time/space

4. [8 points] For each of the programs, give a Big-Oh analysis of the running time.

(1)
```
sum = 0;
for( int i = 0; i < n; i++ )
    sum++;
```

$1+1+n+n+n = 2+3n$ $O(n)$

(2)
```
sum = 0;
for( int i = 0; i < n; i += 2 )
    sum++;
```

$\frac{n}{2}$ $O(n)$

(3)
```
sum = 0;
for( int i = 0; i < n; i++ )
    for( int j = 0; j < n; j++ )
        sum++;
```

n^2 $O(n^2)$

(4)
```
sum = 0;
for( int i = 0; i < n; i++ )
    sum++;
for( int j = 0; j < n; j++ )
    sum++;
```

$2n$ $O(n)$

(5)
```
sum = 0;
for( int i = 0; i < n; i++ )
    for( int j = 0; j < n * n; j++ )
        sum++;
```

n^3 $O(n^3)$

(6)
```
sum = 0;
for( int i = 0; i < n; i++ )
    for( int j = 0; j < i; j++ )
        sum++;
```

$n=$ 0 1 2 3

$(1+0)+(2+1)+(3+2)+(4+3)$

$2\sum_{i=0}^{n} n = 2n^2+n$ $O(n^2)$

(7)
```
sum = 0;
for( int i = 0; i < n; i++ )
    for( int j = 0; j < n * n; j++ )
        for( int k = 0; k < j; k++ )
            sum++;
```

(8)
```
sum = 0;
for( int i = 1; i < n; i = i * 2 )
    sum++;
```

Bonus. Implement the code and execute it for several values of N. Compare your analysis with the actual running times.