Name:________________________________ NetID:______________

Answer all questions in the space provided. Write clearly and legibly, you will not get credit for illegible or incomprehensible answers. This is a closed book exam. However, each student is allowed to bring one page of notes to the exam. Print your name at the top of every page.

Question:	1	2	3	4	5	6	7	8	9	Total
Points:	16	16	15	6	7	10	6	9	15	100
Score:										

1. Short answer

   (a) What expression should be placed inside the call to `malloc` to allocate memory for an `double` array with `n` rows of `m` columns? (4)

   ```
   double* x = malloc(   ?    );
   ```

   (b) The C preprocessor lets you define macros. They can be very handy but also possible cause problems. Why is the following *not* a good macro? (4)

   ```
   #define SQUARE(x) x*x
   ```

   (c) What is the one pointer type that we can not directly perform arithmetic on, and why is it not possible? (4)

   (d) It is absolutely essential to free up memory after you are using dynamically allocated structures. If you don't you'll have memory leaks. Obviously the `free` function call is used for this purpose. So, if you see the following code in a program: (4)

   ```
   free(treenode);
   ```

   and the program *segfaults* on that line – what might be wrong? Name at least two things.

2. More short answer

   (a) There is no “real” boolean datatype in C, so what is used instead? Please give an example. (4)

   (b) Assuming `x` has been previously declared and initialized — Is the following code snippet valid C source code? If not, why not? If so, what is the result when this code is executed? (4)

```
if ( x = 0 )
  printf ( "x is zero\n" );
```

   (c) Is the following snippet valid C source code? If not, why not? If so, what is the result when this code is executed? (4)

```
int a[] = {3, 4, 5};
printf("%d\n", 2[a]);
```

   (d) As part of the Huffman coding assignment, you had to implement a priority queue. What structure did you use to implement it? What is another possible way? Which of the two methods would have better performance as I increase the number of possible items placed in the priority queue? (4)

3. What is the output of this program? (15)

   Hint: the `%x` format specifier prints an integer in hexadecimal format (with lowercase letters), the `#` says to prefix the result with `0x`, and the `04` says to make the output at least 4 characters wide, padding with leading zeros if needed. So, for example, the statement `printf("%#04x", 13);` would result in `0x0d` being printed to standard out.

```
#include <stdio.h>

void main(void)
{
  unsigned char x = 42;
  unsigned char y = 14;
  unsigned char z = 98;

  unsigned char a = x << 3;
  unsigned char b = x >> 3;
  unsigned char c = x & y;
  unsigned char d = x & z;
  unsigned char e = x | y;
  unsigned char f = x ^ y;

  printf("x %#04x, %d\n", x, x);
  printf("y %#04x, %d\n", y, y);
  printf("z %#04x, %d\n", z, z);

  printf("a %#04x, %d\n", a, a);
  printf("b %#04x, %d\n", b, b);
  printf("c %#04x, %d\n", c, c);
  printf("d %#04x, %d\n", d, d);
  printf("e %#04x, %d\n", e, e);
  printf("f %#04x, %d\n", f, f);
}
```

4. Consider the following code. (6)

```
1 void main(void)
2 {
3   unsigned long a[] = {12, 23, 34, 45, 56};
4   unsigned long *x = a;
5   printf("sizeof(unsigned long)=%lu ", sizeof(unsigned long));
6   printf("x=%p, x[0]=%lu\n", x, x[0]);
7   x = x + 3;
8   printf("x=%p, x[0]=%lu\n", x, x[0]);
9 }
```

If the output from lines 5 and 6 is
`sizeof(unsigned long)=8 x=0x7fff78e71c70, x[0]=12`
what is the output from line 8?

5. What is the output of this program? (7)

```
#include <stdio.h>

void main(void)
{
  char data[] = "SPRING";
  data[5] = 'T';
  char *linePt = &data[2];
  *linePt = 'L';
  printf("[%s], [%s]\n", data, linePt);
}
```

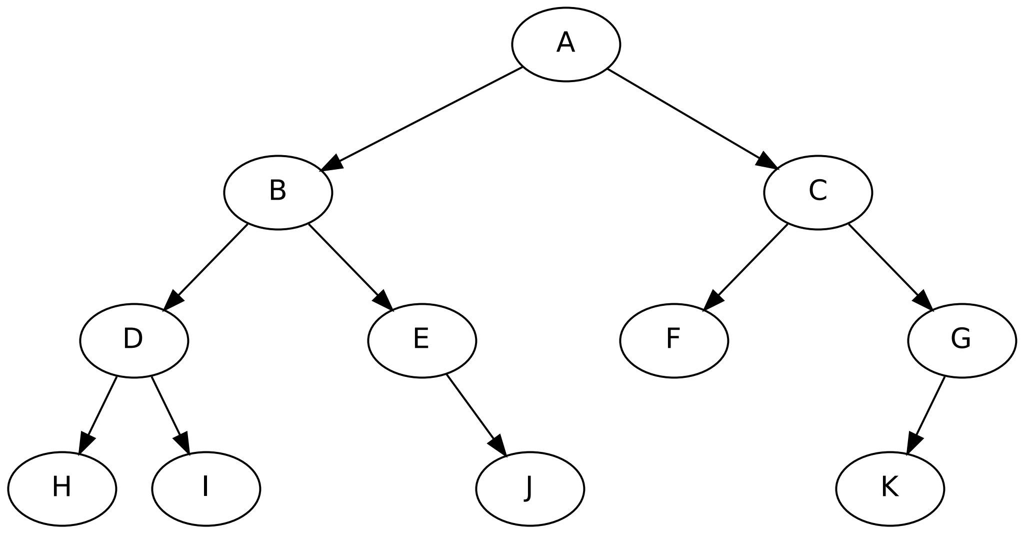
6. The following program is compiled and run with the command: `./a.out 1203201` (10)
   What is the output?

```
#include <stdio.h>

int main(int argc, char* argv[])
{
  char* c_pt;
  int n = 0;
  if(argc == 2)
  {
    c_pt = argv[1];
    while(*c_pt)
    {
      printf("%c, %d\n", *c_pt, n);

      if(*c_pt < '0' || *c_pt > '2') break;
      n = n*3 + *c_pt - '0';
      c_pt++;
    }
    printf("value = %d\n", n);
  }
}
```

7. What is the output of this program? (6)

```
#include <stdio.h>

struct Point
{
  int x;
  int y;
};

struct Point incPoints(struct Point *p1, struct Point p2)
{
  (*p1).x++;
  p1->y++;
  p2.x++;
  p2.y++;
  return p2;
}

void main(void)
{
  struct Point a = {1, 2};
  struct Point b = {3, 4};
  struct Point c = incPoints(&a, b);

  printf("a=(%d, %d)\n", a.x, a.y);
  printf("b=(%d, %d)\n", b.x, b.y);
  printf("c=(%d, %d)\n", c.x, c.y);

}
```

8. For the given tree, write out the following traversals.



(a) Breadth First (also known as level-order): (3)

(b) Depth First, pre-order: (3)

(c) Depth First, post-order: (3)

9. Remember `uuencode`? As part of this binary to text encoding, every three bytes of the binary data is split into four 6 bit groupings. (There's more to the encoding than that, but I'm not going to have you deal with the rest of it on this exam.) (15)

Original bytes, decimal	67								97								116							
Original bytes, hex	43								61								74							
Binary	0	1	0	0	0	0	1	1	0	1	1	0	0	0	0	1	0	1	1	1	0	1	0	0
New hex values	10						36						05						34					
New decimal values	16						54						5						52					

Write a function that takes an array of three bytes and returns a newly allocated array containing the regrouped bits.