

```
>>> orig = generate_random(3,2)
```

```
>>> print(orig)
```

```
[{'red': 10, 'green': 15, 'blue': 20}, {'red': 25, 'green': 30, 'blue': 35}],  
[{'red': 40, 'green': 45, 'blue': 50}, {'red': 55, 'green': 60, 'blue': 65}],  
[{'red': 70, 'green': 75, 'blue': 80}, {'red': 85, 'green': 90, 'blue': 95}]]
```

Let's show the pixel values as a table:

'red': 10, 'green': 15, 'blue': 20	'red': 25, 'green': 30, 'blue': 35
'red': 40, 'green': 45, 'blue': 50	'red': 55, 'green': 60, 'blue': 65
'red': 70, 'green': 75, 'blue': 80	'red': 85, 'green': 90, 'blue': 95

```
>>> orig2= generate_random(5,4)
```

```
>>> print(orig2)
```

```
[{'red': 217, 'green': 120, 'blue': 131}, {'red': 85, 'green': 167, 'blue': 137}, {'red': 191, 'green': 11, 'blue':  
227}, {'red': 34, 'green': 188, 'blue': 86}], [{'red': 11, 'green': 99, 'blue': 71}, {'red': 178, 'green': 239, 'blue':  
212}, {'red': 194, 'green': 216, 'blue': 166}, {'red': 139, 'green': 17, 'blue': 130}], [{'red': 167, 'green': 53,  
'blue': 131}, {'red': 150, 'green': 94, 'blue': 254}, {'red': 29, 'green': 37, 'blue': 86}, {'red': 56, 'green': 212,  
'blue': 143}], [{'red': 176, 'green': 113, 'blue': 13}, {'red': 8, 'green': 154, 'blue': 233}, {'red': 89, 'green':  
173, 'blue': 203}, {'red': 204, 'green': 122, 'blue': 182}], [{'red': 117, 'green': 39, 'blue': 232}, {'red': 210,  
'green': 254, 'blue': 121}, {'red': 193, 'green': 183, 'blue': 127}, {'red': 97, 'green': 100, 'blue': 237}]]
```

'red': 217, 'green': 120, 'blue': 131	'red': 85, 'green': 167, 'blue': 137	'red': 191, 'green': 11, 'blue': 227	'red': 34, 'green': 188, 'blue': 86
'red': 11, 'green': 99, 'blue': 71	'red': 178, 'green': 239, 'blue': 212	'red': 194, 'green': 216, 'blue': 166	'red': 139, 'green': 17, 'blue': 130
'red': 167, 'green': 53, 'blue': 131	'red': 150, 'green': 94, 'blue': 254	'red': 29, 'green': 37, 'blue': 86	'red': 56, 'green': 212, 'blue': 143
'red': 176, 'green': 113, 'blue': 13	'red': 8, 'green': 154, 'blue': 233	'red': 89, 'green': 173, 'blue': 203	'red': 204, 'green': 122, 'blue': 182
'red': 117, 'green': 39, 'blue': 232	'red': 210, 'green': 254, 'blue': 121	'red': 193, 'green': 183, 'blue': 127	'red': 97, 'green': 100, 'blue': 237

```
>>> freq2 = get_freq(orig2)
```

```
>>> print(freq2)
```

```
{'bin_size': 16, 'red': [2, 1, 1, 1, 0, 2, 1, 1, 1, 1, 1, 3, 3, 2, 0, 0], 'green': [1, 1, 2, 1, 0, 1, 2, 3, 0, 1, 2, 2, 0, 2, 1, 1], 'blue': [1, 0, 0, 0, 1, 2, 0, 2, 5, 0, 1, 1, 1, 1, 4, 1]}
```

The default value of bin size is 16, there are 16 bins with bin size of 16 :

Bins	'red'	'green'	'blue'
0 ≤ pixel value ≤ 15	2	1	1
16 ≤ pixel value ≤ 31	1	1	0
32 ≤ pixel value ≤ 47	1	2	0
48 ≤ pixel value ≤ 63	1	1	0
64 ≤ pixel value ≤ 79	0	0	1
80 ≤ pixel value ≤ 95	2	1	2
96 ≤ pixel value ≤ 111	1	2	0
112 ≤ pixel value ≤ 127	1	3	2
128 ≤ pixel value ≤ 143	1	0	5
144 ≤ pixel value ≤ 159	1	1	0
160 ≤ pixel value ≤ 175	1	2	1
176 ≤ pixel value ≤ 191	3	2	1
192 ≤ pixel value ≤ 207	3	0	1
208 ≤ pixel value ≤ 223	2	2	1
224 ≤ pixel value ≤ 239	0	1	4
240 ≤ pixel value ≤ 255	0	1	1

We can see that there are 4 'blue' pixel values of orig2 that are between 224 and 239, inclusive. These pixels are (1,3), (4,2), (5,1), (5,4). Note that these are row and column numbers of the table.

```
>>> freq3=get_freq(orig2,'rgb',32)
```

```
>>> print(freq3)
```

```
{'bin_size': 32, 'red': [3, 2, 2, 2, 2, 4, 5, 0], 'green': [2, 3, 1, 5, 1, 4, 2, 2], 'blue': [1, 0, 3, 2, 5, 2, 2, 5]}
```

The bin size is 32, there are 8 bins with bin size of 32 :

Bins	'red'	'green'	'blue'
0 ≤ pixel value ≤ 31	3	2	1
32 ≤ pixel value ≤ 63	2	3	0
64 ≤ pixel value ≤ 95	2	1	3
96 ≤ pixel value ≤ 127	2	5	2
128 ≤ pixel value ≤ 159	2	1	5
160 ≤ pixel value ≤ 191	4	4	2
192 ≤ pixel value ≤ 223	5	2	2
224 ≤ pixel value ≤ 255	0	2	5

```
>>> w = [[0, -1, 0], [-1, 4, -1], [0, -1, 0]]
```

```
>>> img2 = apply_window(orig2, w)
```

```
>>> print(img2)
```

```
[{'red': 255, 'green': 0, 'blue': 54}, {'red': 0, 'green': 131, 'blue': 0}, {'red': 255, 'green': 0, 'blue': 255},  
{ 'red': 0, 'green': 255, 'blue': 0}], [{'red': 0, 'green': 0, 'blue': 0}, {'red': 255, 'green': 255, 'blue': 220}, {'red':  
239, 'green': 255, 'blue': 9}, {'red': 133, 'green': 0, 'blue': 0}], [{'red': 164, 'green': 0, 'blue': 55}, {'red': 218,  
'green': 0, 'blue': 255}, {'red': 0, 'green': 0, 'blue': 0}, {'red': 0, 'green': 255, 'blue': 31}], [{'red': 236,  
'green': 93, 'blue': 0}, {'red': 0, 'green': 0, 'blue': 255}, {'red': 0, 'green': 196, 'blue': 184}, {'red': 255,  
'green': 0, 'blue': 0}], [{'red': 0, 'green': 0, 'blue': 255}, {'red': 255, 'green': 255, 'blue': 0}, {'red': 183,  
'green': 22, 'blue': 0}, {'red': 0, 'green': 0, 'blue': 165}]]
```

'red': 255, 'green': 0, 'blue': 54	'red': 0, 'green': 131, 'blue': 0	'red': 255, 'green': 0, 'blue': 255	'red': 0, 'green': 255, 'blue': 0
'red': 0, 'green': 0, 'blue': 0	'red': 255, 'green': 255, 'blue': 220	'red': 239, 'green': 255, 'blue': 9	'red': 133, 'green': 0, 'blue': 0
'red': 164, 'green': 0, 'blue': 55	'red': 218, 'green': 0, 'blue': 255	'red': 0, 'green': 0, 'blue': 0	'red': 0, 'green': 255, 'blue': 31
'red': 236, 'green': 93, 'blue': 0	'red': 0, 'green': 0, 'blue': 255	'red': 0, 'green': 196, 'blue': 184	'red': 255, 'green': 0, 'blue': 0
'red': 0, 'green': 0, 'blue': 255	'red': 255, 'green': 255, 'blue': 0	'red': 183, 'green': 22, 'blue': 0	'red': 0, 'green': 0, 'blue': 165

Let's represent the window as a table:

0	-1	0
-1	4	-1
0	-1	0

The value of the pixel 2,2 of img2 (img2[1][1]):

'red': 217, 'green' 0 120, 'blue': 131	'red': 85, 'green' 1 167, 'blue': 137	'red': 191, 'green' 0 11, 'blue': 227	'red': 34, 'green': 188, 'blue': 86
'red': 11, 'green' 1 99, 'blue': 71	'red': 178, 'green' 4 239, 'blue': 212	'red': 194, 'green' 1 216, 'blue': 166	'red': 139, 'green': 17, 'blue': 130
'red': 167, 'green' 0 53, 'blue': 131	'red': 150, 'green' 1 94, 'blue': 254	'red': 29, 'green' 0 37, 'blue': 86	'red': 56, 'green': 212, 'blue': 143
'red': 176, 'green': 113, 'blue': 13	'red': 8, 'green': 154, 'blue': 233	'red': 89, 'green': 173, 'blue': 203	'red': 204, 'green': 122, 'blue': 182
'red': 117, 'green': 39, 'blue': 232	'red': 210, 'green': 254, 'blue': 121	'red': 193, 'green': 183, 'blue': 127	'red': 97, 'green': 100, 'blue': 237

'red': $217 \times 0 + 85 \times (-1) + 191 \times (0) + 11 \times (-1) + 178 \times (4) + 194 \times (-1) + 167 \times (0) + 150 \times (-1) + 29 \times (0) = 272 \rightarrow 255$

272 is not a valid pixel value, so it should be 255.

'green': $120 \times 0 + 167 \times (-1) + 11 \times (0) + 99 \times (-1) + 239 \times (4) + 216 \times (-1) + 53 \times (0) + 94 \times (-1) + 37 \times (0) = 380 \rightarrow 255$

380 is not a valid pixel value, so it should be 255.

'blue': $131 \times 0 + 137 \times (-1) + 227 \times (0) + 71 \times (-1) + 212 \times (4) + 166 \times (-1) + 131 \times (0) + 254 \times (-1) + 86 \times (0) = 220$

```
>>> print(img2[1][1])
```

```
{'red': 255, 'green': 255, 'blue': 220}
```

The value of the first pixel of img2 (img2[0][0]):

Since this is a corner value, we have to duplicate the pixels

'red': 217, 'green': 120, 'blue': 131	'red': 217, 'green': 120, 'blue': 131	'red': 85, 'green': 167, 'blue': 137		
'red': 217, 'green': 120, 'blue': 131	'red': 217, 'green': 120, 'blue': 131	'red': 85, 'green': 167, 'blue': 137	'red': 191, 'green': 11, 'blue': 227	'red': 34, 'green': 188, 'blue': 86
'red': 11, 'green': 99, 'blue': 71	'red': 11, 'green': 99, 'blue': 71	'red': 178, 'green': 239, 'blue': 212	'red': 194, 'green': 216, 'blue': 166	'red': 139, 'green': 17, 'blue': 130
	'red': 167, 'green': 53, 'blue': 131	'red': 150, 'green': 94, 'blue': 254	'red': 29, 'green': 37, 'blue': 86	'red': 56, 'green': 212, 'blue': 143
	'red': 176, 'green': 113, 'blue': 13	'red': 8, 'green': 154, 'blue': 233	'red': 89, 'green': 173, 'blue': 203	'red': 204, 'green': 122, 'blue': 182
	'red': 117, 'green': 39, 'blue': 232	'red': 210, 'green': 254, 'blue': 121	'red': 193, 'green': 183, 'blue': 127	'red': 97, 'green': 100, 'blue': 237

'red': $217 \times (0) + 217 \times (-1) + 85 \times (0) + 217 \times (-1) + 217 \times 4 + 85 \times (-1) + 11 \times (0) + 11 \times (-1) + 178 \times (0) = 338 \rightarrow 255$

338 is not a valid pixel value, so it should be 255.

'green': $120 \times (0) + 120 \times (-1) + 167 \times (0) + 120 \times (-1) + 120 \times 4 + 167 \times (-1) + 99 \times (0) + 99 \times (-1) + 239 \times (0) = -26$

-26 is not a valid pixel value, so it should be 0.

'blue': $131 \times (0) + 131 \times (-1) + 137 \times (0) + 131 \times (-1) + 131 \times 4 + 137 \times (-1) + 71 \times (0) + 71 \times (-1) + 212 \times (0) = 54$

```
>>> print(img2[0][0])
```

```
{'red': 255, 'green': 0, 'blue': 54}
```

The value of the pixel 5,3 of img2 (img2[4][2]):

'red': 217, 'green': 120, 'blue': 131	'red': 85, 'green': 167, 'blue': 137	'red': 191, 'green': 11, 'blue': 227	'red': 34, 'green': 188, 'blue': 86
'red': 11, 'green': 99, 'blue': 71	'red': 178, 'green': 239, 'blue': 212	'red': 194, 'green': 216, 'blue': 166	'red': 139, 'green': 17, 'blue': 130
'red': 167, 'green': 53, 'blue': 131	'red': 150, 'green': 94, 'blue': 254	'red': 29, 'green': 37, 'blue': 86	'red': 56, 'green': 212, 'blue': 143
'red': 176, 'green': 113, 'blue': 13	'red': 8, 'green': 154, 'blue': 233	'red': 89, 'green': 173, 'blue': 203	'red': 204, 'green': 122, 'blue': 182
'red': 117, 'green': 39, 'blue': 232	'red': 210, 'green': 254, 'blue': 121	'red': 193, 'green': 183, 'blue': 127	'red': 97, 'green': 100, 'blue': 237
	'red': 210, 'green': 254, 'blue': 121	'red': 193, 'green': 183, 'blue': 127	'red': 97, 'green': 100, 'blue': 237

'red': $8 \times 0 + 89 \times (-1) + 204 \times (0) + 210 \times (-1) + 193 \times (4) + 97 \times (-1) + 210 \times (0) + 193 \times (-1) + 97 \times (0) = 183$

'green': $154 \times 0 + 173 \times (-1) + 122 \times (0) + 254 \times (-1) + 183 \times (4) + 100 \times (-1) + 254 \times (0) + 183 \times (-1) + 100 \times (0) =$

'blue': $233 \times 0 + 203 \times (-1) + 182 \times (0) + 121 \times (-1) + 127 \times (4) + 237 \times (-1) + 121 \times (0) + 127 \times (-1) + 237 \times (0) = -180 \rightarrow 0$

-180 is not a valid pixel value, so it should be 0.

```
>>> print(img2[4][2])
```

```
{'red': 183, 'green': 22, 'blue': 0}
```