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Ex - 6

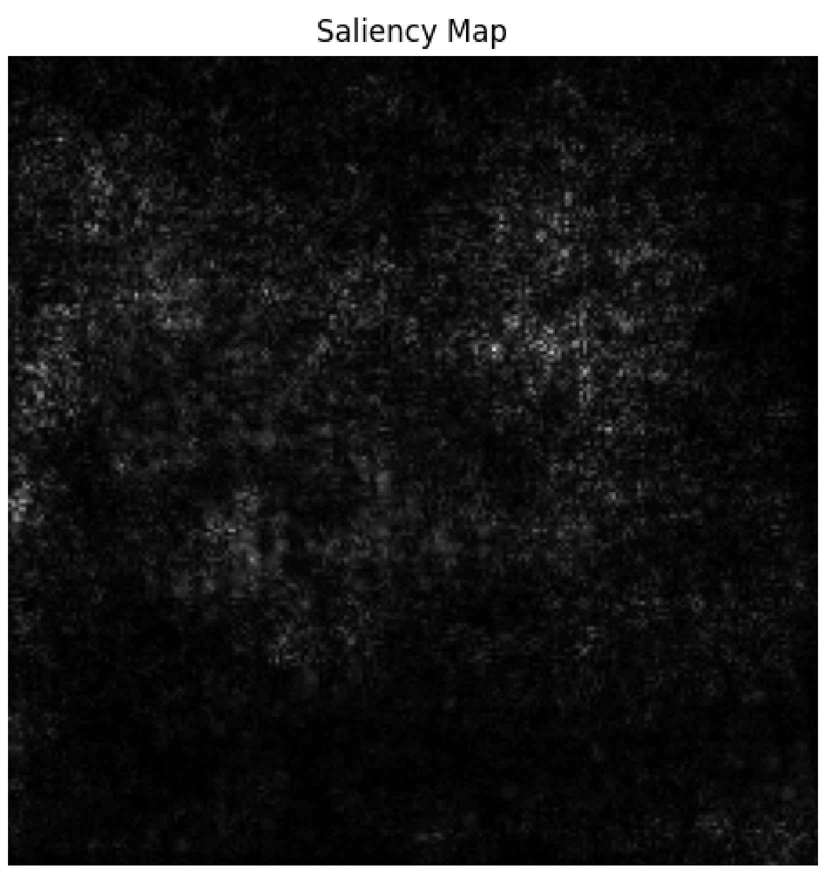
Task 1

In [ ]:
```
import tensorflow as tf
from tensorflow import keras
from keras import layers
import numpy as np
from PIL import Image
import matplotlib.pyplot as plt
from matplotlib.colors import ListedColormap
```

In [ ]:
```
resnet_model = keras.applications.ResNet50(
    include_top=True,
    weights="imagenet",
    classes=1000,
    classifier_activation="softmax",
)
image_file = tf.image.decode_png(tf.io.read_file('ouzel.jpg'))
image = np.expand_dims(image_file, axis=0)
image = tf.keras.applications.resnet50.preprocess_input(image)
# Make a prediction
result = resnet_model.predict(image)
prediction_class = np.argmax(result)
decoded_prediction = keras.applications.resnet50.decode_predictions(result, top=1)[0][0][1]
print(f'The prediction class number is {prediction_class} which is a {decoded_prediction}')
def gradient_input(model,inp,output_index=0):
    inp_tensor = tf.cast(inp, dtype=tf.float32)
    inp_tensor = tf.convert_to_tensor(inp_tensor)
    with tf.GradientTape() as t:
        t.watch(inp_tensor) # enable gradient recording w.r.t. to this tensor
        output = tf.squeeze(model(inp_tensor)) # forward inference
        if output.ndim>0:
            my_output = output[output_index] # pick right element from output
        else:
```

```python
            my_output = output
        gradient = t.gradient(my_output, inp_tensor) # get gradient @my_output/@input
    gradient = np.squeeze(np.array(gradient)) # convert from tensor to numpy array
    return gradient

gredient = gradient_input(resnet_model, image, prediction_class)
# Compute the saliency map
saliency_map = tf.reduce_max(tf.abs(gredient), axis=-1)
# Normalize the saliency map between 0 and 255 for visualization
normalized_saliency_map = np.uint8(255 * (saliency_map - tf.reduce_min(saliency_map)) / (tf.reduce_max(saliency_map)
# Expand dimensions to add a channel for a grayscale image
normalized_saliency_map_with_channel = np.expand_dims(normalized_saliency_map, axis=-1)
plt.figure(figsize=(10, 5))

plt.subplot(1, 2, 1)
plt.imshow(image_file)
plt.title(f'Original Image: {decoded_prediction}')
plt.axis('off')

plt.subplot(1, 2, 2)
plt.imshow(normalized_saliency_map, cmap='gray')
plt.title('Saliency Map')
plt.axis('off')

plt.tight_layout()
plt.show()

# Save the saliency map as a greyscale image
saliency_map_image = tf.keras.preprocessing.image.array_to_img(normalized_saliency_map_with_channel)
saliency_map_image.save('saliency_map.png')
```

```
1/1 [==============================] - 1s 1s/step
The prediction class number is 20 which is a water_ouzel
(224, 224)
```



Task 2

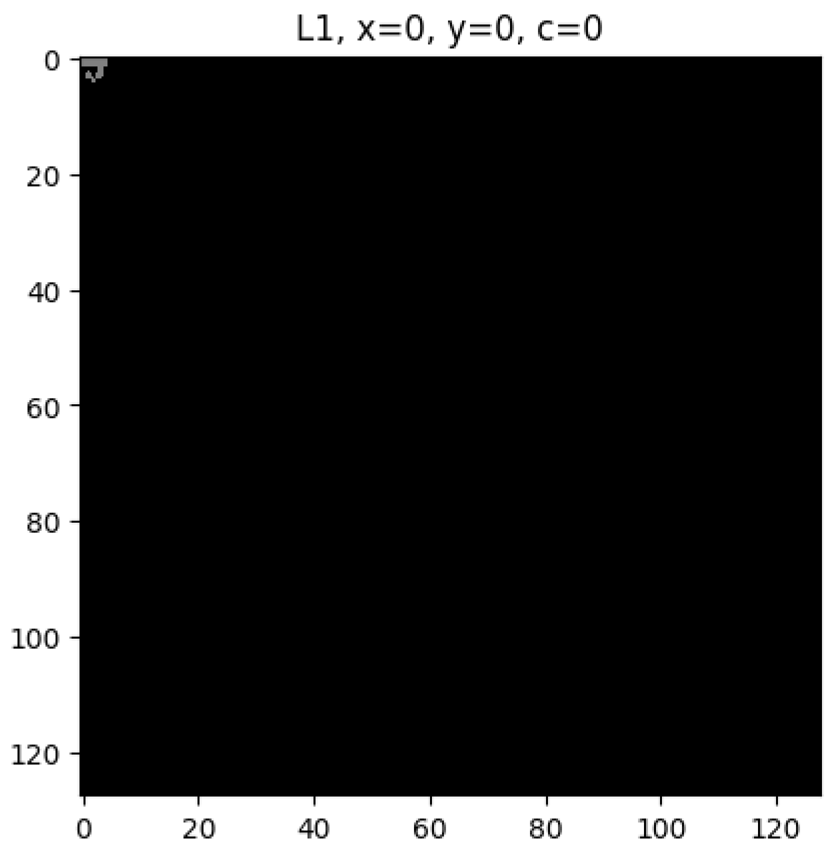
In [ ]:

```
# Build a simple CNN with strided convolution layers
def define_model():
    inputs = tf.keras.Input(shape=(128,128,1),name='Inputs')
    x = layers.Conv2D(16,kernel_size=(5,5),activation='tanh',strides=1,name='L1')(inputs)
    x = layers.Conv2D(16,kernel_size=(5,5),activation='tanh',strides=2,name='L2')(x)
    x = layers.Conv2D(16,kernel_size=(3,3),activation='tanh',strides=1,name='L3')(x)
    x = layers.Conv2D(16,kernel_size=(3,3),activation='tanh',strides=2,name='L4')(x)
    x = layers.Conv2D(16,kernel_size=(3,3),activation='tanh',strides=1,name='L5')(x)
    x = layers.Conv2D(16,kernel_size=(3,3),activation='tanh',strides=2,name='L6')(x)
    x = layers.Flatten()(x)
    outputs = layers.Dense(10,activation='softmax')(x)
    model = keras.Model(inputs=inputs, outputs=outputs)
```

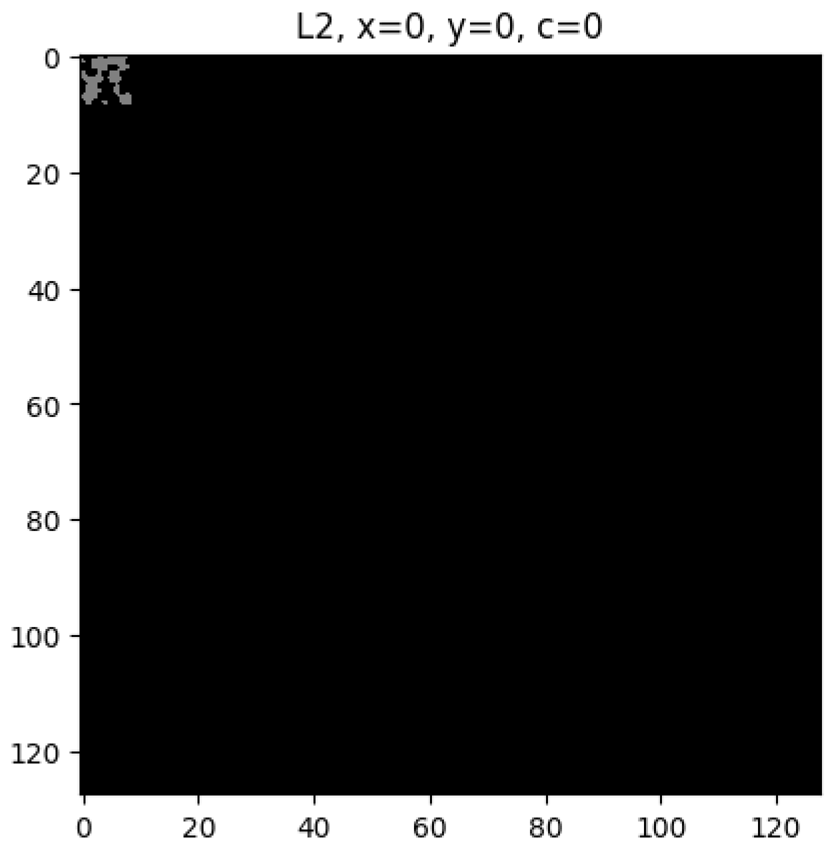
```
    return model


# For an output node in <model> at the intermediate layer <layer_name>
# and spatial position <x>,<y> and channel index <c>, compute the gradient of
# that output node with respect to the input <inp>
def get_gradient(model,layer_name,x,y,c,inp):
    input_tensor = tf.convert_to_tensor(inp, dtype=tf.float32)
    # Define a gradient tape
    with tf.GradientTape() as tape:
        tape.watch(input_tensor)
        intermediate_model = tf.keras.Model(inputs=model.input,
                                            outputs=model.get_layer(layer_name).output)
        output = tf.squeeze(intermediate_model(input_tensor))
        if output.ndim > 0:
            new_output = output[x, y, c]
        else:
            new_output = output
        gradient = tape.gradient(new_output, input_tensor)
    gradient = np.squeeze(np.array(gradient))
    return gradient

model = define_model()
layer_names = [layer.name for layer in model.layers]
layer_names_without_input_and_output = layer_names[1:-2]
for layer in layer_names_without_input_and_output:
    layer_name = layer
    x = 0  # Spatial position x
    y = 0  # Spatial position y
    c = 0  # Channel index

    inp = np.random.uniform(0,1,size=(1,128,128,1))  # Input tensor
    inp = tf.convert_to_tensor(inp, dtype=tf.float32)

    gradient = get_gradient(model, layer_name, x, y, c, inp)
    gradient = gradient * 10000
    size_of_receptive_field = np.max(np.nonzero(gradient)) + 1
    print(f'for the layer {layer}, the receptive field is {size_of_receptive_field}x{size_of_receptive_field}')
    # Convert gradient to image
    image = Image.fromarray(gradient.astype('uint8'))

    # Define your custom black and blue color palette
```

```
colors = ['black', 'grey']
custom_cmap = ListedColormap(colors)

# Display the sample data using the custom color palette
plt.title(f'{layer}, x={x}, y={y}, c={c}')
plt.imshow(image, cmap=custom_cmap)
# plt.colorbar()  # Add a color bar for reference
plt.show()
```

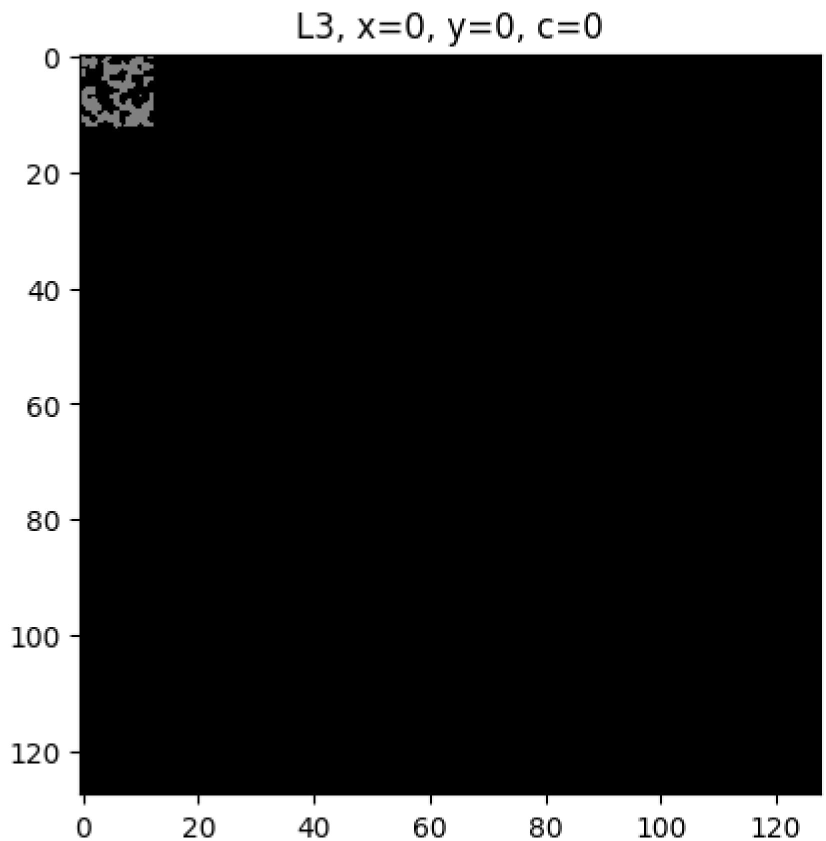
```
for the layer L1, the receptive field is 5x5
```



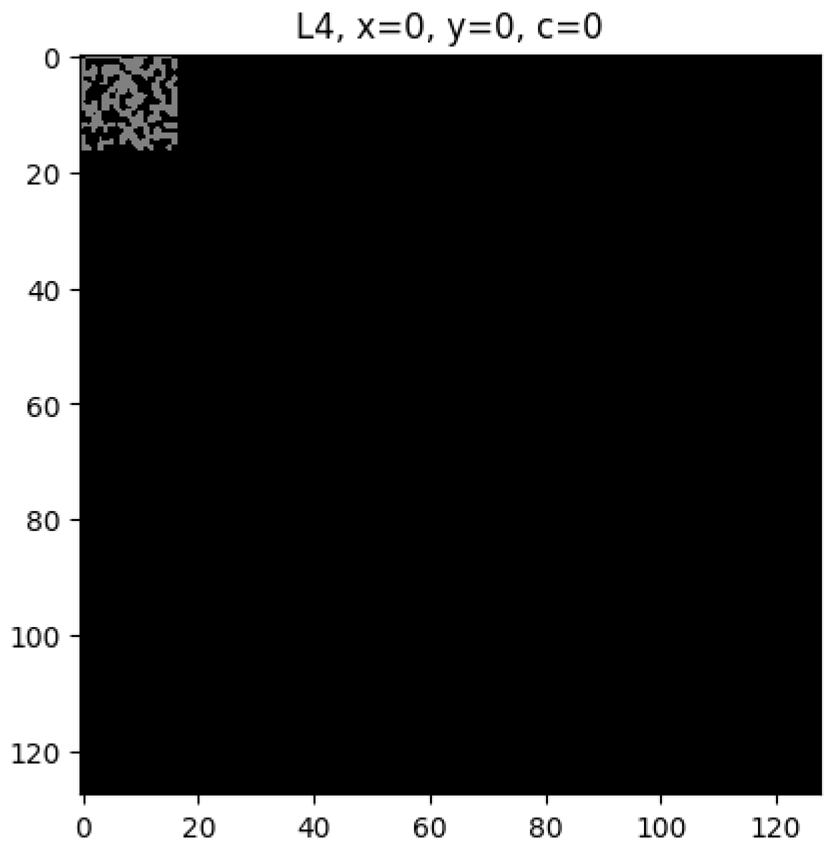

```
for the layer L2, the receptive field is 9x9
```



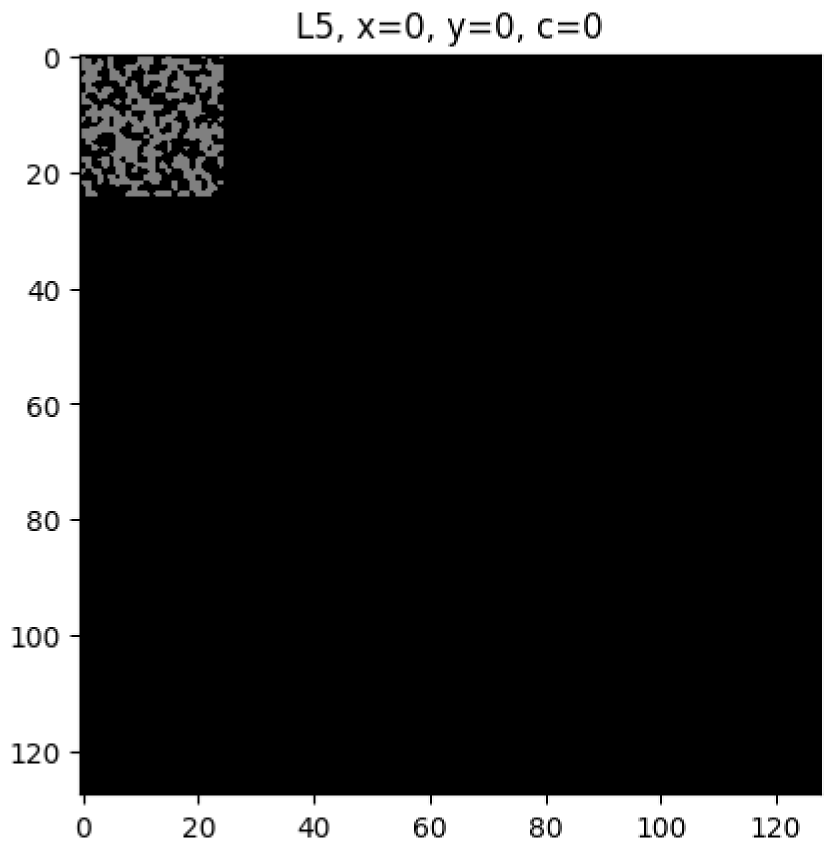
for the layer L3, the receptive field is 13x13



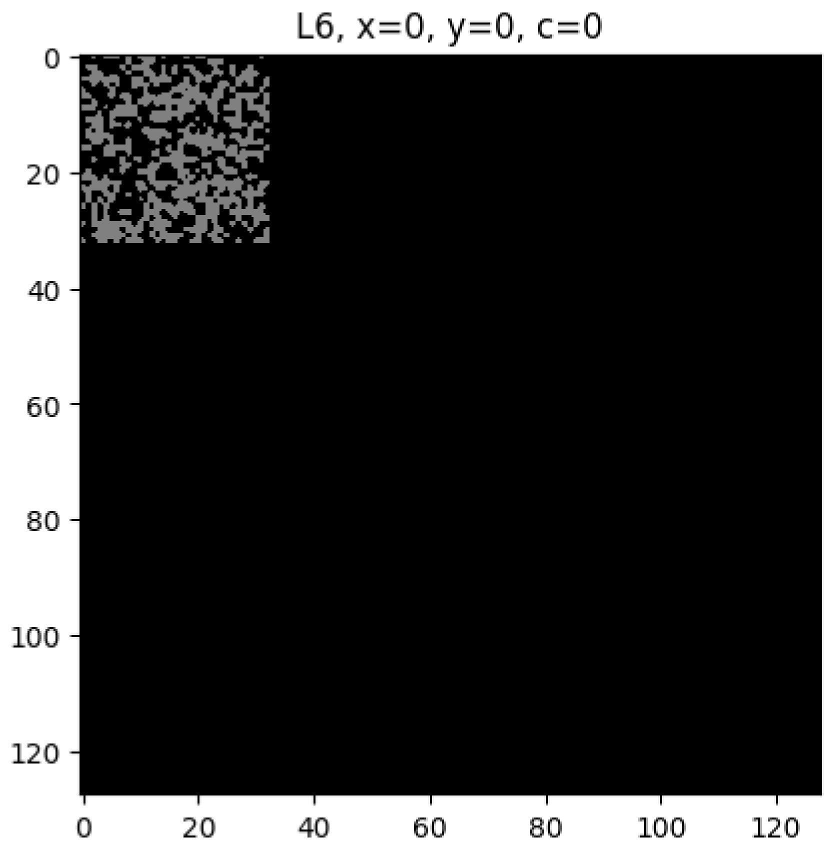
for the layer L4, the receptive field is 17x17



for the layer L5, the receptive field is 25x25



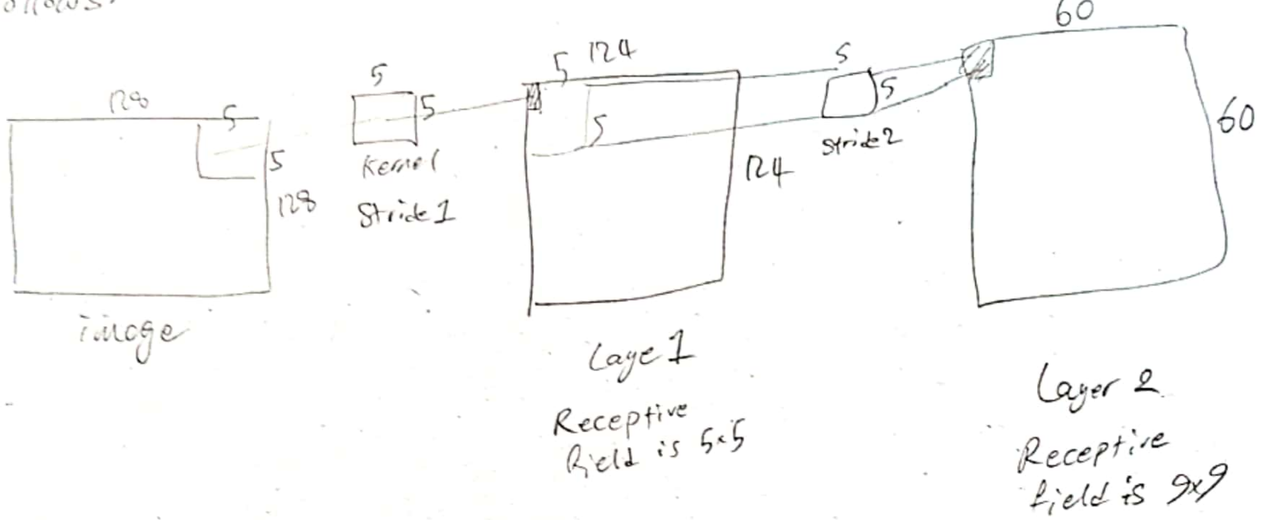
for the layer L6, the receptive field is 33x33



In [ ]:

Task III)

For the first layer for example, the receptive field is as follows:



Hence, the Receptive field of layer m is calculated by:

$$RF_m = \underbrace{RF_{m-1}}_{\text{Receptive field of Previous layer}} + (\underbrace{k_m}_{\text{kernel Size of the Layer}} - 1) \times \underbrace{\prod_{i=1}^{m-1} S_i}_{\text{Product of Strides of the previous Layers}}$$

The validation for formula is done using the print outputs in the previous task's python notebook.

$RF_1 = 5$
$RF_2 = 5 + (5-1) \times 1 = 9$
$RF_3 = 9 + (3-1) \times 2 = 13$
$RF_4 = 13 + (3-1) \times 1 = 17$
$RF_5 = 17 + (3-1) \times 4 = 25$
$RF_6 = 25 + (3-1) \times 4 = 33$

→ based on python outputs are true.