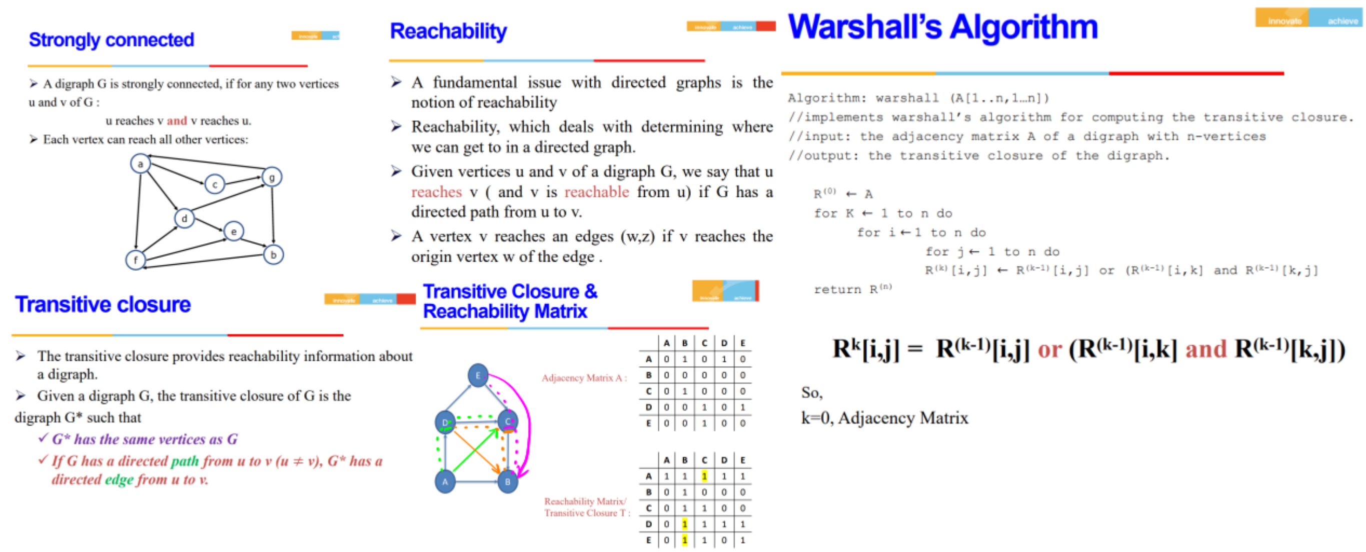


	A	B	C	D	E
A	0	1	0	1	0
B	0	0	0	0	0
C	0	1	0	0	0
D	0	0	1	0	1
E	0	0	1	0	0

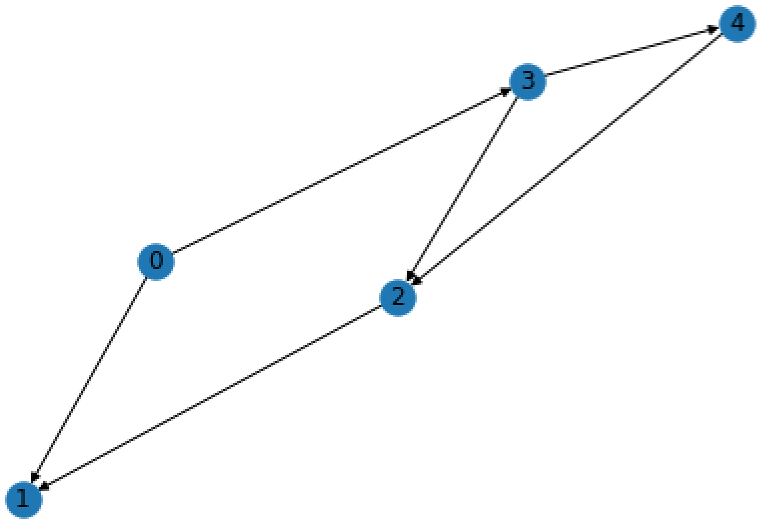
	A	B	C	D	E
A	1	1	1	1	1
B	0	1	0	0	0
C	0	1	1	0	0
D	0	1	1	1	1
E	0	1	1	0	1

In [3]:

```
try:import networkx as nx
except:
    !pip install networkx
    import networkx as nx

try:import matplotlib.pyplot as plt
except:
    !pip install matplotlib
    import matplotlib.pyplot as plt

try:from prettytable import PrettyTable
except:
    !pip install prettytable
    from prettytable import PrettyTable

adm = [[0,1,0,1,0],
       [0,0,0,0,0],
       [0,1,0,0,0],
       [0,0,1,0,1],
       [0,0,1,0,0]
      ]
x = PrettyTable()
x.field_names = [''] + [chr(65+i) for i in range(len(adm))]
i=0
for r in adm:
    x.add_row([chr(65+i)]+r)
    i+=1
print(x)

G = nx.DiGraph()
for i in range(len(adm)):
    for j in range( len(adm) ):
        if adm[i][j] == 1: G.add_edge(i,j)

nx.draw( G ,with_labels=True)
plt.show()
```

```
+---+---+---+---+---+---+
|   | A | B | C | D | E |
+---+---+---+---+---+---+
| A | 0 | 1 | 0 | 1 | 0 |
| B | 0 | 0 | 0 | 0 | 0 |
| C | 0 | 1 | 0 | 0 | 0 |
| D | 0 | 0 | 1 | 0 | 1 |
```

```
| E | 0 | 0 | 1 | 0 | 0 |
+---+---+---+---+---+---+
```



In [16]:

```python
from pprint import pprint
from IPython.display import display, Math
superscript = str.maketrans("0123456789", "⁰¹²³⁴⁵⁶⁷⁸⁹")
def warshall(adm):
    R = adm
    ll = len(adm)
    for k in range(ll):
        #R.append(adm)
        print('for k = {}'.format(k+1))
        for i in range(ll):
            print('for i = {}'.format(i+1))
            for j in range(ll):
                prevRij = R[i][j]
                R[i][j] = R[i][j] or (R[i][k] and R[k][j])
                display(Math("R^#{}@[{},{}] = R^#{}@[{},{}]  or  (R^#{}@[{},{}]  and  R^#
                      .format(k+1,i+1,j+1,k,i+1,j+1,k,i+1,k+1,k,k+1,j+1).replace('#','{').
                             '{} or ( {} and {} ) = '.format(prevRij,R[i][k],R[k][j]) + '

            print('-'*10)
        x = PrettyTable()
        x.field_names = ['R{}'.format(k+1).translate(superscript)] + [chr(65+i) for i in r
        i=0
        for r in R:
            x.add_row([chr(65+i)]+r)
            i+=1
        print(x)
        print('-'*20)
```

In [17]:

```python
warshall(adm)
```

```
for k = 1
for i = 1
```

$$R^1[1,1] = R^0[1,1] or (R^0[1,1] and R^0[1,1]) = 0 or (0 and 0) = 0$$

$$R^1[1,2] = R^0[1,2] or (R^0[1,1] and R^0[1,2]) = 1 or (0 and 1) = 1$$

$$R^1[1,3] = R^0[1,3] or (R^0[1,1] and R^0[1,3]) = 0 or (0 and 0) = 0$$

$$R^1[1,4] = R^0[1,4] or (R^0[1,1] and R^0[1,4]) = 1 or (0 and 1) = 1$$

$$R^1[1,5] = R^0[1,5] or (R^0[1,1] and R^0[1,5]) = 0 or (0 and 0) = 0$$

----
for i = 2

$$R^1[2,1] = R^0[2,1] or (R^0[2,1] and R^0[1,1]) = 0 or (0 and 0) = 0$$

$$R^1[2,2] = R^0[2,2] or (R^0[2,1] and R^0[1,2]) = 0 or (0 and 1) = 0$$

$$R^1[2,3] = R^0[2,3] or (R^0[2,1] and R^0[1,3]) = 0 or (0 and 0) = 0$$

$$R^1[2,4] = R^0[2,4] or (R^0[2,1] and R^0[1,4]) = 0 or (0 and 1) = 0$$

$$R^1[2,5] = R^0[2,5] or (R^0[2,1] and R^0[1,5]) = 0 or (0 and 0) = 0$$

----
for i = 3

$$R^1[3,1] = R^0[3,1] or (R^0[3,1] and R^0[1,1]) = 0 or (0 and 0) = 0$$

$$R^1[3,2] = R^0[3,2] or (R^0[3,1] and R^0[1,2]) = 1 or (0 and 1) = 1$$

$$R^1[3,3] = R^0[3,3] or (R^0[3,1] and R^0[1,3]) = 0 or (0 and 0) = 0$$

$$R^1[3,4] = R^0[3,4] or (R^0[3,1] and R^0[1,4]) = 0 or (0 and 1) = 0$$

$$R^1[3,5] = R^0[3,5] or (R^0[3,1] and R^0[1,5]) = 0 or (0 and 0) = 0$$

----
for i = 4

$$R^1[4,1] = R^0[4,1] or (R^0[4,1] and R^0[1,1]) = 0 or (0 and 0) = 0$$

$$R^1[4,2] = R^0[4,2] or (R^0[4,1] and R^0[1,2]) = 0 or (0 and 1) = 0$$

$$R^1[4,3] = R^0[4,3] or (R^0[4,1] and R^0[1,3]) = 1 or (0 and 0) = 1$$

$$R^1[4,4] = R^0[4,4] or (R^0[4,1] and R^0[1,4]) = 0 or (0 and 1) = 0$$

$$R^1[4,5] = R^0[4,5] or (R^0[4,1] and R^0[1,5]) = 1 or (0 and 0) = 1$$

----
for i = 5

$$R^1[5,1] = R^0[5,1] or (R^0[5,1] and R^0[1,1]) = 0 or (0 and 0) = 0$$

$$R^1[5,2] = R^0[5,2] or (R^0[5,1] and R^0[1,2]) = 0 or (0 and 1) = 0$$

$$R^1[5,3] = R^0[5,3] or (R^0[5,1] and R^0[1,3]) = 1 or (0 and 0) = 1$$

$$R^1[5,4] = R^0[5,4] or (R^0[5,1] and R^0[1,4]) = 0 or (0 and 1) = 0$$

$$R^1[5,5] = R^0[5,5] or (R^0[5,1] and R^0[1,5]) = 0 or (0 and 0) = 0$$

R^1	A	B	C	D	E
A	0	1	0	1	0
B	0	0	0	0	0
C	0	1	0	0	0
D	0	0	1	0	1
E	0	0	1	0	0

----
for k = 2
for i = 1

$$R^2[1,1] = R^1[1,1] or (R^1[1,2] and R^1[2,1]) = 0 or (1 and 0) = 0$$

$$R^2[1,2] = R^1[1,2] or (R^1[1,2] and R^1[2,2]) = 1 or (1 and 0) = 1$$

$$R^2[1,3] = R^1[1,3]or(R^1[1,2]andR^1[2,3]) = 0or(1and0) = 0$$

$$R^2[1,4] = R^1[1,4]or(R^1[1,2]andR^1[2,4]) = 1or(1and0) = 1$$

$$R^2[1,5] = R^1[1,5]or(R^1[1,2]andR^1[2,5]) = 0or(1and0) = 0$$

----

for i = 2

$$R^2[2,1] = R^1[2,1]or(R^1[2,2]andR^1[2,1]) = 0or(0and0) = 0$$

$$R^2[2,2] = R^1[2,2]or(R^1[2,2]andR^1[2,2]) = 0or(0and0) = 0$$

$$R^2[2,3] = R^1[2,3]or(R^1[2,2]andR^1[2,3]) = 0or(0and0) = 0$$

$$R^2[2,4] = R^1[2,4]or(R^1[2,2]andR^1[2,4]) = 0or(0and0) = 0$$

$$R^2[2,5] = R^1[2,5]or(R^1[2,2]andR^1[2,5]) = 0or(0and0) = 0$$

----

for i = 3

$$R^2[3,1] = R^1[3,1]or(R^1[3,2]andR^1[2,1]) = 0or(1and0) = 0$$

$$R^2[3,2] = R^1[3,2]or(R^1[3,2]andR^1[2,2]) = 1or(1and0) = 1$$

$$R^2[3,3] = R^1[3,3]or(R^1[3,2]andR^1[2,3]) = 0or(1and0) = 0$$

$$R^2[3,4] = R^1[3,4]or(R^1[3,2]andR^1[2,4]) = 0or(1and0) = 0$$

$$R^2[3,5] = R^1[3,5]or(R^1[3,2]andR^1[2,5]) = 0or(1and0) = 0$$

----

for i = 4

$$R^2[4,1] = R^1[4,1]or(R^1[4,2]andR^1[2,1]) = 0or(0and0) = 0$$

$$R^2[4,2] = R^1[4,2]or(R^1[4,2]andR^1[2,2]) = 0or(0and0) = 0$$

$$R^2[4,3] = R^1[4,3]or(R^1[4,2]andR^1[2,3]) = 1or(0and0) = 1$$

$$R^2[4,4] = R^1[4,4]or(R^1[4,2]andR^1[2,4]) = 0or(0and0) = 0$$

$$R^2[4,5] = R^1[4,5]or(R^1[4,2]andR^1[2,5]) = 1or(0and0) = 1$$

----

for i = 5

$$R^2[5,1] = R^1[5,1]or(R^1[5,2]andR^1[2,1]) = 0or(0and0) = 0$$

$$R^2[5,2] = R^1[5,2]or(R^1[5,2]andR^1[2,2]) = 0or(0and0) = 0$$

$$R^2[5,3] = R^1[5,3]or(R^1[5,2]andR^1[2,3]) = 1or(0and0) = 1$$

$$R^2[5,4] = R^1[5,4]or(R^1[5,2]andR^1[2,4]) = 0or(0and0) = 0$$

$$R^2[5,5] = R^1[5,5]or(R^1[5,2]andR^1[2,5]) = 0or(0and0) = 0$$

R^2	A	B	C	D	E
A	0	1	0	1	0
B	0	0	0	0	0
C	0	1	0	0	0
D	0	0	1	0	1
E	0	0	1	0	0

----

for k = 3

for i = 1

$$R^3[1,1] = R^2[1,1]or(R^2[1,3]andR^2[3,1]) = 0or(0and0) = 0$$

$$R^3[1,2] = R^2[1,2]or(R^2[1,3]andR^2[3,2]) = 1or(0and1) = 1$$

$$R^3[1,3] = R^2[1,3]or(R^2[1,3]andR^2[3,3]) = 0or(0and0) = 0$$

$$R^3[1,4] = R^2[1,4]or(R^2[1,3]andR^2[3,4]) = 1or(0and0) = 1$$

$$R^3[1,5] = R^2[1,5]or(R^2[1,3]andR^2[3,5]) = 0or(0and0) = 0$$

----

for i = 2

$$R^3[2,1] = R^2[2,1]or(R^2[2,3]andR^2[3,1]) = 0or(0and0) = 0$$

$$R^3[2,2] = R^2[2,2]or(R^2[2,3]andR^2[3,2]) = 0or(0and1) = 0$$

$$R^3[2,3] = R^2[2,3]or(R^2[2,3]andR^2[3,3]) = 0or(0and0) = 0$$

$$R^3[2,4] = R^2[2,4]or(R^2[2,3]andR^2[3,4]) = 0or(0and0) = 0$$

$$R^3[2,5] = R^2[2,5]or(R^2[2,3]andR^2[3,5]) = 0or(0and0) = 0$$

----

for i = 3

$$R^3[3,1] = R^2[3,1]or(R^2[3,3]andR^2[3,1]) = 0or(0and0) = 0$$

$$R^3[3,2] = R^2[3,2]or(R^2[3,3]andR^2[3,2]) = 1or(0and1) = 1$$

$$R^3[3,3] = R^2[3,3]or(R^2[3,3]andR^2[3,3]) = 0or(0and0) = 0$$

$$R^3[3,4] = R^2[3,4]or(R^2[3,3]andR^2[3,4]) = 0or(0and0) = 0$$

$$R^3[3,5] = R^2[3,5]or(R^2[3,3]andR^2[3,5]) = 0or(0and0) = 0$$

----

for i = 4

$$R^3[4,1] = R^2[4,1]or(R^2[4,3]andR^2[3,1]) = 0or(1and0) = 0$$

$$R^3[4,2] = R^2[4,2]or(R^2[4,3]andR^2[3,2]) = 0or(1and1) = 1$$

$$R^3[4,3] = R^2[4,3]or(R^2[4,3]andR^2[3,3]) = 1or(1and0) = 1$$

$$R^3[4,4] = R^2[4,4]or(R^2[4,3]andR^2[3,4]) = 0or(1and0) = 0$$

$$R^3[4,5] = R^2[4,5]or(R^2[4,3]andR^2[3,5]) = 1or(1and0) = 1$$

----

for i = 5

$$R^3[5,1] = R^2[5,1]or(R^2[5,3]andR^2[3,1]) = 0or(1and0) = 0$$

$$R^3[5,2] = R^2[5,2]or(R^2[5,3]andR^2[3,2]) = 0or(1and1) = 1$$

$$R^3[5,3] = R^2[5,3]or(R^2[5,3]andR^2[3,3]) = 1or(1and0) = 1$$

$$R^3[5,4] = R^2[5,4]or(R^2[5,3]andR^2[3,4]) = 0or(1and0) = 0$$

$$R^3[5,5] = R^2[5,5]or(R^2[5,3]andR^2[3,5]) = 0or(1and0) = 0$$

R^3	A	B	C	D	E
A	0	1	0	1	0
B	0	0	0	0	0

```
| C  | 0 | 1 | 0 | 0 | 0 |
| D  | 0 | 1 | 1 | 0 | 1 |
| E  | 0 | 1 | 1 | 0 | 0 |
+----+---+---+---+---+---+
--------------------
for k = 4
for i = 1
```

$$R^4[1,1] = R^3[1,1] or (R^3[1,4] and R^3[4,1]) = 0 or (1 and 0) = 0$$

$$R^4[1,2] = R^3[1,2] or (R^3[1,4] and R^3[4,2]) = 1 or (1 and 1) = 1$$

$$R^4[1,3] = R^3[1,3] or (R^3[1,4] and R^3[4,3]) = 0 or (1 and 1) = 1$$

$$R^4[1,4] = R^3[1,4] or (R^3[1,4] and R^3[4,4]) = 1 or (1 and 0) = 1$$

$$R^4[1,5] = R^3[1,5] or (R^3[1,4] and R^3[4,5]) = 0 or (1 and 1) = 1$$

```
----------
for i = 2
```

$$R^4[2,1] = R^3[2,1] or (R^3[2,4] and R^3[4,1]) = 0 or (0 and 0) = 0$$

$$R^4[2,2] = R^3[2,2] or (R^3[2,4] and R^3[4,2]) = 0 or (0 and 1) = 0$$

$$R^4[2,3] = R^3[2,3] or (R^3[2,4] and R^3[4,3]) = 0 or (0 and 1) = 0$$

$$R^4[2,4] = R^3[2,4] or (R^3[2,4] and R^3[4,4]) = 0 or (0 and 0) = 0$$

$$R^4[2,5] = R^3[2,5] or (R^3[2,4] and R^3[4,5]) = 0 or (0 and 1) = 0$$

```
----------
for i = 3
```

$$R^4[3,1] = R^3[3,1] or (R^3[3,4] and R^3[4,1]) = 0 or (0 and 0) = 0$$

$$R^4[3,2] = R^3[3,2] or (R^3[3,4] and R^3[4,2]) = 1 or (0 and 1) = 1$$

$$R^4[3,3] = R^3[3,3] or (R^3[3,4] and R^3[4,3]) = 0 or (0 and 1) = 0$$

$$R^4[3,4] = R^3[3,4] or (R^3[3,4] and R^3[4,4]) = 0 or (0 and 0) = 0$$

$$R^4[3,5] = R^3[3,5] or (R^3[3,4] and R^3[4,5]) = 0 or (0 and 1) = 0$$

```
----------
for i = 4
```

$$R^4[4,1] = R^3[4,1] or (R^3[4,4] and R^3[4,1]) = 0 or (0 and 0) = 0$$

$$R^4[4,2] = R^3[4,2] or (R^3[4,4] and R^3[4,2]) = 1 or (0 and 1) = 1$$

$$R^4[4,3] = R^3[4,3] or (R^3[4,4] and R^3[4,3]) = 1 or (0 and 1) = 1$$

$$R^4[4,4] = R^3[4,4] or (R^3[4,4] and R^3[4,4]) = 0 or (0 and 0) = 0$$

$$R^4[4,5] = R^3[4,5] or (R^3[4,4] and R^3[4,5]) = 1 or (0 and 1) = 1$$

```
----------
for i = 5
```

$$R^4[5,1] = R^3[5,1] or (R^3[5,4] and R^3[4,1]) = 0 or (0 and 0) = 0$$

$$R^4[5,2] = R^3[5,2] or (R^3[5,4] and R^3[4,2]) = 1 or (0 and 1) = 1$$

$$R^4[5,3] = R^3[5,3] or (R^3[5,4] and R^3[4,3]) = 1 or (0 and 1) = 1$$

$$R^4[5,4] = R^3[5,4] or (R^3[5,4] and R^3[4,4]) = 0 or (0 and 0) = 0$$

$$R^4[5,5] = R^3[5,5] or (R^3[5,4] and R^3[4,5]) = 0 or (0 and 1) = 0$$

```
----------
```

R^4	A	B	C	D	E
A	0	1	1	1	1
B	0	0	0	0	0
C	0	1	0	0	0
D	0	1	1	0	1
E	0	1	1	0	0

----

for k = 5
for i = 1

$$R^5[1,1] = R^4[1,1] or (R^4[1,5] and R^4[5,1]) = 0 or (1 and 0) = 0$$

$$R^5[1,2] = R^4[1,2] or (R^4[1,5] and R^4[5,2]) = 1 or (1 and 1) = 1$$

$$R^5[1,3] = R^4[1,3] or (R^4[1,5] and R^4[5,3]) = 1 or (1 and 1) = 1$$

$$R^5[1,4] = R^4[1,4] or (R^4[1,5] and R^4[5,4]) = 1 or (1 and 0) = 1$$

$$R^5[1,5] = R^4[1,5] or (R^4[1,5] and R^4[5,5]) = 1 or (1 and 0) = 1$$

----

for i = 2

$$R^5[2,1] = R^4[2,1] or (R^4[2,5] and R^4[5,1]) = 0 or (0 and 0) = 0$$

$$R^5[2,2] = R^4[2,2] or (R^4[2,5] and R^4[5,2]) = 0 or (0 and 1) = 0$$

$$R^5[2,3] = R^4[2,3] or (R^4[2,5] and R^4[5,3]) = 0 or (0 and 1) = 0$$

$$R^5[2,4] = R^4[2,4] or (R^4[2,5] and R^4[5,4]) = 0 or (0 and 0) = 0$$

$$R^5[2,5] = R^4[2,5] or (R^4[2,5] and R^4[5,5]) = 0 or (0 and 0) = 0$$

----

for i = 3

$$R^5[3,1] = R^4[3,1] or (R^4[3,5] and R^4[5,1]) = 0 or (0 and 0) = 0$$

$$R^5[3,2] = R^4[3,2] or (R^4[3,5] and R^4[5,2]) = 1 or (0 and 1) = 1$$

$$R^5[3,3] = R^4[3,3] or (R^4[3,5] and R^4[5,3]) = 0 or (0 and 1) = 0$$

$$R^5[3,4] = R^4[3,4] or (R^4[3,5] and R^4[5,4]) = 0 or (0 and 0) = 0$$

$$R^5[3,5] = R^4[3,5] or (R^4[3,5] and R^4[5,5]) = 0 or (0 and 0) = 0$$

----

for i = 4

$$R^5[4,1] = R^4[4,1] or (R^4[4,5] and R^4[5,1]) = 0 or (1 and 0) = 0$$

$$R^5[4,2] = R^4[4,2] or (R^4[4,5] and R^4[5,2]) = 1 or (1 and 1) = 1$$

$$R^5[4,3] = R^4[4,3] or (R^4[4,5] and R^4[5,3]) = 1 or (1 and 1) = 1$$

$$R^5[4,4] = R^4[4,4] or (R^4[4,5] and R^4[5,4]) = 0 or (1 and 0) = 0$$

$$R^5[4,5] = R^4[4,5] or (R^4[4,5] and R^4[5,5]) = 1 or (1 and 0) = 1$$

----

for i = 5

$$R^5[5,1] = R^4[5,1] or (R^4[5,5] and R^4[5,1]) = 0 or (0 and 0) = 0$$

$$R^5[5,2] = R^4[5,2] or (R^4[5,5] and R^4[5,2]) = 1 or (0 and 1) = 1$$

$$R^5[5,3] = R^4[5,3] or (R^4[5,5] and R^4[5,3]) = 1 or (0 and 1) = 1$$

$$R^5[5,4] = R^4[5,4] or (R^4[5,5] and R^4[5,4]) = 0 or (0 and 0) = 0$$

$$R^5[5,5] = R^4[5,5] or (R^4[5,5] and R^4[5,5]) = 0 or (0 and 0) = 0$$

R^5	A	B	C	D	E
A	0	1	1	1	1
B	0	0	0	0	0
C	0	1	0	0	0
D	0	1	1	0	1
E	0	1	1	0	0

----

we can mark cells with i == j as 1 i.e diagonal