Q.2 $\sum \hat{\varepsilon}_i^2 = (y - X\hat{\beta})^T (y - X\beta) = y^T y - y^T X\beta - \hat{\beta}^T X^T y + \hat{\beta}^T X^T X\beta$

$= y^T y - 2\hat{\beta}^T X^T y + \hat{\beta}^T X^T X\beta$

$\bar{y} = \frac{\sum y_i}{n}$

$\sum (y_i - \bar{y})^2 = \sum (y_i^2 - 2y_i\bar{y} + \bar{y}^2)$

$= y^T y - 2n\bar{y}\bar{y} + n\bar{y}^2$

$= y^T y - n\bar{y}^2$

$$\frac{1 - \sum \hat{\varepsilon}_i^2}{\sum (y_i - \bar{y})} = 1 - \left[\frac{y^T y - 2\hat{\beta}^T X^T y + \hat{\beta}^T X^T X\beta}{y^T y - n\bar{y}^2} \right]$$

$$= \frac{2\hat{\beta}^T X^T y - \hat{\beta}^T X^T X\beta - n\bar{y}^2}{y^T y - n\bar{y}^2}$$

$$= \frac{2\hat{\beta}^T X^T y - \hat{\beta}^T X^T (y - \varepsilon) - n\bar{y}^2}{y^T y - n\bar{y}^2}$$

$$= \frac{\hat{\beta}^T X^T y + \hat{\beta}^T X^T \varepsilon - n\bar{y}^2}{y^T y - n\bar{y}^2}$$

but $X^T \varepsilon = 0$

$$= \frac{\hat{\beta}^T X^T y - n\bar{y}^2}{y^T y - n\bar{y}^2}$$