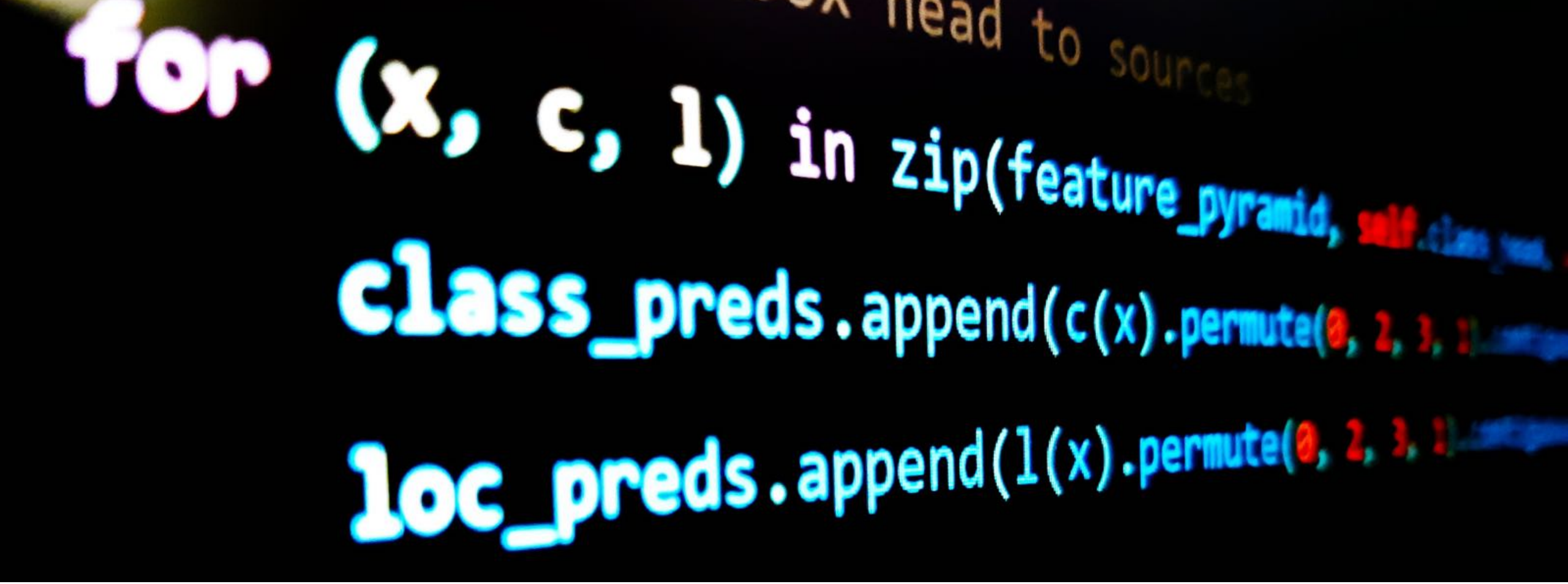


FREQUENCY COUNT

CCDSALG T2 AY 2020-2021

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2]
[3]
[4]
```

Line 1 will be executed only 1 time.

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I
[3]
[4]
```

Value of i	Condition	Enter Loop?
1	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I
[3] I
[4] I
```

Value of i	Condition	Enter Loop?
1	<= 3	Yes

Value of j	Condition	Enter Loop?
1	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I
[3] II
[4] II
```

Value of i	Condition	Enter Loop?
1	<= 3	Yes

Value of j	Condition	Enter Loop?
2	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I
[3] III
[4] III
```

Value of i	Condition	Enter Loop?
1	<= 3	Yes

Value of j	Condition	Enter Loop?
3	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I
[3] IIII-
[4] III-
```

Value of i	Condition	Enter Loop?
1	<= 3	Yes

Value of j	Condition	Enter Loop?
4	<= 3	No

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I-I
[3] IIII-
[4] III-
```

Value of i	Condition	Enter Loop?
2	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I-I
[3] IIII-I
[4] III-I
```

Value of i	Condition	Enter Loop?
2	<= 3	Yes

Value of j	Condition	Enter Loop?
1	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I-I
[3] IIII-II
[4] III-II
```

Value of i	Condition	Enter Loop?
2	<= 3	Yes

Value of j	Condition	Enter Loop?
2	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I-I
[3] IIII-III
[4] III-III
```

Value of i	Condition	Enter Loop?
2	<= 3	Yes

Value of j	Condition	Enter Loop?
3	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I-I
[3] IIII-IIII-
[4] III-III-
```

Value of i	Condition	Enter Loop?
2	<= 3	Yes

Value of j	Condition	Enter Loop?
4	<= 3	No

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I-I-I
[3] IIII-IIII-
[4] III-III-
```

Value of i	Condition	Enter Loop?
3	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I-I-I
[3] IIII-IIII-I
[4] III-III-I
```

Value of i	Condition	Enter Loop?
3	<= 3	Yes

Value of j	Condition	Enter Loop?
1	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I-I-I
[3] IIII-IIII-II
[4] III-III-II
```

Value of i	Condition	Enter Loop?
3	<= 3	Yes

Value of j	Condition	Enter Loop?
2	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I-I-I
[3] IIII-IIII-III
[4] III-III-III
```

Value of i	Condition	Enter Loop?
3	<= 3	Yes

Value of j	Condition	Enter Loop?
3	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I-I-I
[3] IIII-IIII-IIII
[4] III-III-III
```

Value of i	Condition	Enter Loop?
3	<= 3	Yes

Value of j	Condition	Enter Loop?
4	<= 3	No

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I
[2] I-I-I-I
[3] IIII-IIII-IIII
[4] III-III-III
```

Value of i	Condition	Enter Loop?
4	<= 3	No

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to n
[4]         print(i, j)
```

```
[1] I                   = 1
[2] I-I-I-I             = 4
[3] IIII-IIII-IIII      = 3(4)
[4] III-III-III         = 3(3)
```

In this example, the frequency count of the statements inside the inner loop is not dependent on the value of the counter value of the outer loop.

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

What happens if the frequency count of the inner loop is controlled by the counter variable of the outer loop? In this example, the upper bound of the inner loop is changed to the counter variable of the outer loop.

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2]
[3]
[4]
```

Line 1 will be executed only 1 time.

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I
[3]
[4]
```

Value of i	Condition	Enter Loop?
1	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I
[3] I
[4] I
```

Value of i	Condition	Enter Loop?
1	<= 3	Yes

Value of j	Condition	Enter Loop?
1	<= 1	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I
[3] II-
[4] I-
```

Value of i	Condition	Enter Loop?
1	<= 3	Yes

Value of j	Condition	Enter Loop?
2	<= 1	No

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I-I
[3] II-
[4] I-
```

Value of i	Condition	Enter Loop?
2	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I-I
[3] II-I
[4] I-I
```

Value of i	Condition	Enter Loop?
2	<= 3	Yes

Value of j	Condition	Enter Loop?
1	<= 2	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I-I
[3] II-II
[4] I-II
```

Value of i	Condition	Enter Loop?
2	<= 3	Yes

Value of j	Condition	Enter Loop?
2	<= 2	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I-I
[3] II-III-
[4] I-II-
```

Value of i	Condition	Enter Loop?
2	<= 3	Yes

Value of j	Condition	Enter Loop?
3	<= 2	No

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I-I-I
[3] II-III-
[4] I-II-
```

Value of i	Condition	Enter Loop?
3	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I-I-I
[3] II-III-I
[4] I-II-I
```

Value of i	Condition	Enter Loop?
3	<= 3	Yes

Value of j	Condition	Enter Loop?
1	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I-I-I
[3] II-III-II
[4] I-II-II
```

Value of i	Condition	Enter Loop?
3	<= 3	Yes

Value of j	Condition	Enter Loop?
2	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I-I-I
[3] II-III-III
[4] I-II-III
```

Value of i	Condition	Enter Loop?
3	<= 3	Yes

Value of j	Condition	Enter Loop?
3	<= 3	Yes

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I-I-I
[3] II-III-IIII
[4] I-II-III
```

Value of i	Condition	Enter Loop?
3	<= 3	Yes

Value of j	Condition	Enter Loop?
4	<= 3	No

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I
[2] I-I-I-I
[3] II-III-IIII
[4] I-II-III
```

Value of i	Condition	Enter Loop?
4	<= 3	No

NESTED LOOP

```
[1] n = 3
[2] for i = 1 to n
[3]     for j = 1 to i
[4]         print(i, j)
```

```
[1] I                   = 1
[2] I-I-I-I             = 4
[3] II-III-IIII         = 2+3+4
[4] I-II-III            = 1+2+3
```

Notice that the frequency count of the inner loop is affected by the current value of the counter variable of the outer loop. How to represent this?

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

```
[1] <ub> - <lb> + 2

[2]

[3]
```

Solve the outer loop first.

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2]

[3]

Solve the outer loop first.

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2] <ub> - <lb> + 2

[3] <ub> - <lb> + 1

Treat the inner loop as an independent loop first.

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2] $i + 1$

[3] i

Treat the inner loop as an independent loop first.

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2] $i + 1$

[3] i

Since the value of i changes with the outer loop, consider that in every iteration.

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2] $\sum_{i=1}^{n}(i + 1)$

[3] $\sum_{i=1}^{n}(i)$

Use summations to increment the value of i. The value of the upper bound and the lower bound of the summation is already stated in the outer loop.

FREQUENCY COUNT

SUMMATION/ARITHMETIC SERIES

$$\sum_{k=1}^{n} 1 = n$$

$$\sum_{k=1}^{n} k = \frac{n(n+1)}{2}$$

$$\sum_{k=1}^{n} c = cn$$

$$\sum_{k=1}^{n} k^2 = \frac{n(n+1)(2n+1)}{6}$$

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2] $\sum_{i=1}^{n}(i + 1)$

[3] $\sum_{i=1}^{n}(i)$

Simplify the summations using its closed form to get the final frequency count.

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2] $\sum_{i=1}^{n}(i) + \sum_{i=1}^{n}(1)$

[3] $\sum_{i=1}^{n}(i)$

Simplify the summations using its closed form to get the final frequency count.

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2] $\frac{n(n+1)}{2} + n$

[3] $\frac{n(n+1)}{2}$

Simplify the summations using its closed form to get the final frequency count.

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2] $\frac{n(n+1)}{2} + n$

[3] $\frac{n(n+1)}{2}$

$$Total = (n+1) + \frac{n(n+1)}{2} + n + \frac{n(n+1)}{2}$$

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2] $\frac{n(n+1)}{2} + n$

[3] $\frac{n(n+1)}{2}$

$$Total = (n + 1) + \frac{n^2 + n}{2} + n + \frac{n^2 + n}{2}$$

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2] $\frac{n(n+1)}{2} + n$

[3] $\frac{n(n+1)}{2}$

$$Total = \frac{2n + 2 + n^2 + n + 2n + n^2 + n}{2}$$

NESTED LOOP

```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2] $\frac{n(n+1)}{2} + n$

[3] $\frac{n(n+1)}{2}$

$$Total = \frac{2n^2 + 6n + 2}{2}$$

NESTED LOOP

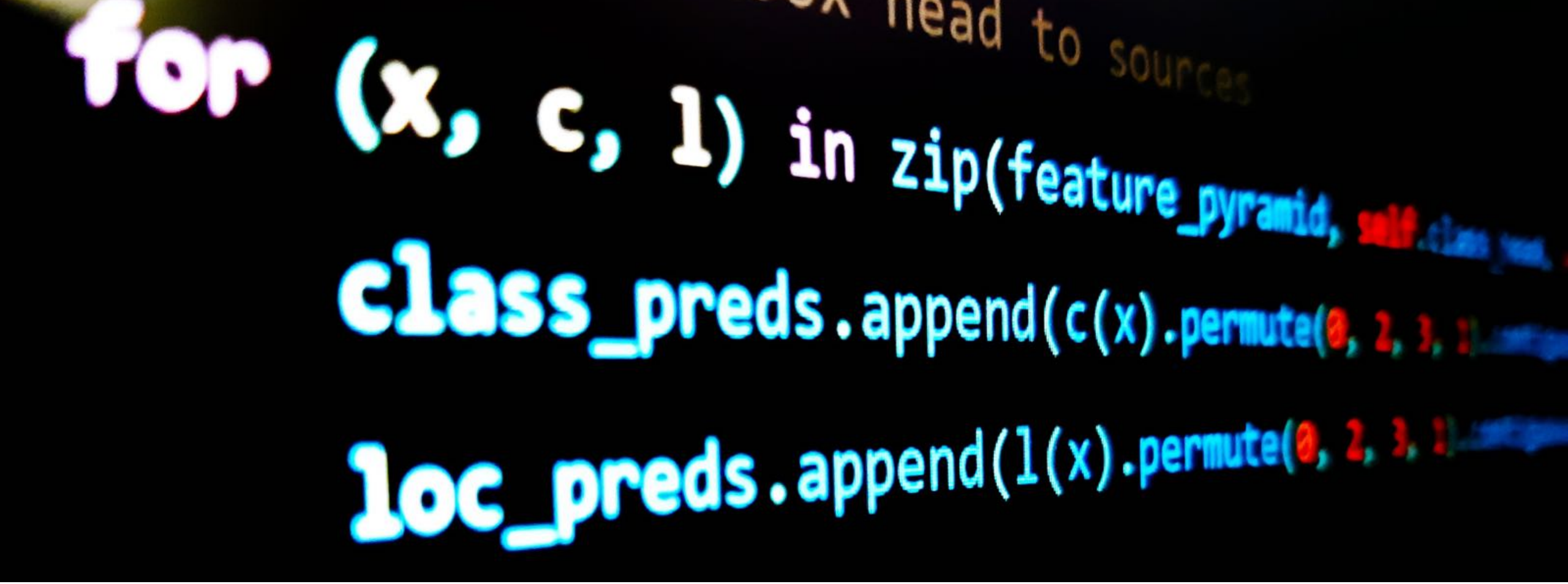
```
[1] for i = 1 to n

[2]     for j = 1 to i

[3]         print(i, j)
```

[1] $n + 1$

[2] $\frac{n(n+1)}{2} + n$

[3] $\frac{n(n+1)}{2}$

$$Total = n^2 + 3n + 1$$



FREQUENCY COUNT

CCDSALG T2 AY 2020-2021