CSC 209 Review 9 Solution

August 31, 2020

1. a) 0

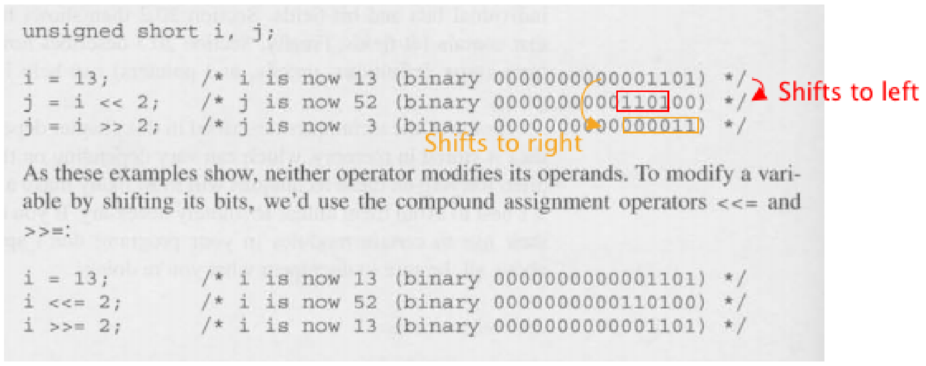
   Notes

   - `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) */
```

Shifts to left
Shifts to right

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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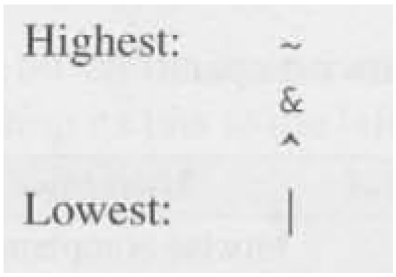
Notes

- There is a precendence to the order of operations



Highest:	~
	&
	^
Lowest:	|

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

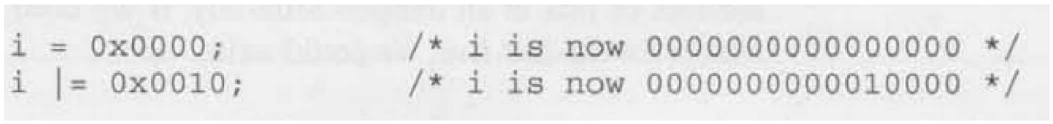
  ```
  i = 0x0010;
  i ^= 0x0010;
  ```

  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)`

2. It swaps the elements between `x` and `y`.

   Notes

   - Preprocessor performs operations of statements in order from left to right

```
#define M(x,y)  ((x)^=(y),(y)^=(x),(x)^=(y))
```

New value of x $\rightarrow$ New value of y $\rightarrow$ New value of x