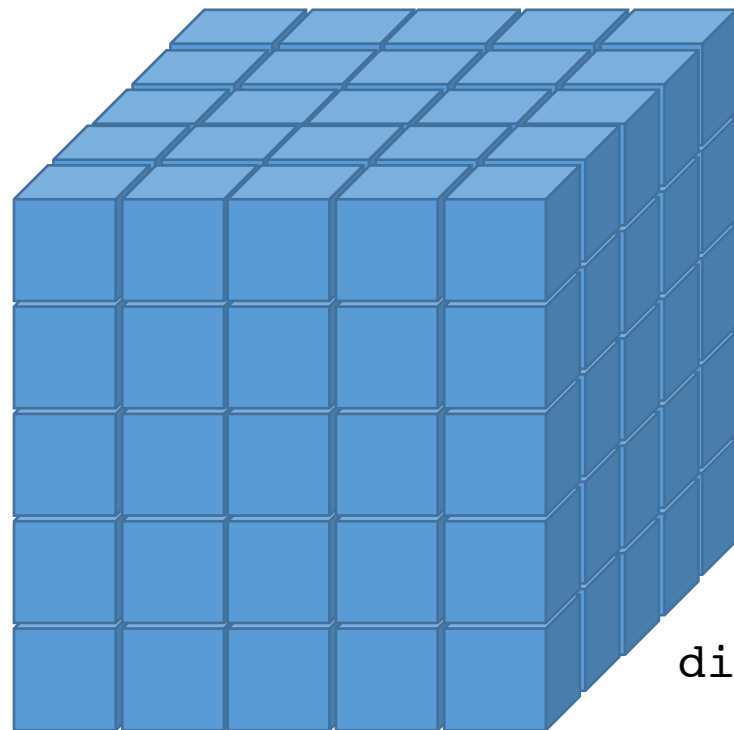


```
X = np.ones((5,5,5))
```

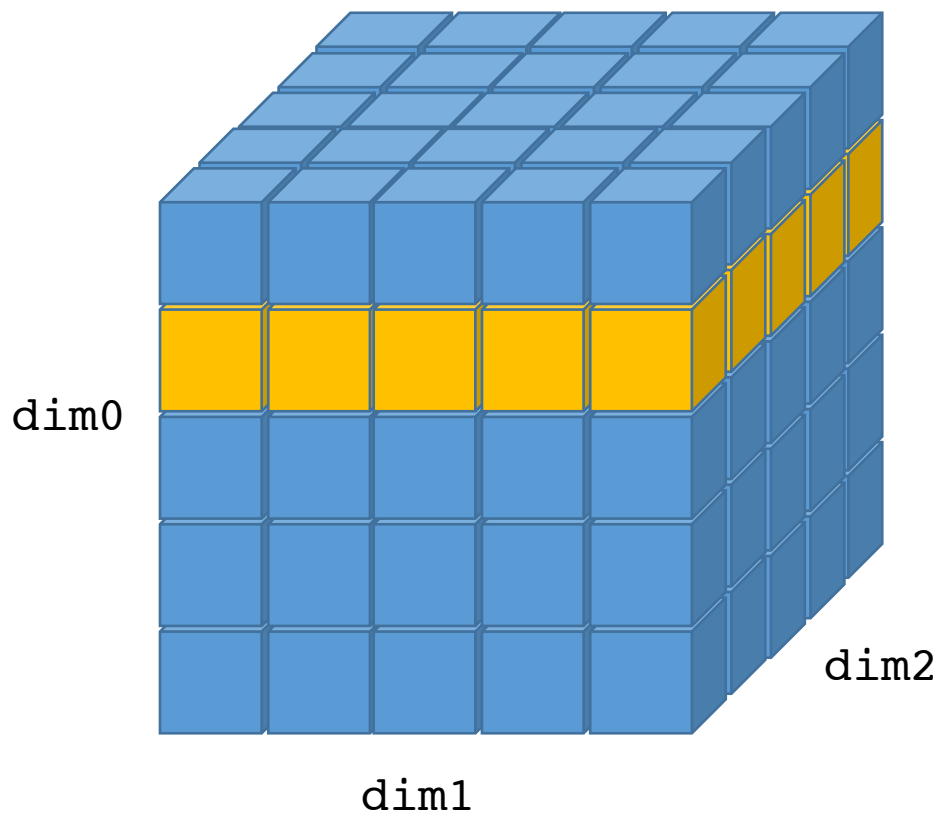
dim0

dim1

dim2

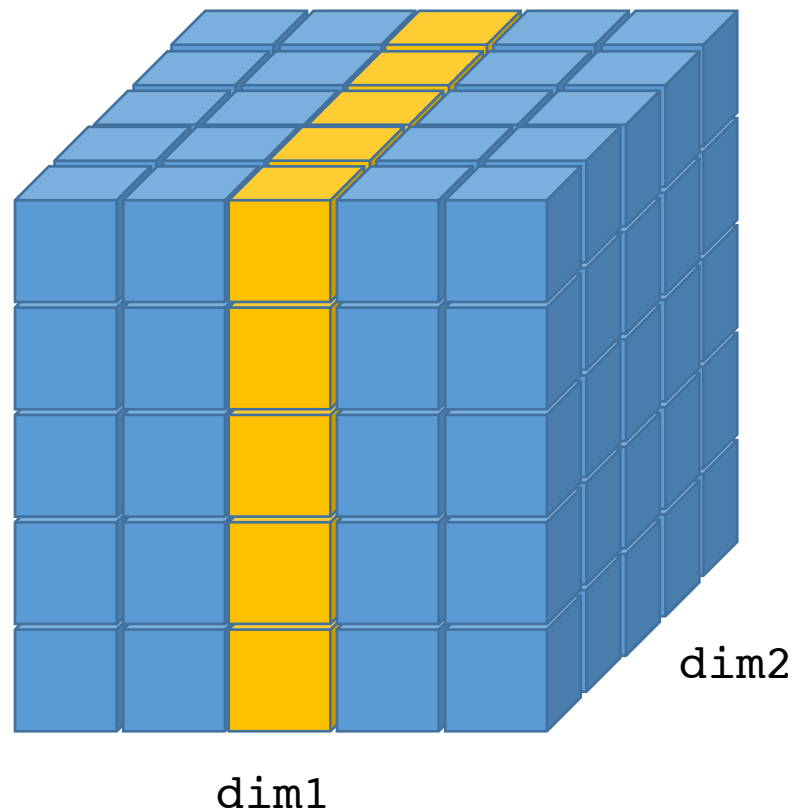


```
X = np.ones((5,5,5))  
A = X[1, :, :]
```

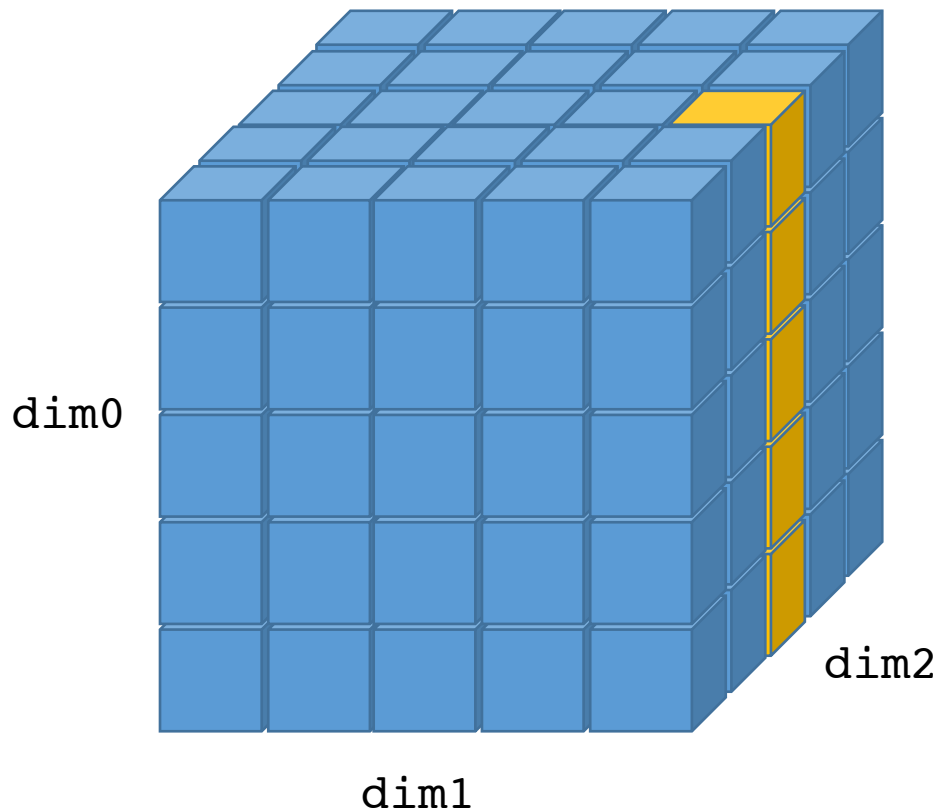


```
X = np.ones((5,5,5))  
A = X[1, :, :]  
B = X[:, 2, :]
```

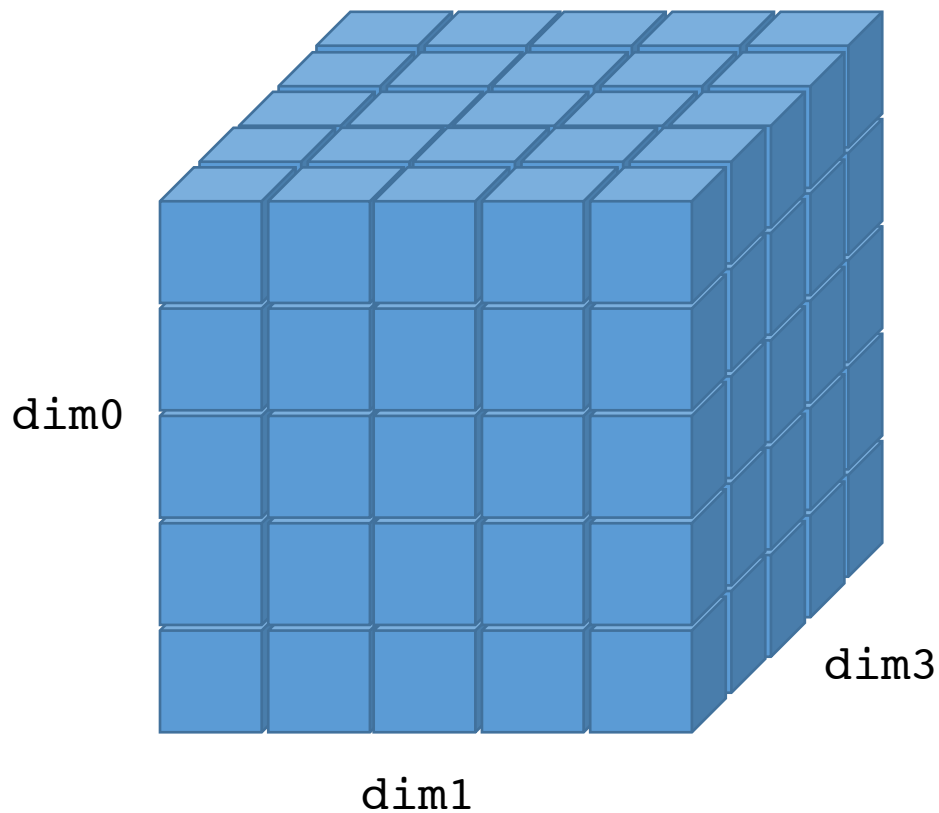
dim0



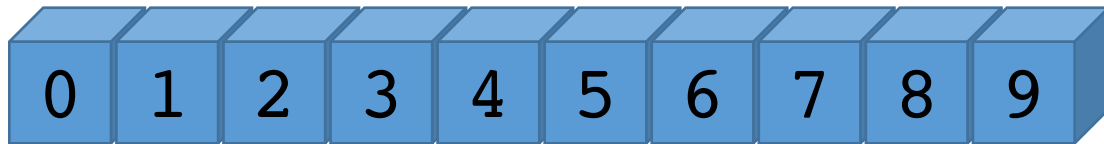
```
X = np.ones((5,5,5))  
A = X[1, :, :]  
B = X[:, 2, :]  
C = X[:, 4, 2]
```



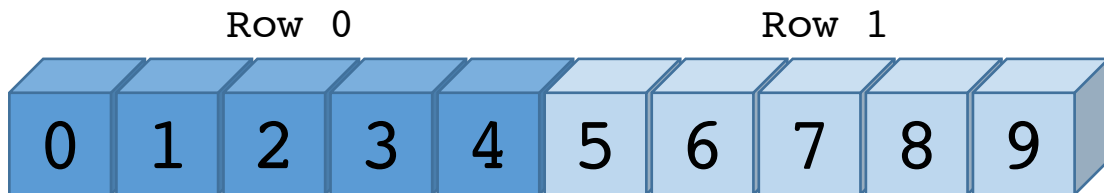

```
X = np.ones((5,5,5))  
A = X[1, :, :]  
B = X[:, 2, :]  
C = X[:, 4, 2]
```



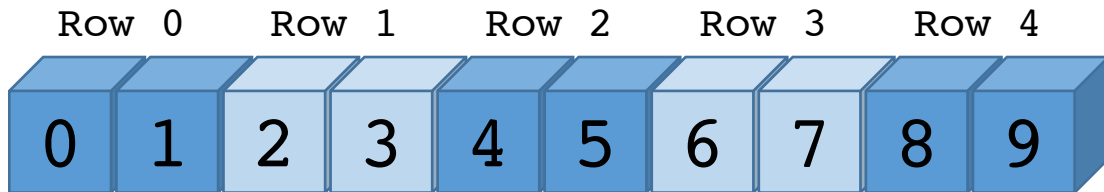
```
X = np.ones(10)
```



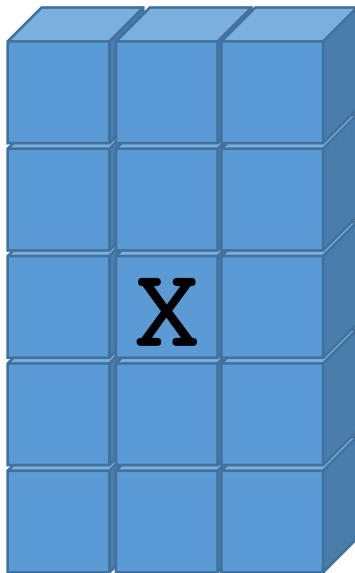
```
X.reshape((2,5))
```



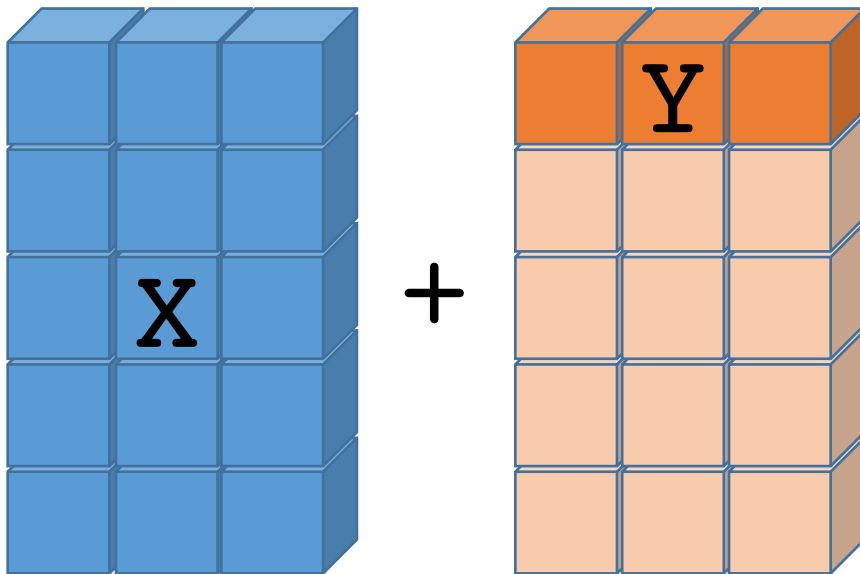
```
X.reshape((5,2))
```



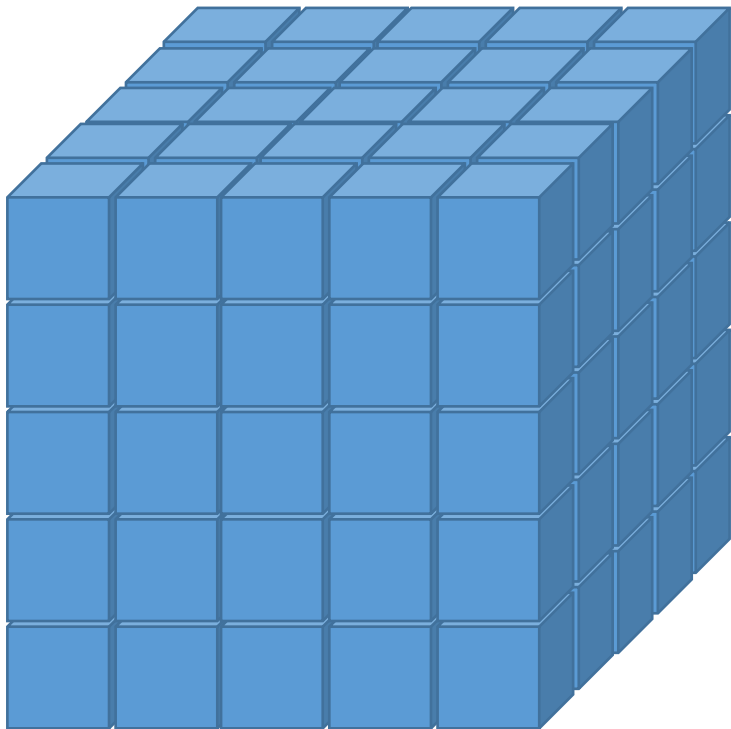
```
X = np.ones((5,3))  
Y = np.ones(3)
```



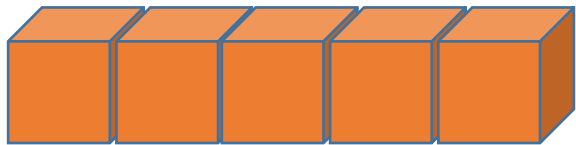

```
X = np.ones((5,3))  
Y = np.ones(3)  
Z = X + Y
```



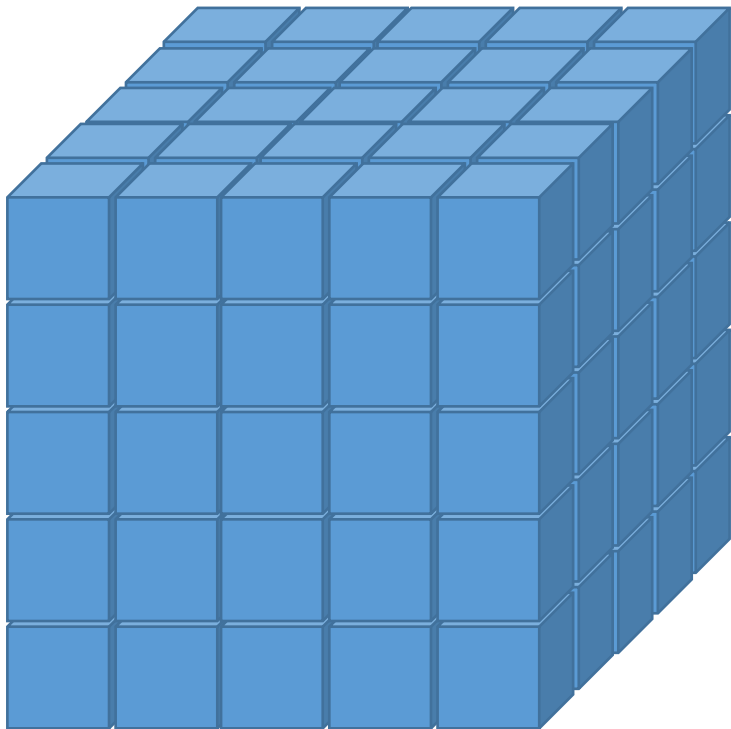
```
X = np.ones((5,5,5))
```



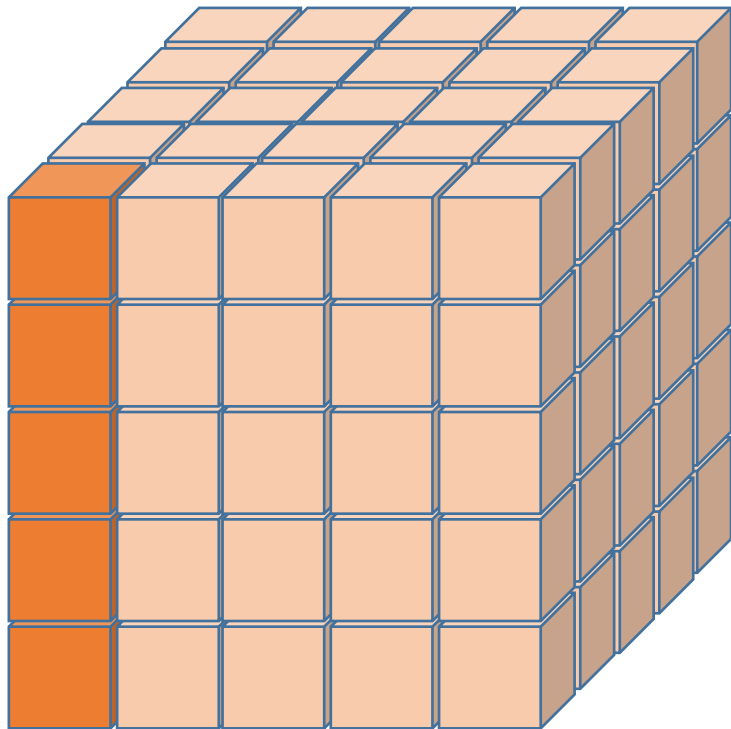
```
Y = np.ones(5)
```



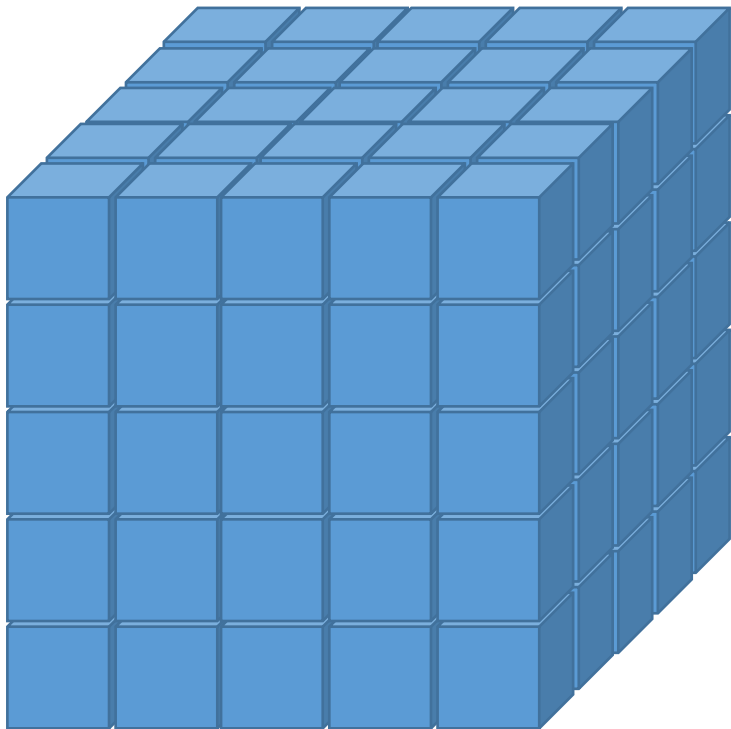
`Z = X + Y.reshape((5,1,1))`



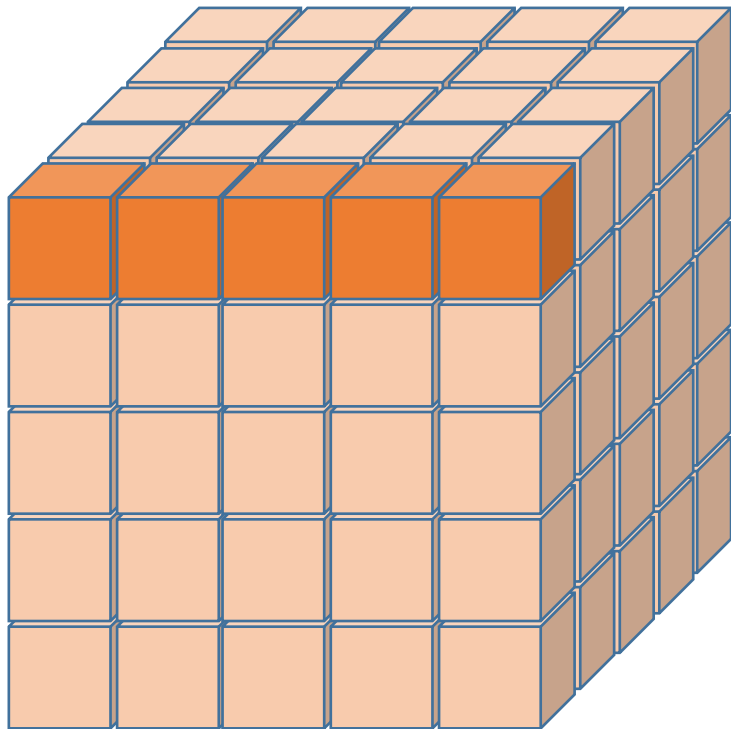
+



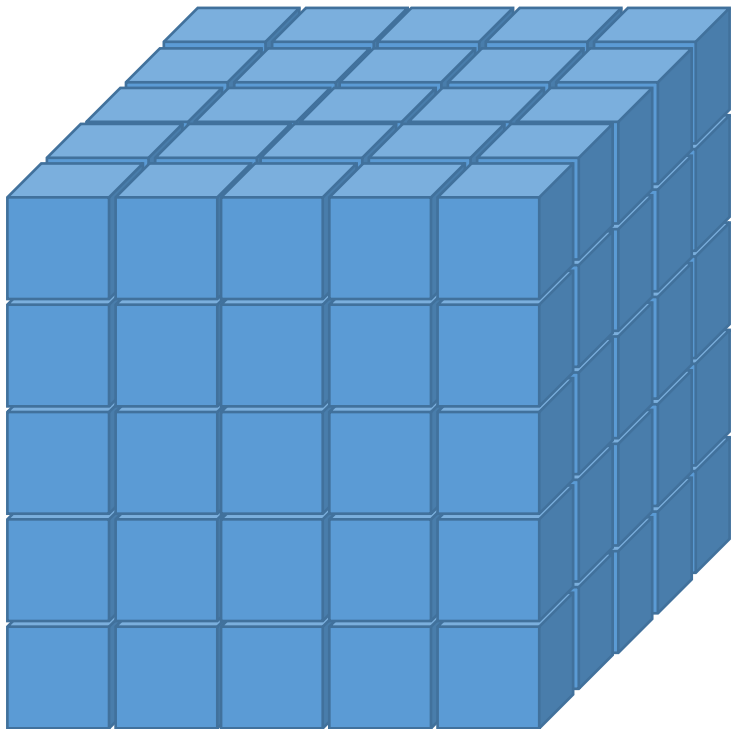
`Z = X + Y.reshape((1,5,1))`



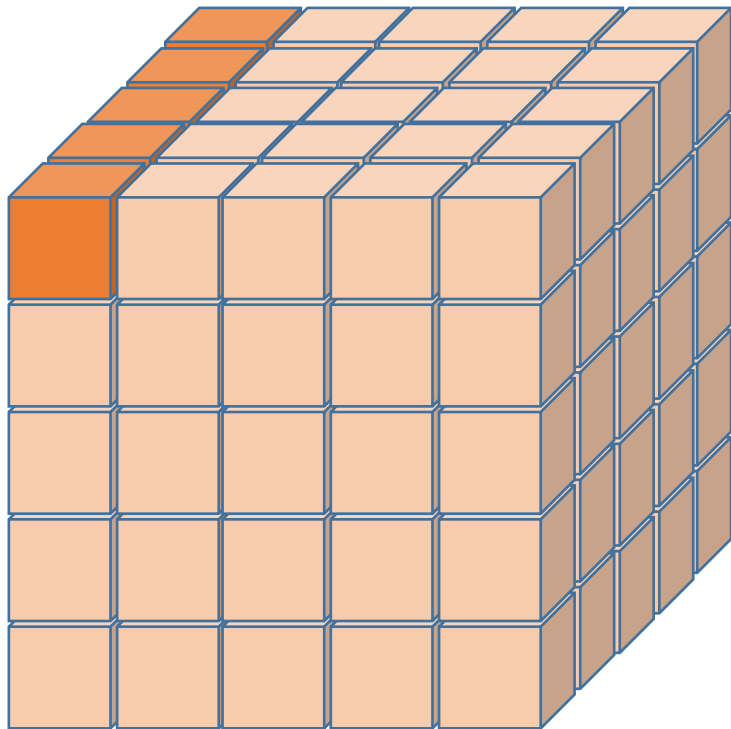
+



`Z = X + Y.reshape((1,1,5))`



+



axis 1

axis 0

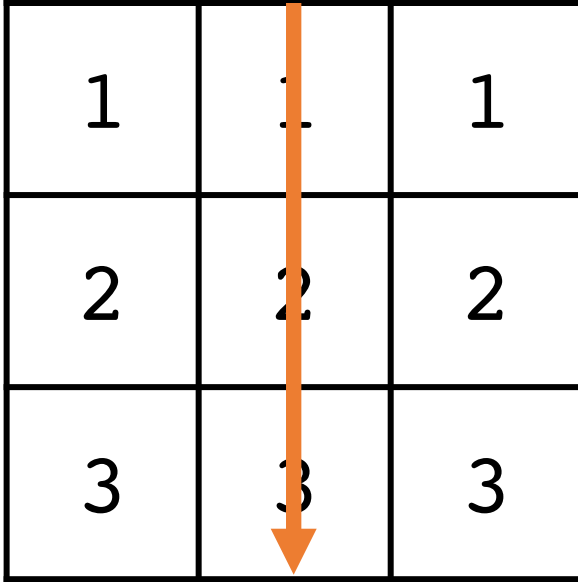
1	1	1
2	2	2
3	3	3

`X.sum(axis = 0)`

axis 1

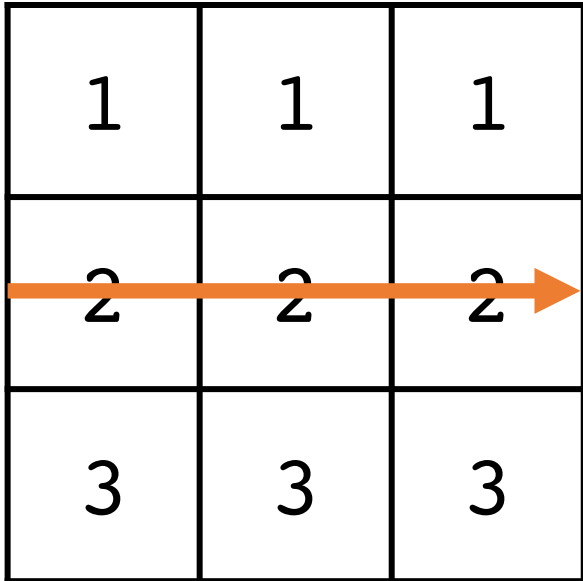
axis 0

1	1	1
2	2	2
3	3	3
6	6	6

A 3x3 grid of numbers. The first column contains 1, 2, 3. The second column contains 1, 2, 3. The third column contains 1, 2, 3. Below the grid, the sum of each column is calculated: 6, 6, 6. An orange arrow points downwards along the second column, indicating the axis of summation.

`X.sum(axis = 1)`

axis 1				
axis 0	1	1	1	3
	2	2	2	6
	3	3	3	9



A

B

C

\times

$=$

A

A_{00}	A_{01}
A_{10}	A_{11}

\times

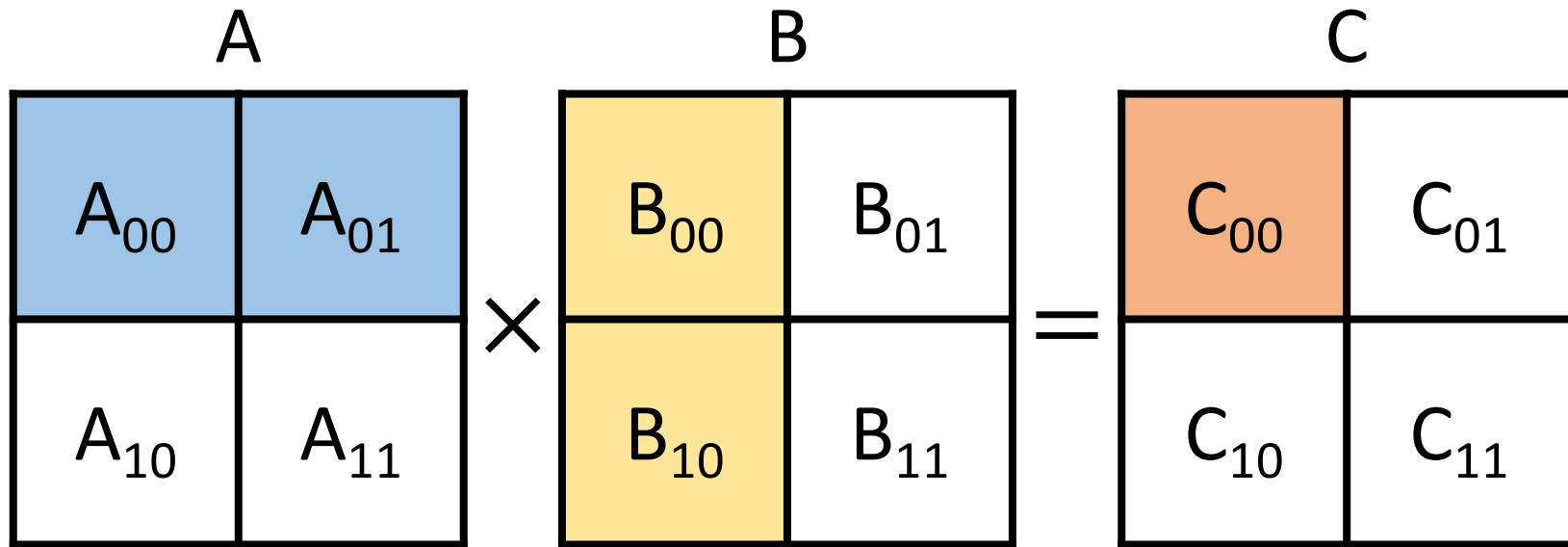
B

B_{00}	B_{01}
B_{10}	B_{11}

$=$

C

C_{00}	C_{01}
C_{10}	C_{11}



$$C_{00} = A_{00}B_{00} + A_{01}B_{10}$$

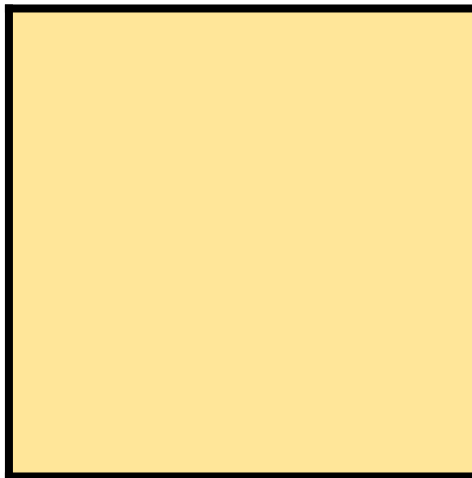
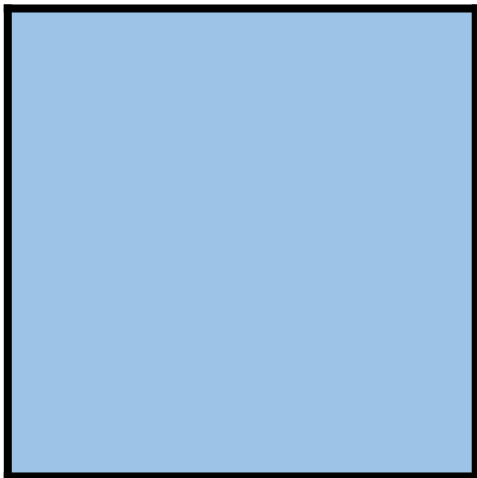
A_{00}

B_{00}

C'

\times

$=$



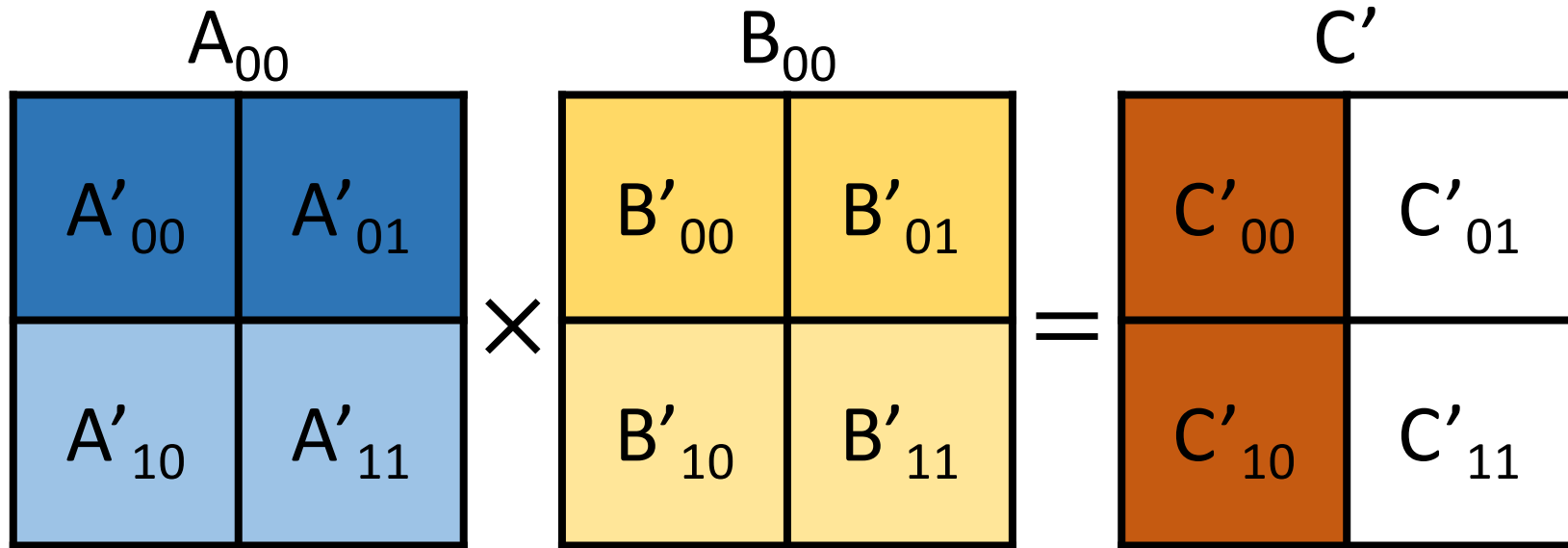
$$\begin{array}{|c|c|} \hline A'_{00} & A'_{01} \\ \hline A'_{10} & A'_{11} \\ \hline \end{array} \times \begin{array}{|c|c|} \hline B'_{00} & B'_{01} \\ \hline B'_{10} & B'_{11} \\ \hline \end{array} = \begin{array}{|c|c|} \hline C'_{00} & C'_{01} \\ \hline C'_{10} & C'_{11} \\ \hline \end{array}$$

Diagram illustrating the multiplication of two 2x2 matrices, A' and B' , resulting in matrix C' .

Matrix A' (blue) is labeled A_{00} above it. Its elements are A'_{00} , A'_{01} , A'_{10} , and A'_{11} .

Matrix B' (yellow) is labeled B_{00} above it. Its elements are B'_{00} , B'_{01} , B'_{10} , and B'_{11} .

The result matrix C' (white) is labeled C' above it. Its elements are C'_{00} , C'_{01} , C'_{10} , and C'_{11} .

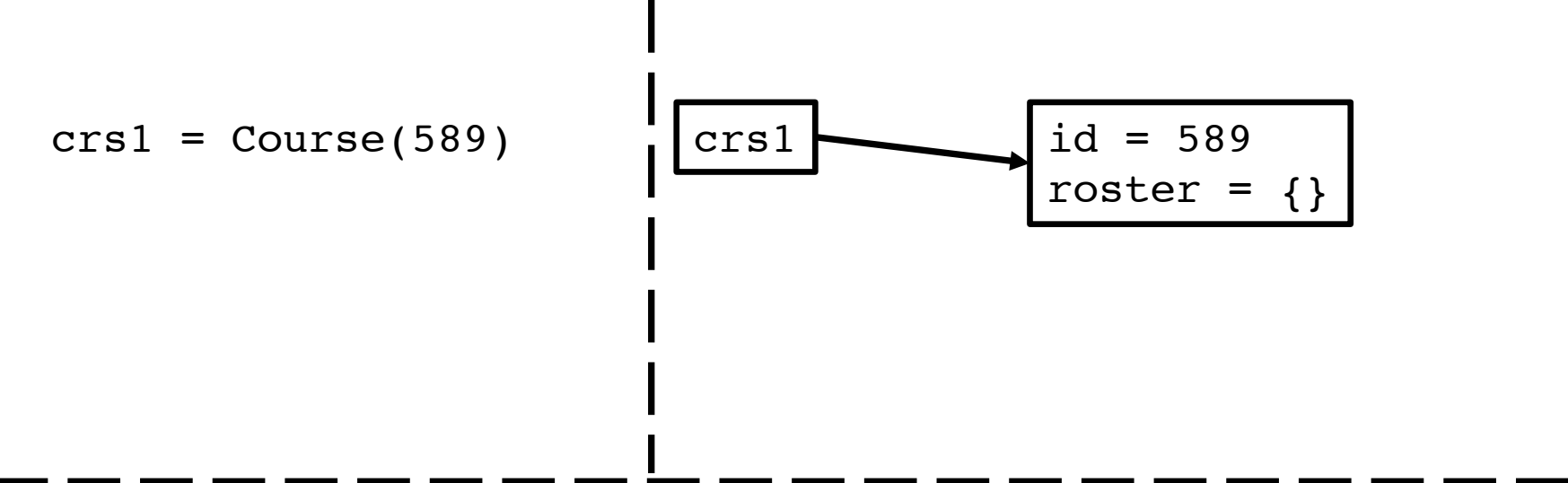


$$C'_{00} = A'_{00}B'_{00} + A'_{01}B'_{10}$$

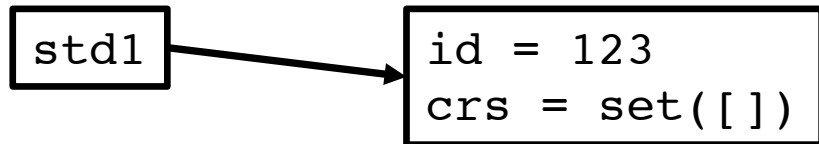
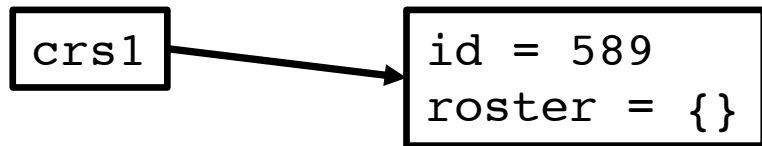
```
crs1 = Course(589)
```

crs1

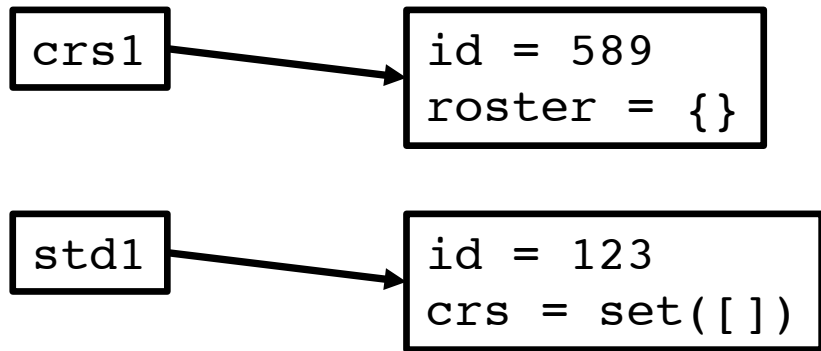
id = 589
roster = {}



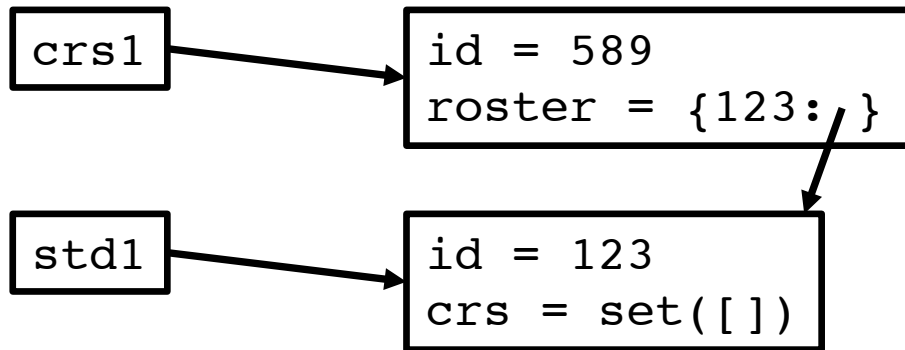
```
crs1 = Course(589)
std1 = Student(123)
```




```
crs1 = Course(589)
sdt1 = Student(123)
crs1.add_student(sdt1)
```

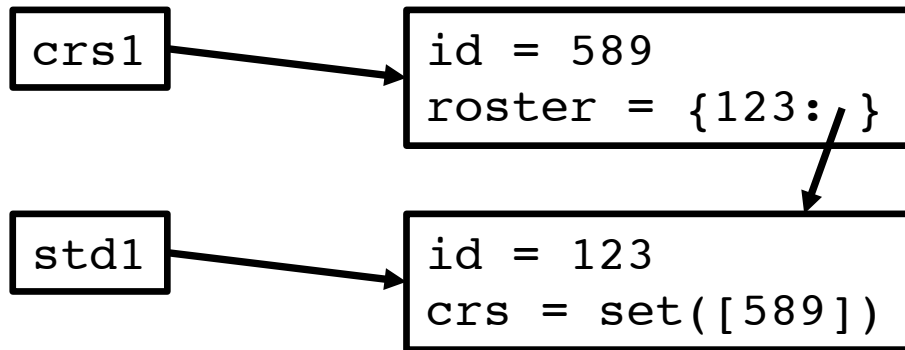


```
crs1 = Course(589)
sdt1 = Student(123)
crs1.add_student(sdt1)
```



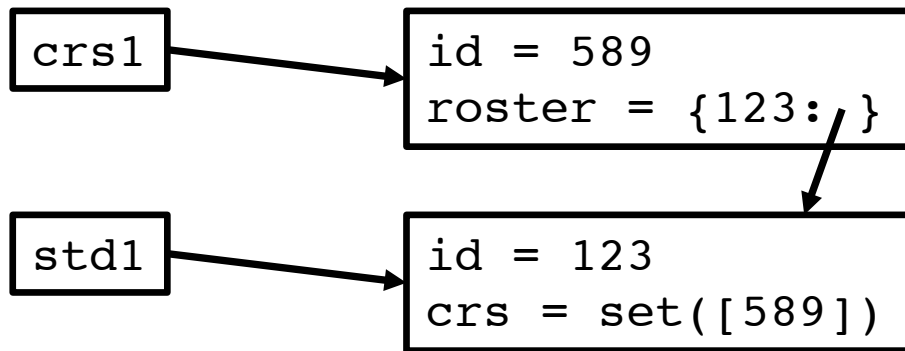
```
self.roster[student.id] = student
```

```
crs1 = Course(589)
sdt1 = Student(123)
crs1.add_student(sdt1)
```

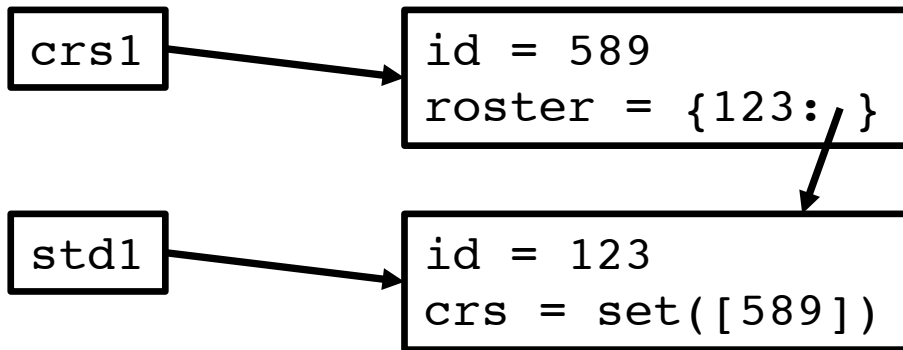


```
self.roster[student.id] = student
student.roster.add(self.id)
```

```
crs1 = Course(589)
sdt1 = Student(123)
crs1.add_student(sdt1)
crs1.drop_student(123)
```

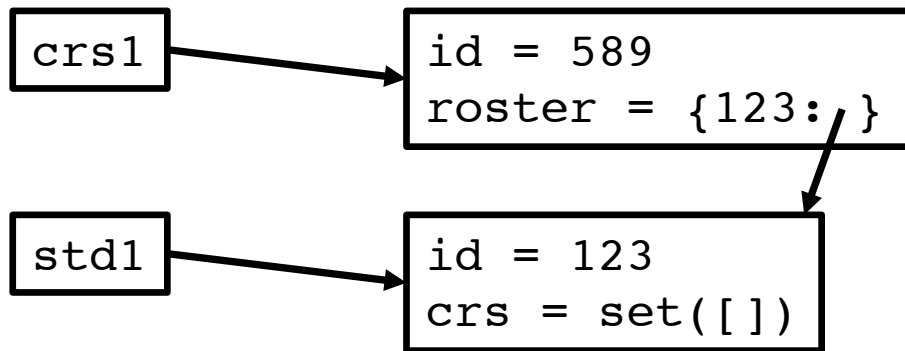


```
crs1 = Course(589)
sdt1 = Student(123)
crs1.add_student(sdt1)
crs1.drop_student(123)
```



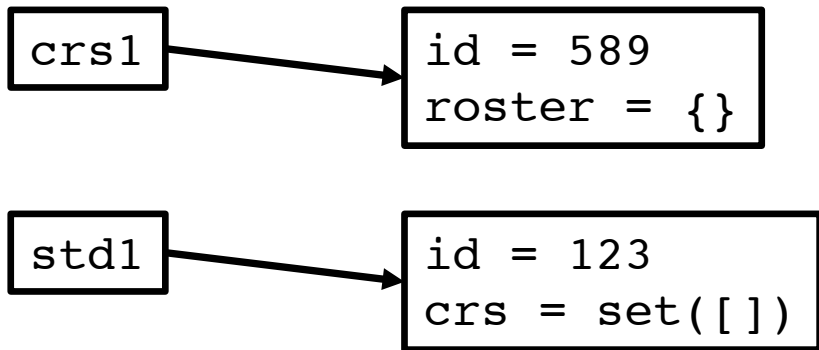
```
student = self.roster[student_id]
```

```
crs1 = Course(589)
sdt1 = Student(123)
crs1.add_student(sdt1)
crs1.drop_student(123)
```



```
student = self.roster[student_id]
student.crs.remove(self.id)
```

```
crs1 = Course(589)
sdt1 = Student(123)
crs1.add_student(sdt1)
crs1.drop_student(123)
```



```
student = self.roster[student_id]
student.crs.remove(self.id)
del self.roster[student_id]
```

$$\begin{bmatrix} 1 & 0 & 2 \\ 0 & 0 & 3 \\ 4 & 5 & 0 \end{bmatrix}$$

indptr:

$[0, 2, 3, 5]$

indices:

$[0, 2, 2, 0, 1]$

data:

$[1, 2, 3, 4, 5]$

$$\begin{bmatrix} 1 & 0 & 2 \\ 0 & 0 & 3 \\ 4 & 5 & 0 \end{bmatrix}$$

`row = A[i,:]`

`indptr:`

`[0, 2, 3, 5]`

`indices:`

`[0, 2, 2, 0, 1]`

`data:`

`[1, 2, 3, 4, 5]`

1	0	2
0	0	3
4	5	0

```
row = A[i,:]
      ↓
s=indptr[i]
e=indptr[i+1]
```

indptr: s e
 ↓ ↓
[0, 2, 3, 5]

indices:
[0, 2, 2, 0, 1]

data:
[1, 2, 3, 4, 5]

$$\begin{bmatrix} 1 & 0 & 2 \\ 0 & 0 & 3 \\ 4 & 5 & 0 \end{bmatrix}$$

```
row = A[i,:]
      ↓
s=indptr[i]
e=indptr[i+1]
row=data[s:e]
```

indptr: s e
 ↓ ↓
[0, 2, 3, 5]

indices:
[0, 2, 2, 0, 1]

data:
[1, 2, 3, 4, 5]