Sigmoid Function : $g(a) = \frac{1}{1+e^{-a}}$

Simplifying $g(a)(1-g(a))$:

$$g(a)(1-g(a)) = \left(\frac{1}{1+e^{-a}}\right)\left(1-\frac{1}{1+e^{-a}}\right)$$

$$= \left(\frac{1}{1+e^{-a}} - \frac{1}{(1+e^{-a})(1+e^{-a})}\right)$$

$$= \left(\frac{1\times(1+e^{-a})}{(1+e^{-a})\times(1+e^{-a})} - \frac{1}{(1+e^{-a})(1+e^{-a})}\right)$$

$$= \left(\frac{1+e^{-a}-1}{(1+e^{-a})^2}\right)$$

$$g(a)(1-g(a)) = \frac{e^{-a}}{(1+e^{-a})^2}$$

Taking First derivative of $g(a)$, using chain rule

$$\frac{dg(a)}{da} = \frac{dg}{du}\frac{1}{u}\frac{du}{da} \quad \Big| \quad u = 1+e^{-a}$$

$$= -\frac{1}{u^2}\frac{dg}{da}\left(1+e^{-a}\right)$$

$$= -\frac{1}{u^2}\left[\frac{dg}{da}(1)+\frac{dg}{da}\left(e^{-a}\right)\right]$$

$$= -\frac{e^{-a}}{u^2}\frac{dg}{da}(-a)$$

$$= -\frac{-1\times e^{2}}{u^2}$$

$$\frac{d\,g(a)}{da} = \frac{e^{-a}}{(1+e^{-a})^2}$$

This shows that $\frac{d\,g(a)}{da} = g(a)(1-g(a)) = \frac{e^{-a}}{(1+e^{-a})^2}$