# Common Regression Methods

| Name | Formula | Definition | Significance |
|---|---|---|---|
| **Ordinary Least Squares (OLS)** | $\min_\beta \sum_{i=1}^n (y_i - X_i\beta)^2$ | Minimizes the sum of squared residuals between observed and predicted values | Provides unbiased, efficient estimates under classical assumptions; foundation for many statistical models |
| **Ridge Regression** | $\min_\beta \sum_{i=1}^n (y_i - X_i\beta)^2 + \lambda\|\beta\|_2^2$ | OLS with $\ell_2$ penalty on coefficients | Shrinks coefficients to reduce variance; useful for multicollinearity and high-dimensional data |
| **Lasso Regression** | $\min_\beta \sum_{i=1}^n (y_i - X_i\beta)^2 + \lambda\|\beta\|_1$ | OLS with $\ell_1$ penalty on coefficients | Promotes sparsity; performs variable selection and regularization |
| **Elastic Net** | $\min_\beta \sum_{i=1}^n (y_i - X_i\beta)^2 + \lambda_1\|\beta\|_1 + \lambda_2\|\beta\|_2^2$ | Combines $\ell_1$ and $\ell_2$ penalties | Balances sparsity and shrinkage; effective when predictors are correlated |
| **Least Absolute Deviations (LAD)** | $\min_\beta \sum_{i=1}^n \|y_i - X_i\beta\|$ | Minimizes the sum of absolute residuals | Robust to outliers; estimates the conditional median |
| **Huber Regression** | $\min_\beta \sum_{i=1}^n L_\delta(y_i - X_i\beta)$, $L_\delta(r) = \begin{cases} \frac{1}{2}r^2 & \|r\| \le \delta \\ \delta(\|r\| - \frac{1}{2}\delta) & \|r\| > \delta \end{cases}$ | Hybrid loss: quadratic for small residuals, linear for large | Robust to outliers while retaining efficiency for small errors |
| **Quantile Regression** | $\min_\beta \sum_{i=1}^n \rho_\tau(y_i - X_i\beta)$, $\rho_\tau(r) = r(\tau - \mathbb{I}\{r < 0\})$ | Estimates conditional quantiles (e.g., median) | Useful for modeling heterogeneous effects and non-normal errors |
| **Principal Component Regression (PCR)** | OLS on principal components of $X$ | Projects predictors onto principal components before regression | Reduces dimensionality and multicollinearity; interpretable in terms of variance explained |
| **Partial Least Squares (PLS)** | OLS on latent variables maximizing covariance between $X$ and $y$ | Finds components that explain both predictors and response | Useful when predictors are highly collinear and $p > n$ |