

CSC 209 Review 9 Solution

September 1, 2020

1. a) 0

Notes

- a) is 0 because $(i \gg 1 + j \gg 1 = i \gg 10 \gg 1 = 0)$
- **Bitwise Shift Operators**
 - has lower precedence than arithmetic operators

Example:

$i \ll 2 + 1$ means $i \ll (2+1)$ and not $(i \ll 2) + 1$

- \ll : Left Shift
- \gg : 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 $\ll=$ and $\gg=$:

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

Shifts to left

Shifts to right

- $\gg=$ / $\ll=$: Are bitwise shift equivalent of $+=$

b) 0

Notes

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

| a | $\sim a$ |
|---|----------|
| 0 | 1 |
| 1 | 0 |

Example:

```

1      0   1   1   1   //<- this is 7
2      -----
3      1   0   0   0   //<- this is 8
4
5      so, ~ 7 = 8

```

- `&`: Bitwise *and*

| a | b | a & b |
|---|---|-------|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

Example:

```

1      0   1   1   1   //<- this is 7
2      0   1   0   0   //<- this is 4
3      -----
4      0   1   0   0   //<- this is 4
5
6      so, 7 & 4 = 4

```

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

c) 1

Notes

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

- \wedge : Bitwise XOR

| a | b | $a \wedge b$ |
|---|---|--------------|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

Example:

```

1      0   1   1   1   //<- this is 7
2      0   1   0   0   //<- this is 4
3      -----
4      0   0   1   1   //<- this is 3
5
6      so, 7 ^ 4 = 3
7

```

d) 0

Example

- i is 0000000000000111
- j is 0000000000001000
- $i \wedge j$ is 0000000000000000 or 0
- k is 0000000000001001
- $i \wedge j \& k$ is 0000000000000000 or 0

Correct Solution

15

Notes

- There is a precedence to the order of operations

| | |
|----------|----------|
| Highest: | \sim |
| | $\&$ |
| | \wedge |
| 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

```

1           2           3
#define M(x,y) ((x)^(y), (y)^(x), (x)^(y))

```

New value of x → New value of y, using x from 1 → New value of x, using y from 2, x from 1

3. `#define MK_COLOR(r,g,b) (long) ((b | (g << 8)) | (b | (r << 16)))`

Rough Work

1. store b in bit 0

b

2. store g in bit 8

b | g << 8

3. store r in bit 16

b | r << 16

Correct Solution

```
#define MK_COLOR(r,g,b) (long) ((r | (g << 8)) | (r | (b << 16)))
```

Notes

- First Byte is furthest from 0x and first byte is closest to 0x



4. • GET_RED

```
#define GET_RED(c) (long) (c & 0x007)
```

• GET_GREEN

```
#define GET_GREEN(c) (long) ((c >> 8) & 0x007)
```

• GET_BLUE

```
#define GET_BLUE(c) (long) ((c >> 16) & 0x007)
```

Notes

- 0x0007 in binary is 0x00000000000001111
- `c >> 4` shifts `c` to right by 4 bits and return overlapping value between `c >> 4` and `0x00000000000001111` (0x007)
- Test code is below

```
1  #include <stdio.h>
2  #include <stdlib.h>
3
4  #define MK_COLOR(r,g,b) (long) ( (r | (g << 8)) | (r | (b << 16)) )
5  #define GET_RED(c) (long) (c & 0x007)
6  #define GET_GREEN(c) (long) ((c >> 8) & 0x007)
7  #define GET_BLUE(c) (long) ((c >> 16) & 0x007)
8
9  int main() {
10     long i, r = 4, g = 5, b = 6, r2, g2, b2;
11
12     i = MK_COLOR(r,g,b);
```

```
13
14     r2 = GET_RED(i);
15     g2 = GET_GREEN(i);
16     b2 = GET_BLUE(i);
17
18     printf("%ld\n", i);
19     printf("%ld\n", r2);
20     printf("%ld\n", g2);
21     printf("%ld\n", b2);
22
23     return 0;
24 }
```

5. a)

```
    unsigned short swap_bytes(unsigned short i) {
2         unsigned short j, k;
3
4         j = i & 0x007; // extract first byte
5
6         i = i >> 4;
7         k = i & 0x007; // extract second byte
8
9         i = i >> 4; // shift down later two bytes
10
11        i |= j << 8; // add first byte to position of fourth byte
12        i |= k << 12; // add second byte to position of third byte
13
14    }
```

b)

```
    unsigned short swap_bytes(unsigned short i) {
2
3        i = i >> 8 | i << 8;
4
5        return i;
6    }
```

Rough Works

1. Extract first two bytes

```
j = i & 0x0007
i = i >> 4
k = i & 0x0007
```

2. Shift later two bytes down

```
i = i >> 4
```

3. Add first two bytes to last two bytes

```
i |= j << 8;  
i |= k << 12;
```

```
61 unsigned int rotate_left(unsigned int i, int n) {  
2     unsigned int j;  
3  
4     for(int index = 0; index < n; index++) {  
5         // if exists, store last byte a separate variable  
6         j = i & (1 << 28);  
7         printf("%x\n", j);  
8         // shift everything by 4 bits  
9         i = i << 1;  
10  
11        // add value in the first byte of hex  
12        if (j) {  
13            i |= j;  
14        }  
15  
16    }  
17  
18    return i;  
19 }  
20  
21 unsigned int rotate_right(unsigned int i, int n) {  
22  
23    return i;  
24 }
```