c) $\ell(z,t) = -\sum_{i=1}^{N} t_i \ln(z_i)$, $t \in [0,1]^{1\times N}$

$$D_z \ell(z,t) = \left[\frac{\partial \ell(z,t)}{\partial z_1}, \ldots\ldots, \frac{\partial \ell(z,t)}{\partial z_N}\right]$$

$$\frac{\partial \ell(z,t)}{\partial z_i} = \frac{\partial}{\partial z_i}(-t_i \ln(z_i))$$

$$= \frac{-t_i}{z_i}$$

d) division by zero if $z_i \approx 0$

QUESTION 3:

a) $\tanh(x) = \dfrac{e^x - e^{-x}}{e^x + e^{-x}}$

$$\frac{\partial \tanh(x)}{\partial x} = \frac{\left(\frac{\partial}{\partial x}(e^x - e^{-x})\right)(e^x+e^{-x}) - (e^x - e^{-x})\left(\frac{\partial}{\partial x}(e^x+e^{-x})\right)}{(e^x+e^{-x})^2}$$

$$= \frac{(e^x+e^{-x})(e^x+e^{-x}) - (e^x-e^{-x})(e^x-e^{-x})}{(e^x+e^{-x})^2}$$

$$= \cancel{\frac{(e^x+e^{-x})^2}{(e^x+e^{-x})^2}} - \frac{(e^x-e^{-x})^2}{(e^x+e^{-x})^2}$$

$$= \cancel{1 - \tan} \quad 1 - \tanh^2 x$$