EECE.3170: Microprocessor Systems Design I

Summer 2016

Homework 2 Solution

1. Assume the state of an x86 processor's registers and memory are:

	Address	Lo			<u>Hi</u>
EAX: EECE3170h	20100h	10	00	08	00
EBX: 00000001h	20104h	10	10	FF	FF
ECX: 00000002h	20108h	08	00	19	91
EDX: 00000004h	2010Ch	20	40	60	80
ESI: 00020100h	20110h	02	00	AB	0F
EDI: 00020110h	20114h	30	99	11	55
	20118h	40	AA	7C	EE
	2011Ch	FF	BB	42	D2
	20120h	30	CC	30	90

What is the result of each of the instructions listed below? Assume that the instructions execute in sequence—in other words, the result of each instruction may depend on the results of earlier instructions. Correctly evaluating each instruction will earn you 5 points.

Note that you may assume any constant values shown using less than 32 bits are zero-extended to 32 bits if necessary (for example, 000Fh = 0000000Fh).

```
MOV DL, FEh

Solution: DL = FEh
```

MOV DH, AL

Solution: DH = AL = 70h (EDX now = 000070FEh)

MOVSX BX, BYTE PTR [ESI+000Fh]

Solution: BX = sign-extended byte at address ESI+000Fh = 00020100h + 000Fh = 0002010Fh

 \rightarrow BX = 80h sign-extended = **FF80h**

MOV [EDI+ECX], EBX

Solution: Double-word at address EDI+ECX = EBX

EDI+ECX = 00020110h + 00000002h = 00020112h

 \rightarrow (20112h) = EBX = **0000FF80h** (bytes ordered as 80h, FFh, 00h, 00h)

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MOV [ESI+4*ECX], AX

Solution: Word at address ESI+4*ECX = AX

ESI + 4*ECX = 20100h + 4*2 = 20108h

 \rightarrow (20108h) = **3170h** (bytes ordered as 70h, 31h)

XCHG CL, [ESI]

Solution: Swap byte values in CL, address 20110h \rightarrow CL = 10h, (20110h) = 02h

MOVZX EAX, WORD PTR [EDI+ECX]

Solution: EAX = zero-extended word at address EDI+ECX = 20110h + 00000010h = 20120h

 \rightarrow EAX = **0000CC30h** (original word underlined)

MOV DX, [EDI+FFFFFFAh]

Solution: DX = word at address EDI+FFFFFFAh = 20110h + (-6) = 2010Ah

 \rightarrow DX = 9119h

LEA ECX, [*ESI*+*EBX*+0017*h*]

Solution: ECX = ESI + EBX + 0017h = 20100h + 0000FF80h + 0017h =**30097h**

MOVSX EBX, BYTE PTR [ESI+4]

Solution: EBX = sign-extended byte at address 20104h = **0000010h** (original byte underlined)

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2. Assume the initial state of an x86 processor's registers, memory, and carry flag are:

EAX: 00003170h					
EBX: 9876DCBAh	Address	Lo			Hi
ECX: 00001995h	8440h	FF	03	99	87
EDX: AC921E14h	8444h	08	09	F6	BB
ESI: 00008440h	8448h	78	15	00	00
CF: 0					

What is the result of each of the instructions listed below? Assume that the instructions execute in sequence—in other words, the result of each instruction may depend on the results of earlier instructions. Correctly evaluating each instruction will earn you 5 points.

Note that you may assume any constant values shown using less than 32 bits are zero-extended to 32 bits if necessary (for example, 000Fh = 0000000Fh).

```
AX, BX
ADD
Solution: AX = AX + BX = 3170h + DCBAh = 0E2Ah, CF = 1
ADC
         EAX, ECX
Solution: EAX = EAX + ECX + CF = 00000E2Ah + 00001995h + 1 = 000027C0h, CF = 0
INC
         WORD PTR [ESI]
Solution: Add 1 to word at address ESI = 00008440h
         → Word @ 8440h = 03FFh + 1 = 0400h (byte @ 8440h = 00h, byte @ 8441h = 04h)
         BYTE PTR [ESI+4]
MUL
Solution: AX = AL * unsigned byte @ (ESI+4)
         \rightarrow Address = ESI + 4 = 8440h + 4 = 8444h; byte @ 8444h = 08h
         \rightarrow AX = C0h * 08h = 192 * 8 = 1536 = 0600h
SUB
         AX, [ESI+8]
Solution: AX = AX - word @ ESI+8
         \rightarrow Address = ESI + 8 = 8440h + 8 = 8448h; word @ 8448h = 1578h
         \rightarrow AX = 0600 – 1578h = F088h, CF = 1 (since borrow out of MSB required)
DEC
         AH
Solution: AH = AH - 1 = F0 - 1 = EFh
IMUL
        AH
Solution: AX = AL * AH (signed multiplication) = 88h * EFh = -120 * -17 = 2040 = 07F8h
```

IDIV

DL

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Solution: AL = AX / DL (signed division) = 07F8h / 14h = 2040 / 20 = 102 = **66h** AH = AX % DL (remainder) = 2040 % 20 =**00h**

DIVDH

Solution: AL = AX / DH (unsigned division) = 0066h / 1Eh = 102 / 30 = **03h** AH = AX % DH (remainder) = 102 % 30 = 12 = 0Ch

NEG AH

Solution: AH = -AH = -0Ch = - $(0000\ 1100_2)$ = $(1111\ 0011_2 + 1 = 1111\ 0100_2)$ = **F4h**