2. take derivative to w, it should be same as the separable case, the parameter ε and β have no effect on derivate of w.

$$\nabla_w L = w - \sum_{i=1}^{m} a_i y_i x_i = 0 \Rightarrow w = \sum_{i=1}^{m} a_i y_i x_i \qquad (2)$$

take derivative to b, same as seperable case.

$$\nabla_b L = -\sum_{i=1}^{m} a_i y_i = 0 \Rightarrow \sum_{i=1}^{m} a_i y_i = 0 \qquad (3)$$

take derivative to ε, new parameter, but we can just simply take derivative to it

$$\nabla_\varepsilon L = \sum_{i=1}^{m} C - \sum_{i=1}^{m} a_i - \sum_{i=1}^{m} \beta_i = 0 \Rightarrow C = a_i + \beta_i \qquad (4)$$

For a:

$$\forall_i \ a_i(y_i(w^T x + b) - 1 + \varepsilon_i) = 0 \Rightarrow a_i = 0 \text{ or } y_i(w^T x_i + b) = 1 - \varepsilon_i \qquad (5)$$

For β:

$$\forall_i \ \beta_i \varepsilon_i = 0 \Rightarrow \beta_i = 0 \text{ or } \varepsilon_i = 0 \qquad (6)$$

3. when $d=3$ with $x, x' \in R^2$

$K(x, x') = (\langle x, x' \rangle + c)^3$

$= (x_1x_1' + x_2x_2' + c)^2 (x_1x_1' + x_2x_2' + c)$

$= (x_1^2 x_1'^2 + x_2^2 x_2'^2 + 2x_1x_1'x_2x_2' + 2c x_2x_2' + 2c x_1x_1'$

$+ c^2)(x_1x_1' + x_2x_2' + c)$

$= x_1^3x_1'^3 + x_1^2x_1'^2x_2x_2' + cx_1^2x_1'^2 + x_2^2x_2'^2x_1x_1' + x_2^3x_2'^3 +$

$cx_2^2x_2'^2 + 2x_1^2x_1'^2x_2x_2' + 2x_2^2x_2'^2x_1x_1' + 2cx_1x_1'x_2x_2' +$

$2cx_1^2x_1'^2 + 2cx_1x_1'x_2x_2' + 2c^2x_1x_1' + 2cx_1x_1'x_2x_2' +$

$2cx_2^2x_2'^2 + 2c^2x_2x_2' + c^2x_1x_1' + c^2x_2x_2' + c^3$

~~ot~~ combine these polynomial function

$= x_1^3x_1'^3 + x_2^3x_2'^3 + 3cx_1^2x_1'^2 + 3cx_2^2x_2'^2 + 3x_1^2x_1'^2x_2x_2' + 3x_2^2x_2'^2x_1x_1' +$

$6cx_1x_1'x_2x_2' + 3c^2x_1x_1' + 3c^2x_2x_2' + c^3$

splitting...

$$= [x_1^3, x_2^3, \sqrt{3c}\,x_1^2, \sqrt{3c}\,x_2^2, \sqrt{3}x_2x_1, \sqrt{3}x_1x_2, \sqrt{6c}\,x_1x_2, c\sqrt{3}x_1, c\sqrt{3}x_2, c^{\frac{3}{2}}] \begin{bmatrix} x_1'^3 \\ x_2'^3 \\ \sqrt{3c}\,x_1'^2 \\ \sqrt{3c}\,x_2'^2 \\ \sqrt{3}x_2'x_1' \\ \sqrt{3}x_1'x_2' \\ \sqrt{6c}\,x_1'x_2' \\ c\sqrt{3}x_1' \\ c\sqrt{3}x_2' \\ c^{\frac{3}{2}} \end{bmatrix}$$

So, $\phi(x) = [x_1^3, x_2^3, \sqrt{3c}\,x_1^2, \sqrt{3c}\,x_2^2, \sqrt{3}x_2x_1, \sqrt{3}x_1x_2, \sqrt{6c}\,x_1x_2, c\sqrt{3}x_1, c\sqrt{3}x_2, c^{\frac{3}{2}}]^T$

maps a 2-D data point x into 10-D space as $\phi(x)$