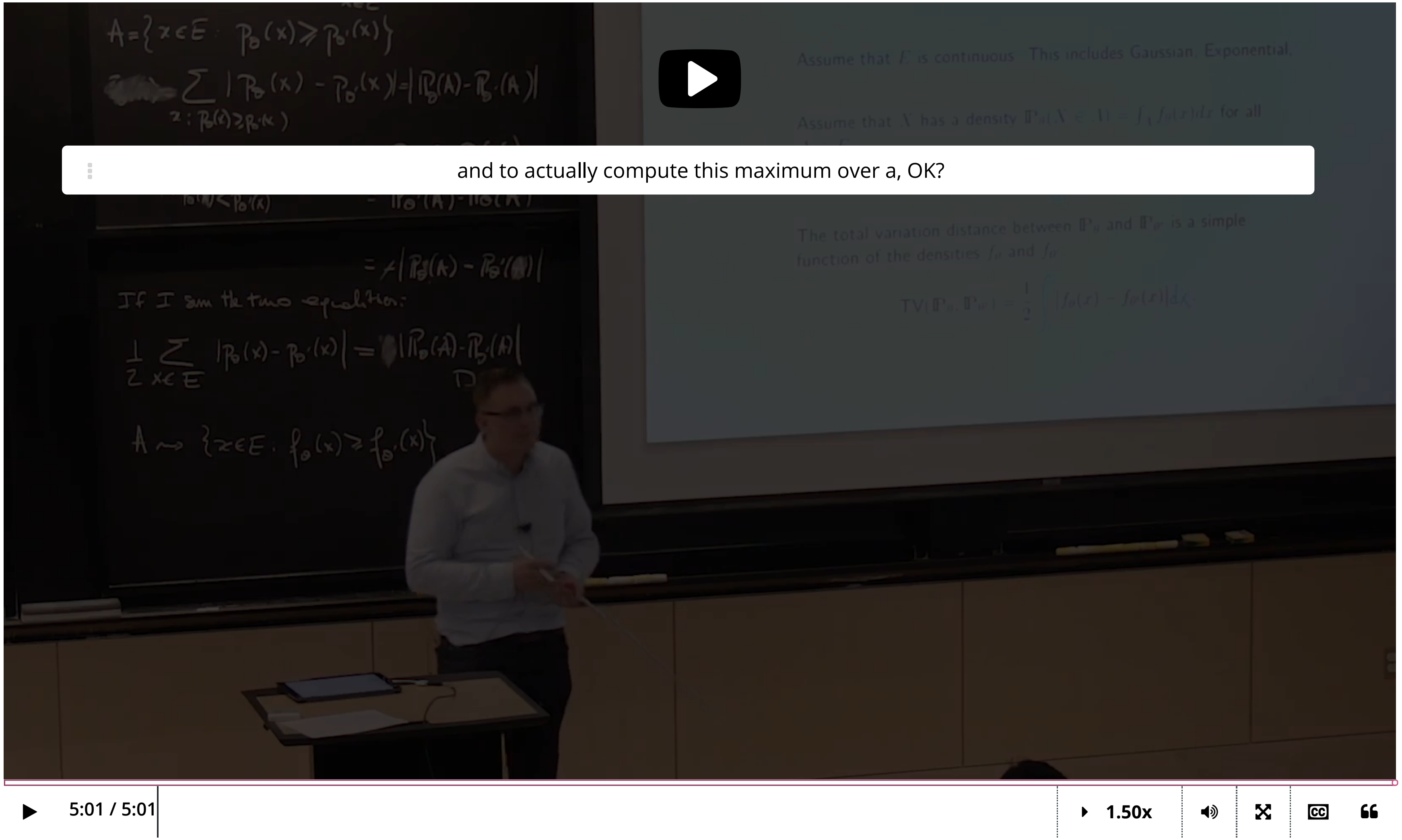
6. Total Variation Distance for Continuous Distributions

Total Variation Distance for Continuous Distributions



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Let $\mathbf{P}$ and $\mathbf{Q}$ be probability distributions on a **continuous** sample space E with probability density functions f and g. Then, the total variation distance between $\mathbf{P}$ and $\mathbf{Q}$

$$\mathrm{TV}(\mathbf{P},\mathbf{Q}) = \max_{A\subset E}|\mathbf{P}(A) - \mathbf{Q}(A)|,$$

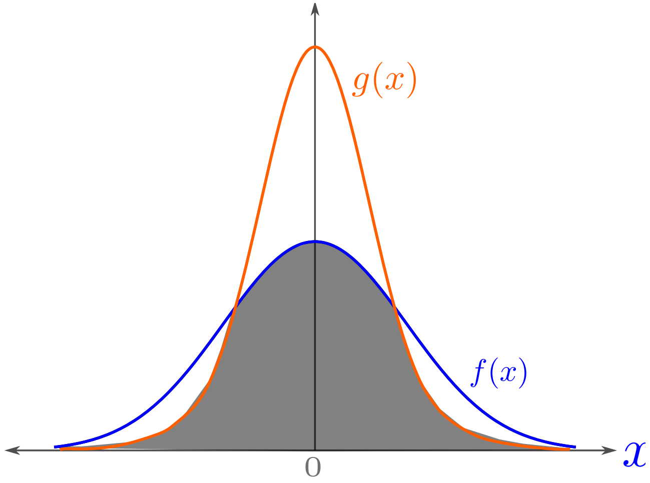
can be computed as

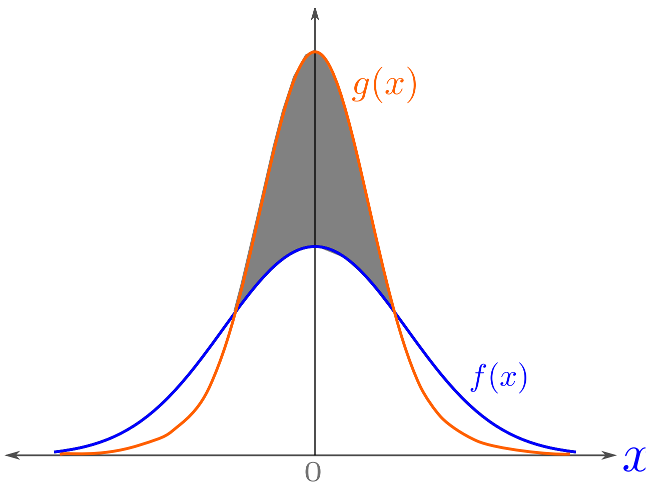
$$\mathrm{TV}(\mathbf{P},\mathbf{Q}) = \frac{1}{2}\int_{x\in E}|f(x) - g(x)|.$$

Graphical Interpretation of Total Variation

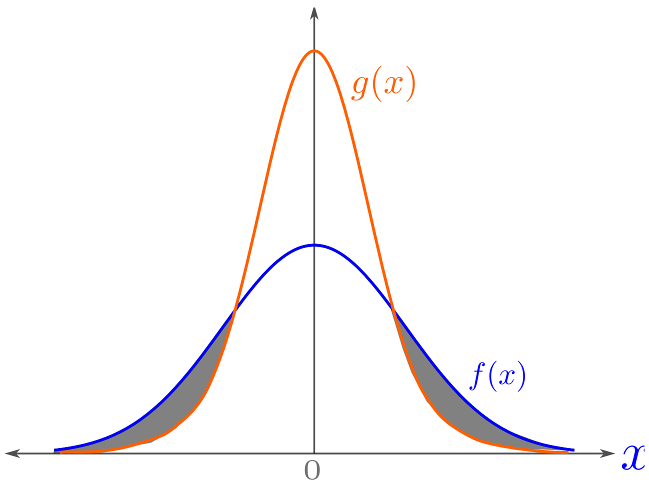
1/1 point (graded)

Let $X \sim \mathbf{P}$ and $Y \sim \mathbf{Q}$ be Gaussian random variables with mean 0. Let f denote the probability density function of X and g denote the density of Y. Which answer is a correct graphical interpretation of $2\mathrm{TV}(\mathbf{P},\mathbf{Q})$, 2 times the total variation distance between $\mathbf{P}$ and $\mathbf{Q}$?

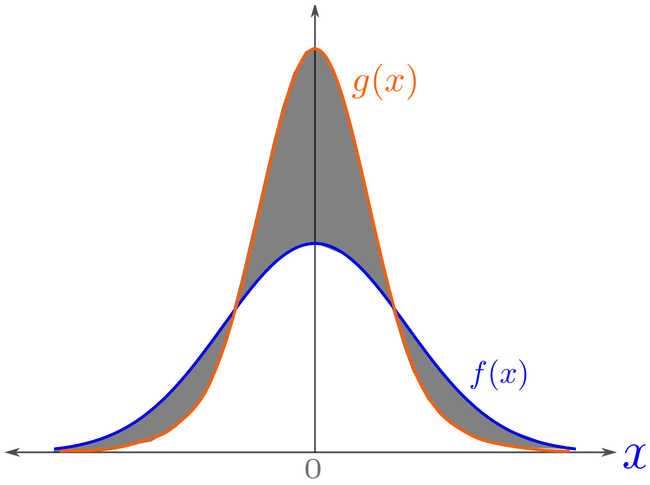




$g(x)$
$f(x)$
0
x



$g(x)$
$f(x)$
0
x

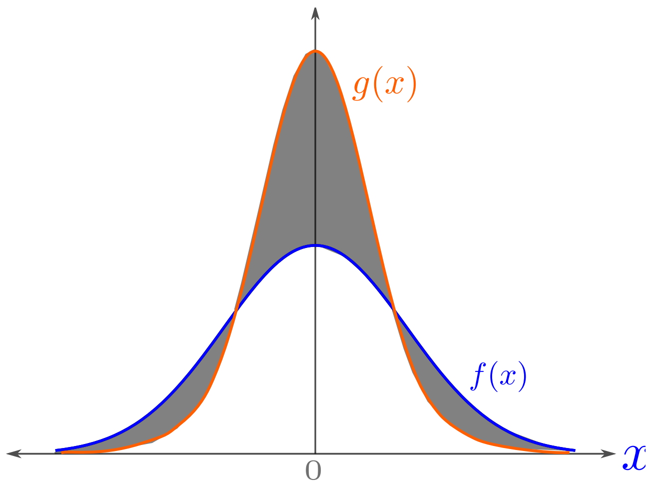


Solution:

Recall the formula for total variation when both distributions are continuous:

$$\mathrm{TV}(\mathbf{P},\mathbf{Q}) = \frac{1}{2}\int_{\mathbb{R}} |f(x) - g(x)|\, dx$$

The integral on the right hand side is precisely the (unsigned) area **between** the densities f and g:



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Answers are displayed within the problem

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