2.2 Derivative of Log-likelihood:

$$L = \sum_{i=1}^{I} y_i \log\left(\frac{1}{1+e^{-w^T x_i}}\right) + \sum_{i=1}^{I} (1-y_i)\log\left(\frac{\cancel{exp}\, e^{-w^T x_i}}{1+e^{-w^T x_i}}\right)$$

Simplifying the equation, we have

$$L = \sum_{i=1}^{I} \left[y_i \log(1) - y_i \log(1+e^{-w^T x_i})\right] + \sum_{i=1}^{I} \left[(1-y_i)\log(e^{-w^T x_i}) - (1-y_i)\log(1+e^{-w^T x_i})\right]$$

$$L = -\sum_{i=1}^{I} y_i \cancel{\log(1+e^{-w^T x_i})} + \sum_{i=1}^{I} \left[\log(e^{-w^T x_i}) - y_i \log(e^{-w^T x_i}) - \log(1+e^{-w^T x_i}) + y_i \cancel{\log(1+e^{-w^T x_i})}\right]$$

$$L = \sum_{i=1}^{I} \log(e^{-w^T x_i}) - y_i \log(e^{-w^T x_i}) - \log(1+e^{-w^T x_i})$$

Taking derivative w.r.t w

$$\frac{\partial L}{\partial w} = \sum_{i=1}^{I} \frac{1}{\cancel{e^{-w^T x_i}}}\left(-x_i \cdot \cancel{e^{-w^T x_i}}\right) - y_i \cdot \frac{1}{\cancel{e^{-w^T x_i}}}\left(-x_i \cdot \cancel{e^{-w^T x_i}}\right) - \frac{1}{1+e^{-w^T x_i}}\left(-x_i \cdot e^{-w^T x_i}\right)$$

$$\frac{\partial L}{\partial w} = -\sum_{i=1}^{I} \left[(1-y_i) \cdot x_i - \frac{x_i \cdot e^{-w^T x_i}}{1+e^{-w^T x_i}}\right]$$

$$\frac{\partial L}{\partial w} = -\sum_{i=1}^{I} \left(-y_i + 1 - \frac{e^{-w^T x_i}}{1+e^{-w^T x_i}}\right) x_i$$

$$\frac{\partial L}{\partial w} = -\sum_{i=1}^{I} \left(-y_i + \frac{1+\cancel{e^{-w^T x_i}} - \cancel{e^{-w^T x_i}}}{1+e^{-w^T x_i}}\right) x_i$$

$$\frac{\partial L}{\partial w} = -\sum_{i=1}^{I} \left(-y_i + \frac{1}{1+e^{-w^T x_i}}\right) x_i = \boxed{-\sum_{i=1}^{I} \left(\frac{1}{1+\exp(-w^T x_i)} - y_i\right) x_i}$$