Activity 15

Algebraic Properties of Bitwise Operations

Commutativity
- a | b = b | a
- a ⊕ b = b ⊕ a
- a & b = b & a

Associativity
- (a | b) | c =a | (b | c)
- (a ⊕ b) ⊕ c = a ⊕ (b ⊕ c)
- (a & b) & c = a & (b & c)

Distributivity
- a & (b | c) = (a & b) | (a & c)
- a & (b ⊕ c) = (a & b) ⊕ (a & c)
- a | (b & c) = (a | b) & (a | c)

Identities
- a | 0 = a
- a ⊕ 0 = a
- a & –1 = a

Inverse
- a ⊕ a = 0

Annihilator
- a & 0 = 0

Cancellation
- ¬(¬a) = a

Complement
- a | ¬a = –1
- a & ¬a = 0

Idempotency
- a & a = a
- a | a = a

Absorption
- a | (a & b) = a
- a & (a | b) = a

DeMorgan's Laws
- ¬(a & b) = ¬a | ¬b
- ¬(a | b) = ¬a & ¬b

Other Properties of 0, –1
- a | –1 = –1
- ¬0 = –1
- ¬–1 = 0

```
  0 00000000
  0 00000000

  1 00000001
 -1 11111111

  2 00000010
 -2 11111110

  3 00000011
 -3 11111101

  4 00000100
 -4 11111100

  5 00000101
 -5 11111011

  6 00000110
 -6 11111010

  7 00000111
 -7 11111001

  8 00001000
 -8 11111000

  9 00001001
 -9 11110111

 10 00001010
-10 11110110

 11 00001011
-11 11110101

 12 00001100
-12 11110100

 13 00001101
-13 11110011

 14 00001110
-14 11110010

 15 00001111
-15 11110001

 16 00010000
-16 11110000
```

```
 120 01111000
-120 10001000

 121 01111001
-121 10000111

 122 01111010
-122 10000110

 123 01111011
-123 10000101

 124 01111100
-124 10000100

 125 01111101
-125 10000011

 126 01111110
-126 10000010

 127 01111111
-127 10000001
```

```
-127 10000001
-126 10000010
-125 10000011
-124 10000100
-123 10000101
-122 10000110
-121 10000111
-120 10001000

 -16 11110000
 -15 11110001
 -14 11110010
 -13 11110011
 -12 11110100
 -11 11110101
 -10 11110110
  -9 11110111
  -8 11111000
  -7 11111001
  -6 11111010
  -5 11111011
  -4 11111100
  -3 11111101
  -2 11111110
  -1 11111111
   0 00000000
   1 00000001
   2 00000010
   3 00000011
   4 00000100
   5 00000101
   6 00000110
   7 00000111
   8 00001000
   9 00001001
  10 00001010
  11 00001011
  12 00001100
  13 00001101
  14 00001110
  15 00001111
  16 00010000

 120 01111000
 121 01111001
 122 01111010
 123 01111011
 124 01111100
 125 01111101
 126 01111110
 127 01111111
```

1. Multiply 15 × 10 using the shift-and-add algorithm. Note: $15 = 1111_2$, $10 = 1010_2$, and $150 = 10010110_2$.

2. Zero out the AL register using an XOR instruction.

3. Swap the values in AL and BL using the XOR Swap algorithm.

	; **AL =**	**BL =**
mov al, 1001b		
mov bl, 1100b	; 1001	1100
____________________	; _______	_______
____________________	; _______	_______
____________________	; _______	_______

4. Write a sequence of instructions that will compute the absolute value of the integer in EAX without using a conditional jump. (You will need to use a second register, like EBX.)

5. Suppose $a = 1111$ and $b = 0011$, so $a = -1$ and $b = 3$ using a 4-bit two's complement representation. Compute the minimum: $\min(a, b) = b \oplus ((a \oplus b) \,\&\, ((a - b) \gg^{s} 3))$

6. $25{,}351 = 0110\ 0011\ 0000\ 0111_2$.

   What is the binary representation of 25,350? ______________________________

   What is the binary representation of 25,352? ______________________________

7. Isolate the rightmost 1-bit of AL.

   mov al, 10110000b

   mov bl, al

   ____

   ____

8. Verify that $5 + 7 = (5 \oplus 7) + ((5 \,\&\, 7) \ll 1)$.