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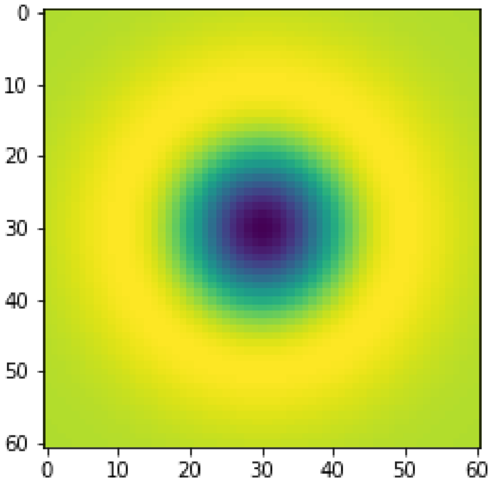
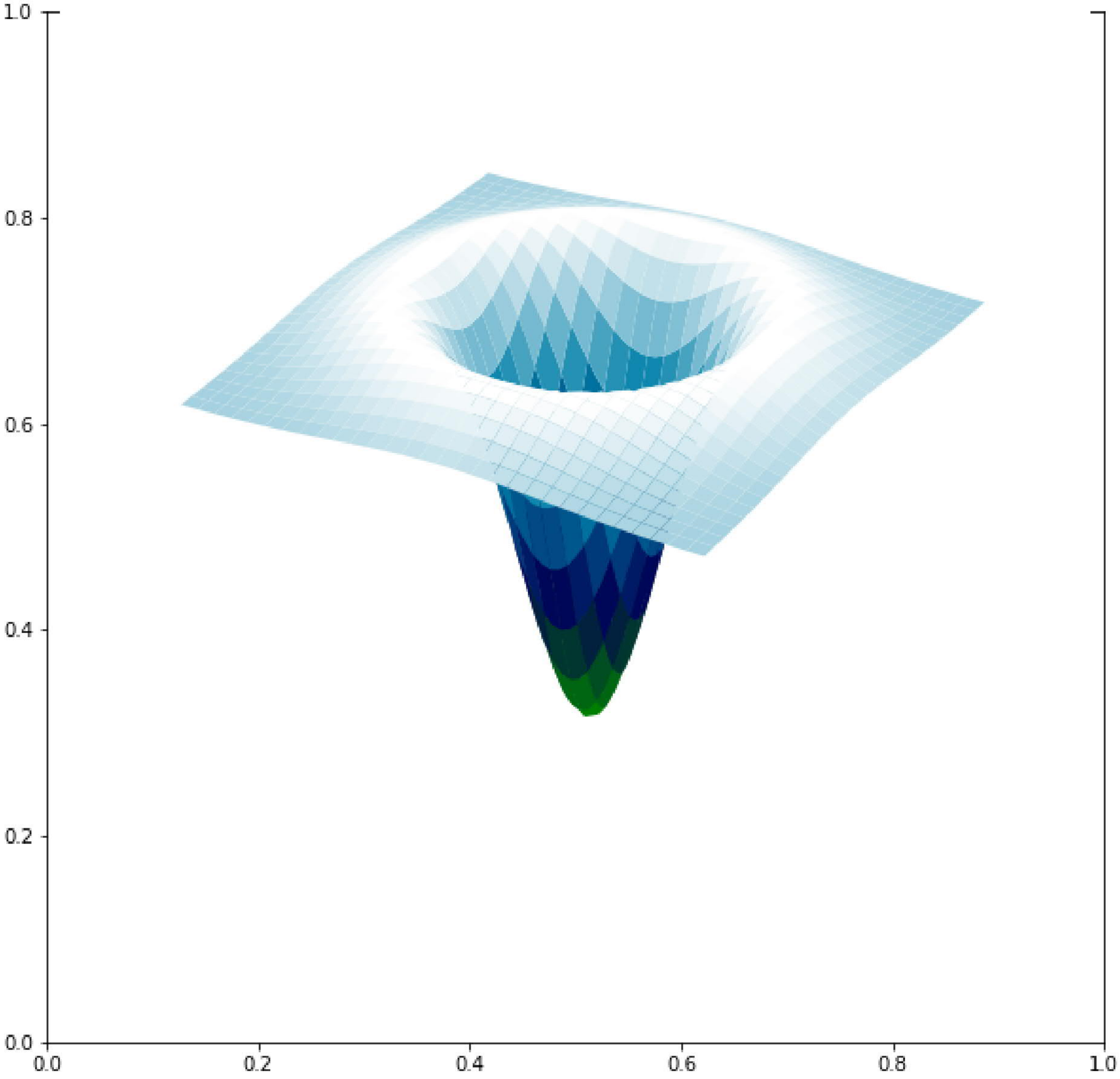
In [ ]:

```
#Q1)
import numpy as np
import matplotlib.pyplot as plt

sigma = 10
hw = 3 * sigma
X, Y = np.meshgrid(np.arange(-hw, hw+1, 1),np.arange(-hw, hw+1, 1))

log = 1/(2 * np.pi * sigma ** 2) * (X **2 /(sigma ** 2) + Y **2 /(sigma ** 2) -2)*np.ex

plt.imshow(log)
plt.show()
```



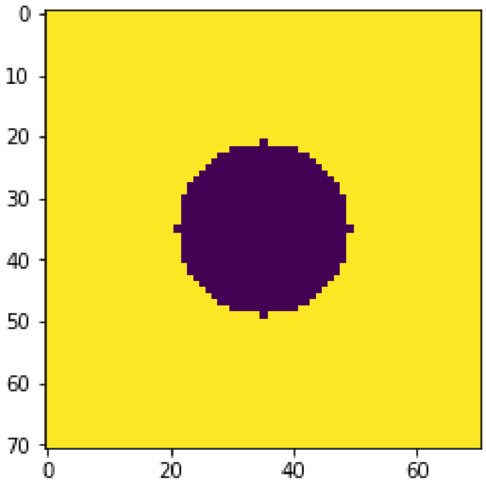
In [ ]:

```
#Q2)
import cv2 as cv
import matplotlib.pyplot as plt
import numpy as np
from mpl_toolkits.mplot3d import Axes3D
from matplotlib import cm
from matplotlib.ticker import LinearLocator, FormatStrFormatter



fig,ax = plt.subplots(figsize = (10, 10))
ax = fig.add_subplot(111, projection = '3d')


surf1 = ax.plot_surface(X, Y, log, cmap = cm.ocean, linewidth = 0, antialiased = True)

ax.zaxis.set_major_locator(LinearLocator(10))
ax.zaxis.set_major_formatter(FormatStrFormatter('%.02f'))

plt.axis('off')
plt.show()
```



In [ ]:

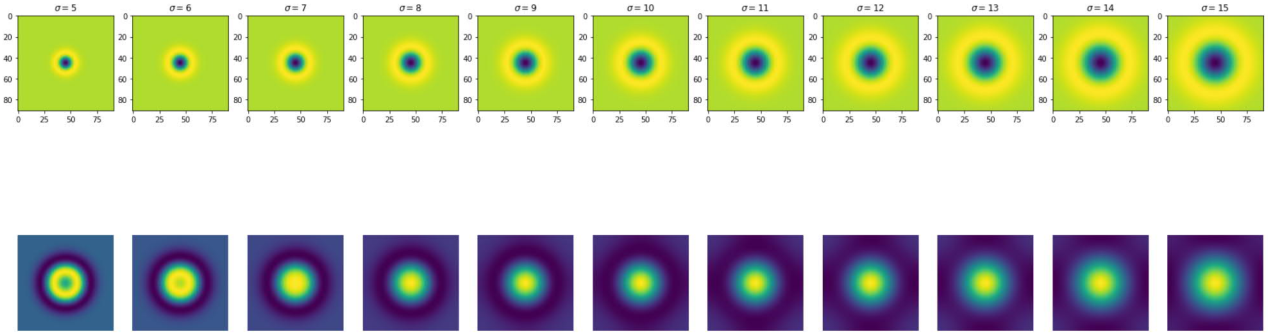
```
#Q2)#Genrating the circle
import numpy as np
import cv2 as cv
import matplotlib.pyplot as plt

w,h = 71,71
hw , hh = w // 2 , h//2

f = np.ones((h,w) , dtype = np.float32) * 255
X, Y = X, Y = np.meshgrid(np.arange(-hh, hh+1, 1),np.arange(-hw, hw+1, 1))
r = w//5
f *= X**2 + Y**2 > r**2
plt.imshow(f)
plt.show()
```



In [ ]:

```
s = 11
fig,ax = plt.subplots(2, s, figsize = (30,10))
scale_space = np.empty((h, w, s) , dtype = np.float32)
sigmas = np.arange(5,16,1)
for i,sigma in enumerate(np.arange(5,16,1)):

    log_hw = 3 * np.max(sigmas)
    X, Y = np.meshgrid(np.arange(-log_hw, log_hw+1, 1),np.arange(-log_hw, log_hw+1, 1))

    log = 1/(2 * np.pi * sigma ** 2) * (X **2 /(sigma ** 2) + Y **2 /(sigma ** 2) -2)*n
    f_log = cv.filter2D(f, -1, log)
    scale_space[:,:,i] = f_log
    ax[0, i].imshow(log)
    ax[0,i].set_title(r'$\sigma = {}$'.format(sigma))
    ax[1, i].imshow(f_log)
    ax[1, i].axis('off')

indices = np.unravel_index(np.argmax(scale_space , axis = None), scale_space.shape)
print(indices)
print(sigmas[indices[2]])
```

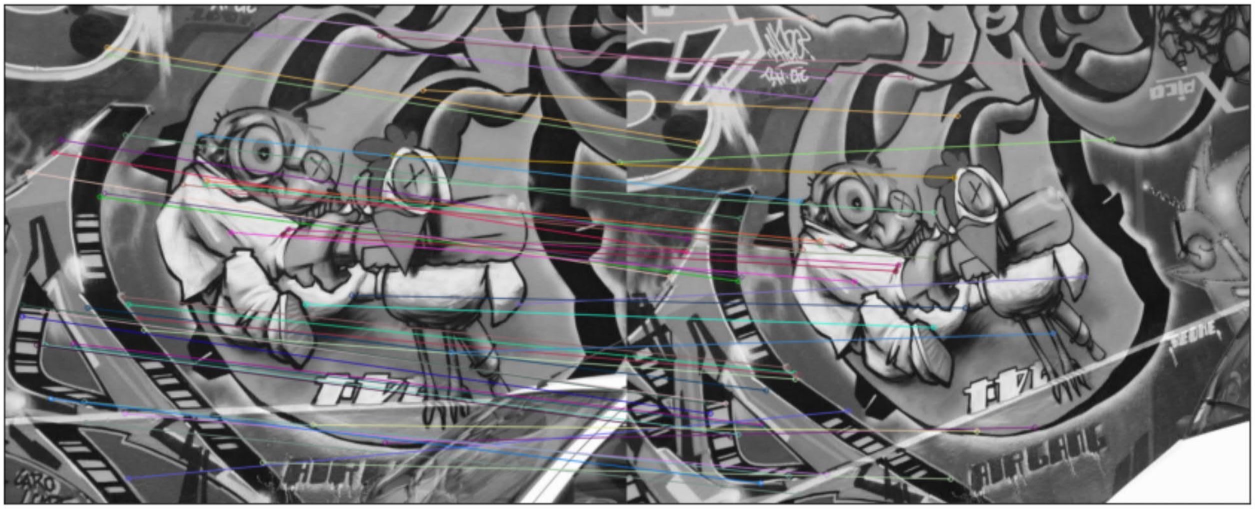
```
(35, 35, 5)
10
```



In [ ]:

```
#Q3)
import cv2
import matplotlib.pyplot as plt

img1 = cv2.imread('img1.ppm')
img2 = cv2.imread('img2.ppm')
```

```
img1 = cv2.cvtColor(img1, cv2.COLOR_BGR2GRAY)
img2 = cv2.cvtColor(img2, cv2.COLOR_BGR2GRAY)

sift = cv2.SIFT_create()

keypoints_1, descriptors_1 = sift.detectAndCompute(img1,None)
keypoints_2, descriptors_2 = sift.detectAndCompute(img2,None)

bf = cv2.BFMatcher(cv2.NORM_L1, crossCheck=True)

matches = bf.match(descriptors_1,descriptors_2)
matches = sorted(matches, key = lambda x:x.distance)

img3 = cv2.drawMatches(img1, keypoints_1, img2, keypoints_2, matches[:50], img2, flags=
plt.figure(figsize=(15,15))
plt.imshow(img3)
plt.xticks([]), plt.yticks([])
plt.show()
```

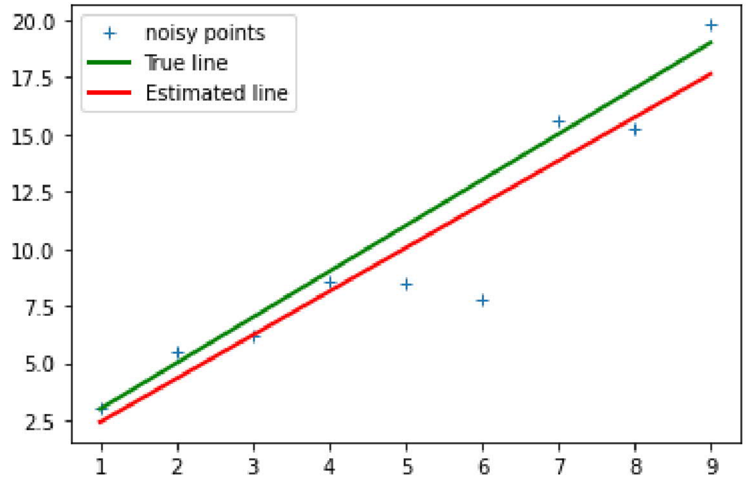


In [ ]:

```
#Q4)
#least square line fitting
m = 2 # Line equation : y = m*x + c . m i s the s lope . c i s the int e r c ept .
c = 1
x = np.arange (1 ,10 , 1)
np.random.seed(45)
n = 2.*np. random.randn(len(x))
o = np . zeros (x.shape)
# o[=1] = 20
y = m*x + c + n + o

n= len(x)
X = np.concatenate([x.reshape(n,1), np.ones((n,1))], axis=1)
B = np.linalg.pinv(X.T @ X) @ X.T @ y
mstar = B[0]
cstar = B[1]

plt.plot(x, y, '+', label = 'noisy points')
plt.plot([x[0], x[-1]], [m*x[0] + c, m*x[-1]+c ], color='g', linewidth=2, label=r'True
plt.plot([x[0], x[-1]], [mstar*x[0] + cstar, mstar*x[-1]+cstar ], color='r', linewidth=
plt.legend()
```

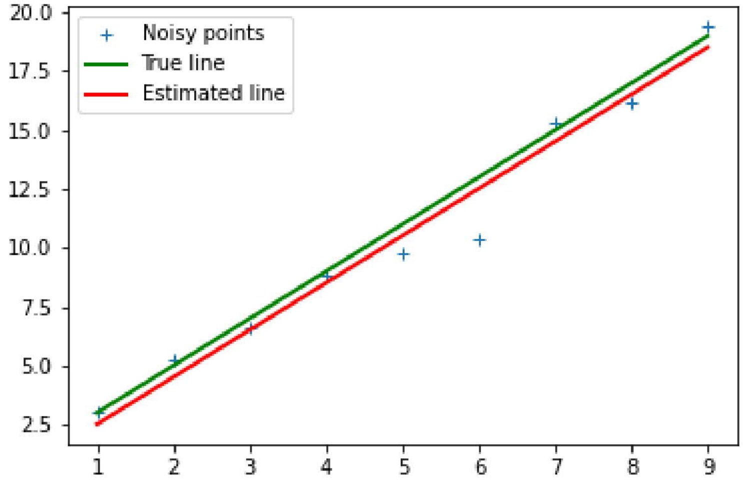
```
<matplotlib.legend.Legend at 0x1b3eb23fb80>
```

Out[ ]:



In [ ]:

```
#Q5)
m = 2 # Line equation : y = m*x + c . m is the slope .c is the intercept.
c = 1
x = np.arange (1 ,10 , 1)
np.random.seed(45)
noise = np.random.randn( len(x) )
o = np.zeros(x.shape)
# o [-1] = 20
y = m*x + c + noise + o

n = len(x)

u11 = np.sum((x - np.mean(x))**2)
u12 = np.sum((x - np.mean(x))*(y - np.mean(y)))
u21 = u12
u22 = np.sum((y - np.mean(y))**2)

U = np.array([[u11,u12],[u21,u22]])
W,V = np.linalg.eig(U)
ev_corresponding_to_smallest_ev = V[:,np.argmin(W)]

a = ev_corresponding_to_smallest_ev[0]
b = ev_corresponding_to_smallest_ev[1]
d = a*np.mean(x) + b*np.mean(y)

mstar = -a/b
cstar = d/b

plt.plot(x,y,'+',label='Noisy points')
plt.plot([x[0],x[-1]],[m*x[0]+c,m*x[-1] + c], color='g',linewidth=2, label=r'True line'
plt.plot([x[0],x[-1]],[mstar*x[0] + cstar,mstar*x[-1] + cstar], color='r', linewidth=2,
plt.legend(loc = 'best')
plt.show()
```


Noisy points
True line
Estimated line
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
1
2
3
4
5
6
7
8
9

In [ ]: