CSC 209 Review 9 Solution

August 31, 2020

1. a) 0

   Notes

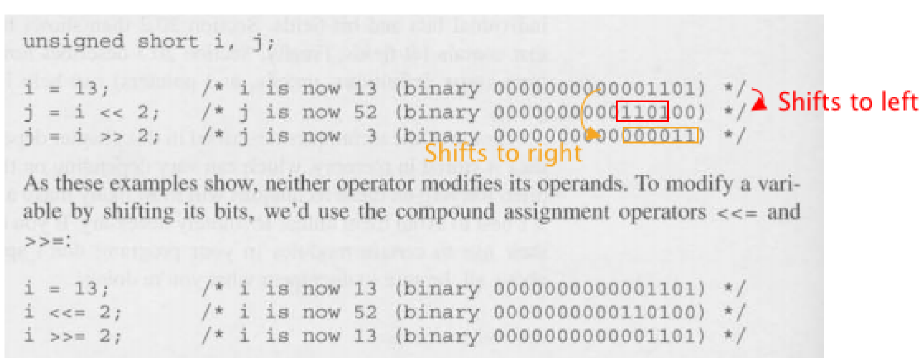
   - `a)` is 0 because (`i >> 1 + j >> 1` = `i >> 10 >> 1 = 0`)
   - **Bitwise Shift Operators**
     - has lower precedence than arithematic operators

       Example:

       `i << 2 + 1` means `i << (2+1)` and not `(i << 2) + 1`

     - << : Left Shift
     - >> : Right Shift
     - *Tip:* Always shift only on unsigned numbers for portability

       Example



```
unsigned short i, j;

i = 13;       /* i is now 13 (binary 0000000000001101) */
j = i << 2;   /* j is now 52 (binary 0000000000110100) */
j = i >> 2;   /* j is now  3 (binary 0000000000000011) */
```

As these examples show, neither operator modifies its operands. To modify a variable by shifting its bits, we'd use the compound assignment operators <<= and >>=:

```
i = 13;       /* i is now 13 (binary 0000000000001101) */
i <<= 2;      /* i is now 52 (binary 0000000000110100) */
i >>= 2;      /* i is now 13 (binary 0000000000001101) */
```


     - >>= / <<= : Are bitwise shift equivalent of + =

   b) 0

   Notes

- `i` is `1111111111111111`
- `i` is `0000000000000000`
- so `i & i = 0`
- : Bitwise complement (NOT)

a	∼ a
0	1
1	0

Example:

```
    0   1   1   1   //<- this is 7
    --------------
    1   0   0   0   //<- this is 8

    so, ~ 7 = 8
```

- `&`: Bitwise *and*

a	b	a & b
0	0	0
0	1	1
1	0	0
1	1	1

Example:

```
    0   1   1   1   //<- this is 7
    0   1   0   0   //<- this is 4
    --------------
    0   1   0   0   //<- this is 4

    so, 7 & 4 = 4
```

- : Bitwise *exclusive or*
- |: Bitwise *inclusive or*

c) 1

<u>Notes</u>

- `i` is `1111111111111110`
- `j` is `0000000000000000`
- `i & j` is `0000000000000000` or 1
- `i & j ^ k` is 1

- ^: Bitwise XOR

a	b	a ^ b
0	0	0
0	1	1
1	0	1
1	1	0

Example:

```
    0   1   1   1   //<- this is 7
    0   1   0   0   //<- this is 4
    --------------
    0   0   1   1   //<- this is 3

    so, 7 ^ 4 = 3

```

d) 0

Example

- `i` is 0000000000000111
- `j` is 0000000000001000
- `i ^ j` is 0000000000000000 or 0
- `k` is 0000000000001001
- `i ^ j & k` is 0000000000000000 or 0

Correct Solution

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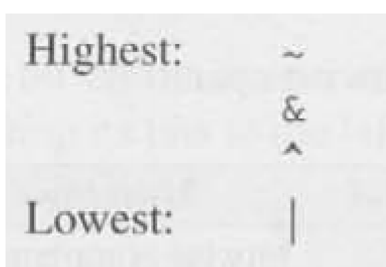
Notes

- There is a precendence to the order of operations



e)

- toggling from 0 to 1

```
i = 0x0000;
i |= 0x0001;
```

or

`i |= 1 << 0;` where `i = 0x0000;`

- toggling from 1 to 0

```
i = 0x0001;
i &= ~0x0001;
```

or

`i &= ~(1 << 0);` where `i = 0x0001;`

Correct Solution

- toggling from 0 to 1 of 4th bit

```
i = 0x0010;
i ^= 0x0000;
```

or

`i ^= 1 << 4;` where `i = 0x0000;`

- toggling from 1 to 0 of 4th bit

```
i = 0x0010;
i ^= 0x0010;
```

or

`i ^= (1 << 4);` where `i = 0x0010;`

Notes

- Toggling can be done using bitwise XOR
- **Setting a bit**
  - Is done using | or bitwise OR

```
i = 0x0000;          /* i is now 0000000000000000 */
i |= 0x0010;         /* i is now 0000000000010000 */
```

  - The idiom of above is `i |= 1 << j`

- **Clearing a bit**
  - Is done using | or bitwise AND

```
i = 0x00ff;          /* i is now 0000000011111111 */
i &= ~0x0010;        /* i is now 0000000011101111 */
```

  - The idiom of above is `i &=` ∼`(i << j)`