriate LEDs On/Off to get the flashing effect when indicating a turn, otherwise (to keep straight) the LEDS are all off. You must call the Delay routine you wrote above in parts (a).

```
; Turn Indicator Program
; All AREA declarations and EQU statements here (assume done for you)
; Make your own pseudo-op statements if needed



Start
      ; All initialization code here (assume done for you)
mLoop




        B mLoop
```

[20 points] ***Problem 6***: The two columns below represent the same program with C on the left and ASM on the right. Some rows are missing from each column. Fill any row needed to make both columns completely equivalent. You also need to fill in the parameters for the function `foo` and the condition for the C `while` loop. You also should fill in the value of the variable `sY` where specified. You may not need all boxes. No more than one statement/op per box. No extra boxes.

// Don’t fill in this line
int32_t sY;
// Don’t fill in this line
int32_t foo(□) { **// fill param**
int32_t b = a;
int32_t c = 0;
while (□) { **// fill in cond**
b = b * a;
++c;
} // only thing in this box is }
return (b);
} // only thing in this box is }
void bar(int32_t a) {
// Don’t fill in this line
sY = a; // nothing else on this line
} // only thing in this box is }
} // only thing in this box is }
int main() { // ignore main() in ASM
sY = 0xDC; // ignore this in ASM
bar(2); // ignore this in ASM
// sY at this point is: □
return (0); // ignore this in ASM
} // ignore this in ASM

AREA DATA ; assume starts at 0x2000.0000
uX DCD 0x09
AREA CODE ; assume starts at 0x0000.2000
foo ; rest of this line is empty
MOV R1, R0
MOV R2, #0
LDR R3, =uX
LDR R3, [R3]
loop CMP R2, R3
BHS cont
cont MOV R0, R1
bar ; do not add branches below this line
MOV R1, =sY
LDR R2, [R1]
BL foo
CMP R0, R2
BLE next
next; rest of this line is empty
BX LR
main ; ignore main and this entire box ; in ASM