**Measure of Variation**

* **Range**
  + R = Xhighest – Xlowest
* **Variance**
  + Sample variance:
    - ← shortcut formula; does not need x-bar
    - For grouped frequency data, replace (∑ Xi)2 with (∑ f ⋅ Xm)2 and Xi2 with f ⋅ Xm2
  + Population variance:
  + Sample variance is used to estimate population variable
  + Dividing by (n – 1) gives an unbiased estimate of σ2
* Standard deviation = square root of variance
  + Sample standard deviation = s
  + Population standard deviation = σ
* Variance/standard deviation is always positive (or zero)
* The sum of variations (x – x-bar) is always zero
* The larger the value of s or s2, the larger the variability
* **Empirical (normal) rule**
* For a normal distribution:
  + Approx. 68% of data values are within (X-bar – s, X-bar + s)
  + Approx. 95% of data values are within (X-bar – 2s, X-bar + 2s)
  + Approx. 99.7% of data values are within (X-bar – 3s, X-bar + 3s)
* **Chebyshev’s Theorem:**
  + In any distribution (regardless of shape), the proportions of values that fall within k standard deviations of the mean is at least  **1 – 1/k2**, where k > 1 and is not necessarily an integer