3. Review

Meaning of Conditional Expectation

2/3 points (graded)

Consider the model $Y|\mathbf{X} \sim \mathcal{N}(\mathbf{X}^T\beta, 1)$, where $\mathbf{X}$ is a p-dimensional random variable. Here, β is a fixed constant. Indicate whether the following statements are true, or false.

$\mathbb{E}[Y|\mathbf{X}]$ is a constant random variable.

- ○ True
- ◉ False ✔

If X_i's are iid Gaussian, then the conditional mean, $\mathbb{E}[Y|\mathbf{X}]$ is Gaussian random variable. (Assume β is a real-valued vector).

- ○ True ✔
- ◉ False ✖

The expected value of Y, $\mathbb{E}[Y]$ is a non-constant random variable, if we assume that each X_i has mean μ.

- ○ True
- ◉ False ✔

Solution:

- False. Note that the conditional mean is equal to $\mathbf{X}^T\beta$, which indeed is a random variable.
- True. Note that $\mathbf{X}^T\beta = \sum_{i=1}^{p} X_i\beta_i$ is a sum of iid Gaussian random variables, and is itself a Gaussian random variable.
- False. Note that $\mathbb{E}[Y] = \mathbb{E}[\mathbb{E}[Y|\mathbf{X}]] = \mathbb{E}[\mathbf{X}^T\beta] = \sum_{i=1}^{p} \beta_i\mu$, which is constant, using the law of iterated expectations.

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ℹ Answers are displayed within the problem

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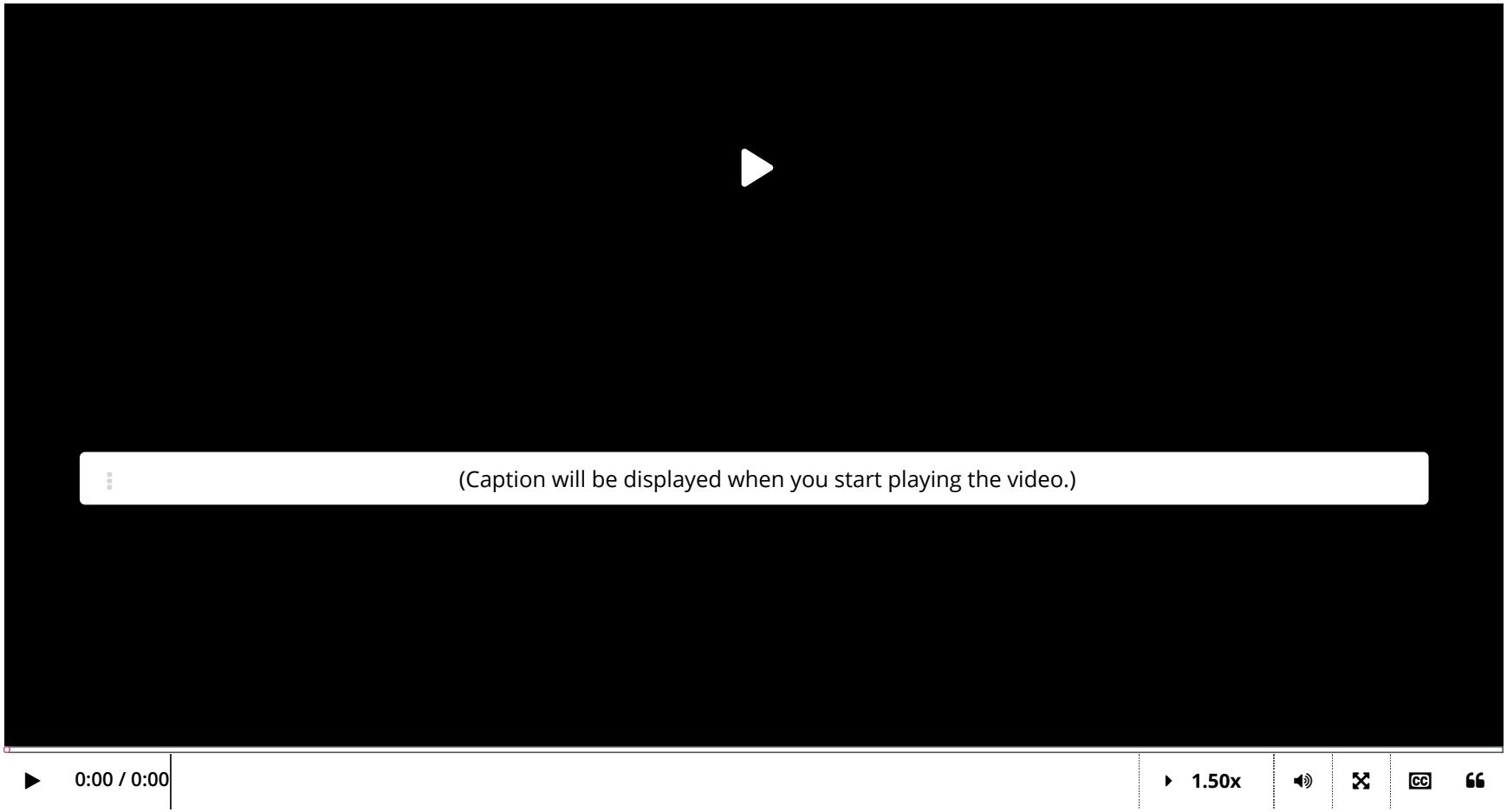

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Previously, we encountered the idea of a **regression function** . More precisely, given a pair of random variables X,Y, we can write down the function $\mu\left(x\right)$ defined to be

$$\mu\left(x\right) := \mathbb{E}\left[Y \mid X = x\right].$$

In the Linear Regression unit, the assumption was that $\mu(x)$ was a linear function of x. For example, in the one-variable case, we assumed $\mu(x) = a + bx$; and for higher dimensions, $\mu(\mathbf{x}) = \mathbf{x}^T\beta$.

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