Problem 48. (12 points):

3M decides to make Post-Its by printing yellow squares on white pieces of paper. As part of the printing process, they need to set the CMYK (cyan, magenta, yellow, black) value for every point in the square. 3M hires you to determine the efficiency of the following algorithms on a machine with a 2048-byte direct-mapped data cache with 32 byte blocks.

You are given the following definitions:

```
struct point_color {
    int c;
    int m;
    int y;
    int k;
};

struct point_color square[16][16];
register int i, j;
```

Assume:

- `sizeof(int) = 4`

- `square` begins at memory address 0

- The cache is initially empty.

- The only memory accesses are to the entries of the array `square`. Variables `i` and `j` are stored in registers.

A. What percentage of the writes in the following code will miss in the cache?

```
for (i=0; i<16; i++){
    for (j=0; j<16; j++) {
        square[i][j].c = 0;
        square[i][j].m = 0;
        square[i][j].y = 1;
        square[i][j].k = 0;
    }
}
```

Miss rate for writes to `square`: _____ %

B. What percentage of the writes in the following code will miss in the cache?

```
for (i=0; i<16; i++){
    for (j=0; j<16; j++) {
        square[j][i].c = 0;
        square[j][i].m = 0;
        square[j][i].y = 1;
        square[j][i].k = 0;
    }
}
```

Miss rate for writes to square: _____ %

C. What percentage of the writes in the following code will miss in the cache?

```
for (i=0; i<16; i++){
    for (j=0; j<16; j++) {
        square[i][j].y = 1;
    }
}
for (i=0; i<16; i++) {
    for (j=0; j<16; j++) {
        square[i][j].c = 0;
        square[i][j].m = 0;
        square[i][j].k = 0;
    }
}
```

Miss rate for writes to square: _____ %