$$
\begin{aligned}
D &= 2[\ell(\hat{\boldsymbol{\beta}}_{max}) - \ell(\hat{\boldsymbol{\beta}})] \\
&= 2\left[-\frac{1}{2}N\log(2\pi\sigma^2) + \frac{1}{2\sigma^2}(\mathbf{y}-\mathbf{X}\hat{\boldsymbol{\beta}})^\top(\mathbf{y}-\mathbf{X}\hat{\boldsymbol{\beta}}) + \frac{1}{2}N\log(2\pi\sigma^2)\right] \\
&= \frac{1}{\sigma^2}(\mathbf{y}^\top\mathbf{y} - 2\hat{\boldsymbol{\beta}}^\top\mathbf{X}^\top\mathbf{y} + \hat{\boldsymbol{\beta}}^\top\mathbf{X}^\top\mathbf{X}\hat{\boldsymbol{\beta}}) \\
&= \frac{1}{\sigma^2}(\mathbf{y}^\top\mathbf{y} - \hat{\boldsymbol{\beta}}^\top\mathbf{X}^\top\mathbf{y})
\end{aligned}
$$