Q2&Q3

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In [17]:
```
import numpy as np
from cvxopt import matrix
from cvxopt.solvers import qp
from sklearn.preprocessing import PolynomialFeatures
```

In [18]:
```
poly = PolynomialFeatures(interaction_only=False)
```

In [29]:
```
X = np.array([[1, 0], [0, 1], [0, -1], [-1, 0], [0, 2], [0, -2], [-2, 0]])
Y = np.array([-1, -1, -1, 1, 1, 1, 1])
Xt=poly.fit_transform(X)
print(Xt)
```

```
[[ 1.  1.  0.  1.  0.  0.]
 [ 1.  0.  1.  0.  0.  1.]
 [ 1.  0. -1.  0. -0.  1.]
 [ 1. -1.  0.  1. -0.  0.]
 [ 1.  0.  2.  0.  0.  4.]
 [ 1.  0. -2.  0. -0.  4.]
 [ 1. -2.  0.  4. -0.  0.]]
```

In [20]:
```
A = matrix(Y,(1,7),'d')
b =matrix(0,(1,1),'d')
h = matrix(0,(7,1),'d')
G = matrix(-np.eye(7),(7,7),'d')
p = matrix(-1,(7,1),'d')
XX = Xt@Xt.T
YY = Y.reshape(7,1)@Y.reshape(1,7)
Q = matrix(XX*YY,(7,7),'d')
```

In [21]:
```
sol=qp(Q,p,G, h,A,b)
```

```
     pcost       dcost       gap    pres   dres
 0: -2.1712e+00 -5.0654e+00  2e+01  3e+00  2e+00
 1: -3.8978e+00 -5.7620e+00  6e+00  1e+00  7e-01
 2: -1.7493e+00 -2.7818e+00  1e+00  5e-16  6e-15
 3: -1.9825e+00 -2.0130e+00  3e-02  4e-16  1e-15
 4: -1.9997e+00 -2.0001e+00  4e-04  7e-16  2e-15
```

```
 5: -2.0000e+00 -2.0000e+00  4e-06  3e-16  1e-15
 6: -2.0000e+00 -2.0000e+00  4e-08  3e-16  1e-15
Optimal solution found.
```

```
In [25]: alpha = np.array(sol['x'])
         print(alpha)
```

```
[[3.75668650e-08]
 [9.99999978e-01]
 [9.99999977e-01]
 [1.33333334e+00]
 [3.33333329e-01]
 [3.33333328e-01]
 [5.23032669e-10]]
```

Q2: 由上可知道 2,3,4,5,6 F support vectores

```
In [59]: SV = [[0, 1], [0, -1], [-1, 0], [0, 2], [0, -2]]
```

```
In [30]: w = 0
         for i in range(len(alpha)):
             w = w +Xt[i]*alpha[i]*Y[i]
         print(w)
```

```
[ 5.18168890e-17 -1.33333337e+00 -2.22044605e-16  1.33333330e+00
  0.00000000e+00  6.66666670e-01]
```

```
In [58]: b=Y[1] -Xt[1]@w
         print(b)
```

```
-1.6666666700348152
```

Q3: 由上可知 $-4x_1 + 4x_1^2 + 2x_2^2 = 5$ 是 linear curve

Q4: the kernel in question 2 and 4 are different space, so they cannot be the same. (one's dimmension is 2, the other is 6)