$$
\begin{aligned}
E(y_i) &= E(\beta_0 + \beta_1 x_{i1} + \cdots + \beta_{n-1} x_{in-1} + \epsilon) \\
&= E\left(\sum_{j=0}^{n-1} \beta_j x_{ij}\right) + E(\epsilon) \\
&= \sum_{j=0}^{n-1} \beta_j x_{ij}
\end{aligned}
$$

$$
\begin{aligned}
V(y_i) &= V(\beta_0 + \beta_1 x_{i1} + \cdots + \beta_{n-1} x_{in-1} + \epsilon) \\
&= V(\beta_0 + \beta_1 x_{i1} + \cdots + \beta_{n-1} x_{in-1}) + V(\epsilon) \\
&= V(\epsilon) \\
&= \sigma^2
\end{aligned}
$$

$$
\begin{aligned}
E(\hat{\beta}) &= E((\boldsymbol{X}^T \boldsymbol{X})^{-1}) \boldsymbol{X}^T \boldsymbol{y} \\
&= E((\boldsymbol{X}^T \boldsymbol{X})^{-1} \boldsymbol{X}^T (\boldsymbol{X}\boldsymbol{\beta} + \epsilon)) \\
&= E((\boldsymbol{X}^T \boldsymbol{X})^{-1} \boldsymbol{X}^T \boldsymbol{X}\boldsymbol{\beta}) + E((\boldsymbol{X}^T \boldsymbol{X})^{-1} \boldsymbol{X}^T \epsilon) \\
&= E(\boldsymbol{\beta}) + (\boldsymbol{X}^T \boldsymbol{X})^{-1} \boldsymbol{X}^T E(\epsilon) \\
&= \boldsymbol{\beta}
\end{aligned}
$$

$$
\begin{aligned}
V(\hat{\beta}) &= V((\boldsymbol{X}^T \boldsymbol{X})^{-1} \boldsymbol{X}^T \boldsymbol{y}) \\
&= V((\boldsymbol{X}^T \boldsymbol{X})^{-1} \boldsymbol{X}^T (\boldsymbol{X}\boldsymbol{\beta} + \epsilon)) \\
&= V((\boldsymbol{X}^T \boldsymbol{X})^{-1} \boldsymbol{X}^T \boldsymbol{X}\boldsymbol{\beta}) + V((\boldsymbol{X}^T \boldsymbol{X})^{-1} \boldsymbol{X}^T \epsilon) \\
&= ((\boldsymbol{X}^T \boldsymbol{X})^{-1} \boldsymbol{X}^T)^2 V(\epsilon) \\
&= - - - \\
&= (\boldsymbol{X}^T \boldsymbol{X})^{-1} \sigma^2
\end{aligned}
$$