$: \sum_{i=1}^{N} X_i = 0 \qquad N_1 = N_{-1} = N/2$

$$\mu_{-1} = \frac{1}{N_{-1}} \sum_{i:\, y_i^* = -1} X_i \qquad \mu_1 = \frac{1}{N_1} \sum_{i:\, y_i^* = 1} X_i \qquad \Sigma = \frac{1}{N}\left[\sum_{i:\, y_i^*=-1} (X_i - \mu_{-1})^T \cdot (X_i - \mu_{-1}) + \sum_{i:\, y_i^*=1} (X_i - \mu_1)^T \cdot (X_i - \mu_1)\right]$$

$$\frac{\partial}{\partial \beta} \sum_{i=1}^{N} (y_i^* - X_i \cdot \beta)^2 \overset{!}{=} 0$$

$\mu_1 + \mu_{-1} = 0$

$\mu_1 = -\mu_{-1}$

$$\Sigma \cdot \beta + \frac{1}{4}\underbrace{(\mu_1 - \mu_{-1})^T \cdot (\mu_1 - \mu_{-1})}_{= \mu_1^T \mu_1 - \mu_1^T \mu_{-1} - \mu_{-1}^T \mu_1 + \mu_{-1}^T \mu_{-1}} \cdot \beta = \frac{1}{2}(\mu_1 - \mu_{-1})^T$$

derivation is correct

$$0 = \sum_{i=1}^{N} -2 x_i^T (y_i^* - x_i \beta) \quad = -2 \sum_{i=1}^{N} (y_i^* x_i^T - x_i^T (x_i \beta)) \quad | : 2 \quad | \cdot \frac{1}{N_1}$$

$$0 = -\left[\frac{1}{N_{-1}} \sum_{y_i^*=-1} - x_i^T + \frac{1}{N_1} \sum_{y_i^*=1} x_i^T\right] + \frac{2}{N} \sum_{i=1}^{N} x_i^T (x_i \beta)$$

This is the same as the solution

$$= -(-\mu_{-1}^T + \mu_1^T) + \frac{2}{N}\left(\sum_{i:\, y=-1} x_i^T (x_i \beta) + \sum_{i:\, y=1} x_i^T (x_i \beta)\right) \quad | + (\mu_1 - \mu_{-1})^T \quad | : 2$$

$$\frac{1}{2}(\mu_1 - \mu_{-1})^T = \frac{1}{N}\left(\sum_{y=-1} x_i^T x_i + \sum_{y=1} x_i^T x_i\right)\beta$$

$$= \frac{1}{N}\left[\sum_{y=-1} ((x_i^T - \mu_{-1}^T) - \mu_1^T)((x_i - \mu_{-1}) - \mu_1) + \sum_{y=1} ((x_i^T - \mu_1^T) - \mu_{-1}^T)((x_i - \mu_1) - \mu_{-1})\right]\beta$$

$$= \frac{1}{N}\Big[\sum_{y=-1} \big((x_i - \mu_{-1})^T (x_i - \mu_{-1}) - (x_i - \mu_{-1})^T \mu_1 - \mu_1^T (x_i - \mu_{-1}) + \mu_1^T \mu_1\big)$$
$$+ \sum_{y=1} \big((x_i - \mu_1)^T (x_i - \mu_1) - (x_i - \mu_1)^T \mu_{-1} - \mu_{-1}^T (x_i - \mu_1) + \mu_{-1}^T \mu_{-1}\big)\Big]\beta$$

$$= \frac{1}{N}\Big[\overbrace{\sum_{y=-1} (x_i - \mu_{-1})^T (x_i - \mu_{-1}) + \sum_{y=1} (x_i - \mu_1)^T (x_i - \mu_1)}^{= N \cdot \Sigma} + \sum_{y=-1} [(-x_i^T \mu_1) - (\mu_1^T x_i)] + \sum_{y=1} [(-x_i^T \mu_{-1}) - (\mu_{-1}^T x_i)]$$
$$+ N_{-1} \cdot (\mu_{-1}^T \mu_1 + \mu_1^T \mu_{-1} + \mu_1^T \mu_1) + N_1 (\mu_1^T \mu_{-1} + \mu_{-1}^T \mu_1 + \mu_{-1}^T \mu_{-1})\Big]\beta$$

$$= \frac{1}{N}\Big[N \Sigma + \frac{N}{2}(-\mu_{-1}^T \mu_1 - \mu_1^T \mu_{-1} - \mu_1^T \mu_{-1} - \mu_{-1}^T \mu_1) + \frac{N}{2}[\mu_{-1}^T \mu_1 + \mu_1^T \mu_{-1}]\Big]\beta$$

$$= \Big[\Sigma + \frac{1}{2}\big(\mu_1^T \mu_1 + \overbrace{2\mu_{-1}^T \mu_1 - 2\mu_{-1}^T \mu_1 - 2\mu_1^T \mu_{-1} + 2\mu_1^T \mu_{-1}}^{= 0} + \mu_{-1}^T \mu_{-1}\big)\Big]\beta$$

$$= \Big[\Sigma + \frac{1}{2}(\mu_1^T \mu_1 + \mu_{-1}^T \mu_{-1})\Big]\beta$$

eq 46 - eq 50 from solution

$$= \Big[\Sigma + \frac{1}{4}(2\mu_1^T \mu_1 + 2\mu_{-1}^T \mu_{-1})\Big]\beta$$

$$= \Big[\Sigma + \frac{1}{4}(\mu_1^T \mu_1 - \mu_1^T \mu_{-1} - \mu_{-1}^T \mu_1 + \mu_{-1}^T \mu_{-1})\Big]\beta$$

$$= \Sigma \beta + \frac{1}{4}\big((\mu_1 - \mu_{-1})^T \cdot (\mu_1 - \mu_{-1})\big)\beta = \frac{1}{2}(\mu_1 - \mu_{-1})^T$$

$\sum^{N}$

This is similiar to the alternate solution.
It should be correct