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mathematics

# Understanding statistical error bars

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- Why should we quote error bars on our measurements?
- What distinguishes a sample mean from a population mean?
- What integrals should be calculated to give the expectation and variance?
- State the central limit theorem and explain what each of the terms in this theorem represent.



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- How is the cumulative probability distribution function defined and how is the probability density function defined?
- What is the variance of the random variable  $S = \frac{1}{N} \sum_{i=1}^N X_i$  if each of the  $X_i$ s in this sum is a independent and identically distributed random variable taken from a distribution with variance  $\sigma$ ?
- Explain in your own words why a sample mean gives an estimate of the true population mean.
- Give the expression that allows you to calculate an estimate of the true population from a sample taken from that population and explain how this result is derived.



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- We can calculate a weighted sample average as  $\mu_S = \frac{1}{W} \sum_{i=1}^{N_S} w_i x_i$ , where  $W = \sum_{i=1}^{N_S} w_i$ . In these expressions the  $x_i$ s are the values of the quantities in our samples and the  $w_i$ s are the sample weights. Show, using the maths from the video, that an appropriate estimator for the population variance for this weighted sample is  $\sigma^2 = \frac{W}{W - \sum w_i^2} \frac{1}{W} \sum_{i=1}^{N_S} w_i (x_i - \mu_S)^2$ , where  $W_2 = \sum_{i=1}^{N_S} w_i^2$ .