In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
```

In [2]:
```
X = np.array([
    [1,1,2],
    [1,2,4],
    [1,-3,-6]
])
```

In [3]:
```
XTX = X.T @ X
XTX
```

Out[3]:
```
array([[ 3,  0,  0],
       [ 0, 14, 28],
       [ 0, 28, 56]])
```

In [4]:
```
y = np.array([[1],[2],[-3]])
```

In [5]:
```
XTy = X.T@y
XTy
```

Out[5]:
```
array([[ 0],
       [14],
       [28]])
```

In [6]:
```
I = np.identity(3)
```

In [7]:
```
lambs = [10**-5, -10**-5, 10**-4, -10**-4, 10**-3, -10**-3, 10**-2, -10**-2, 1
```

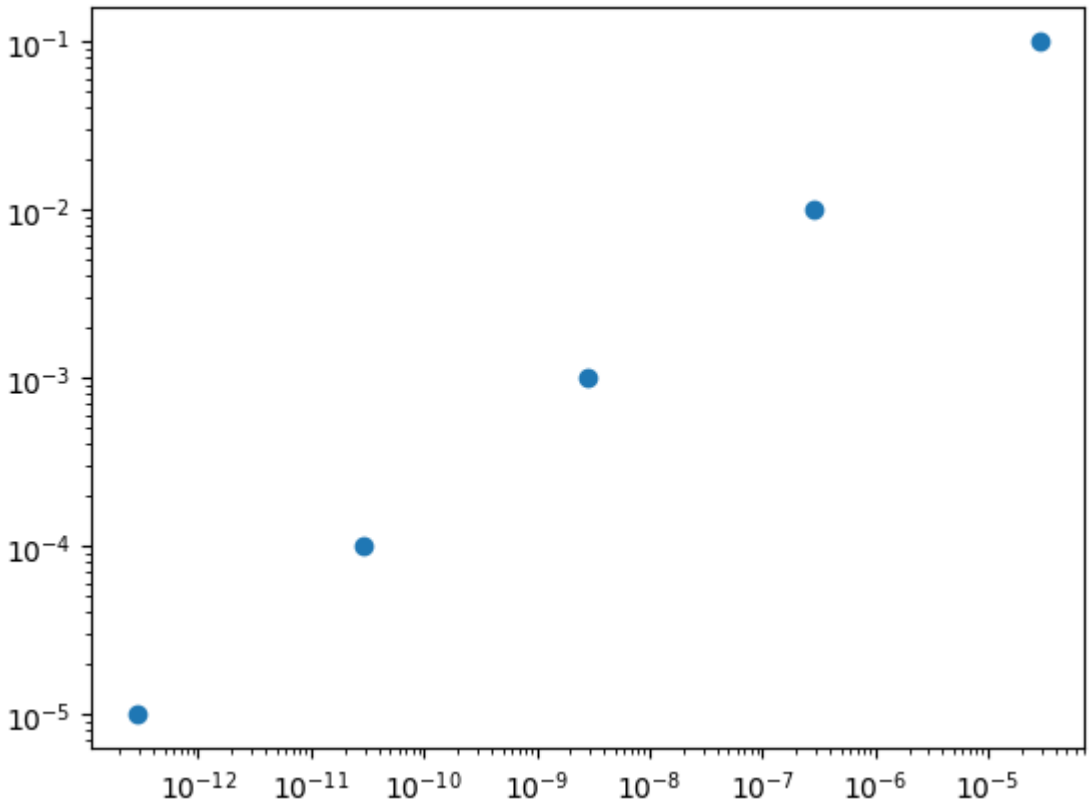
In [8]:
```
betas = []
Es = []
```

In [9]:
```
for lamb in lambs:
    beta = np.linalg.inv(XTX + lamb*I) @ (XTy)
    E = (y-X @ beta).T @ (y-X @ beta)
    betas.append(beta)
    Es.append(E[0][0])
    print('lambda=',lamb)
    print(beta)
    print('E=',E[0][0])
    print()
```

```
lambda= 1e-05
[[0.        ]
 [0.19999997]
 [0.39999994]]
E= 2.862344269347365e-13

lambda= -1e-05
[[0.        ]
 [0.20000003]
 [0.40000006]]
E= 2.8495412816463214e-13

lambda= 0.0001
[[0.        ]
 [0.19999971]
 [0.39999943]]
E= 2.8570304562615895e-11

lambda= -0.0001
[[0.        ]
 [0.20000029]
 [0.40000057]]
E= 2.8571905264224383e-11

lambda= 0.001
[[0.        ]
 [0.19999714]
 [0.39999429]]
E= 2.8570611966605127e-09

lambda= -0.001
[[0.        ]
 [0.20000286]
 [0.40000571]]
E= 2.8572238143031656e-09

lambda= 0.01
[[0.        ]
 [0.19997143]
 [0.39994287]]
E= 2.8563267066576884e-07

lambda= -0.01
[[0.        ]
 [0.20002858]
 [0.40005715]]
E= 2.857959356546184e-07

lambda= 0.1
[[0.        ]
 [0.19971469]
 [0.39942939]]
E= 2.84899705127708e-05

lambda= -0.1
[[0.        ]
 [0.20028612]
 [0.40057225]]
E= 2.8653236485623464e-05
```

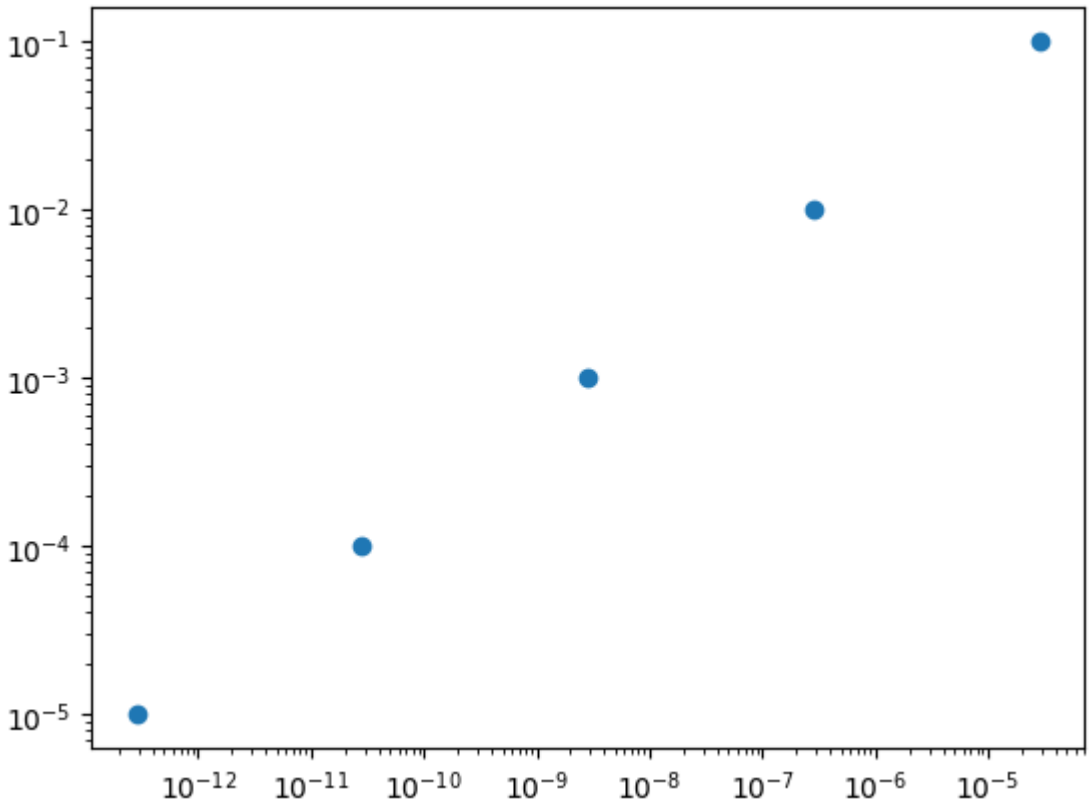
In [14]:
```
# convert y-axis to Logarithmic scale
plt.yscale("log")
plt.xscale("log")

plt.scatter(Es, lambs)
```

Out[14]:
```
<matplotlib.collections.PathCollection at 0x7f82a0637c70>
```



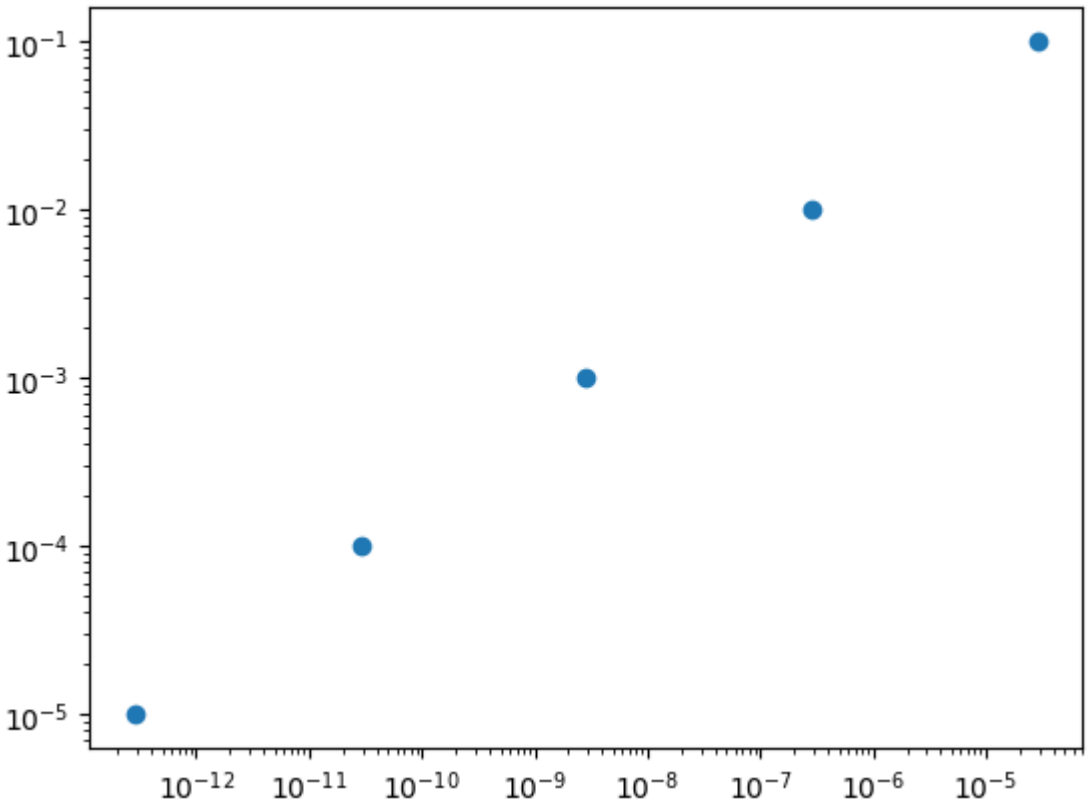
In [16]:
```
# convert y-axis to Logarithmic scale
plt.yscale("log")
plt.xscale("log")

plt.scatter([Es[i] for i in range(len(Es)) if i % 2 == 0], [lambs[i] for i in
```

Out[16]:
```
<matplotlib.collections.PathCollection at 0x7f829ffa5ba0>
```



In [18]:
```
# convert y-axis to Logarithmic scale
plt.yscale("log")
plt.xscale("log")

plt.scatter([Es[i] for i in range(len(Es)) if i % 2 == 1], [-lambs[i] for i in
```

Out[18]:
```
<matplotlib.collections.PathCollection at 0x7f829f153400>
```


10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-12}
10^{-11}
10^{-10}
10^{-9}
10^{-8}
10^{-7}
10^{-6}
10^{-5}