# Probability Formula Review



## I. Types and characteristics of probability

A. Types of probability

1. Classical: $P(A) = \frac{A}{N}$ 2. Empirical: $P(A) = \frac{A}{n}$

3. Subjective: Use empirical formula assuming past data of similar events is appropriate.

B. Probability characteristics

1. Range for probability: $0 \leq P(A) \leq 1$ 2. Value of complements: $P(\tilde{A}) = 1 - P(A)$

## II. Probability rules



A. **Addition** is used to find the sum or union of 2 events.

1. General rule: P(A or B) = P(A) + P(B) - P(A and B)

2. Special rule: P(A or B) = P(A) + P(B) is used when events are mutually exclusive.

B. **Multiplication** is used to determine joint probability or the intersection of 2 events.

1. General rule: P(A and B) = P(A) $\times$ P(B I A)

2. Special rule: P(A and B) = P(A) $\times$ P(B) is used when the events are independent.

**Note:** For independent events, the joint probability is the product of the marginal probabilities.

C. **Bayes' theorem** is used to find conditional probability.

$$P(A|B) = \frac{P(A) \times P(B|A)}{P(A) \times P(B \mid A) + P(\tilde{A}) \times P(B \mid \tilde{A})}$$

**Note:** The denominator is when condition B happens. It happens with A and with $\tilde{A}$.

## III. Counting rules

A. The **counting rule of multiple events:** If one event can happen M ways and a second event can happen N ways, then the two events can happen (M)(N) ways. For 3 events, use (M)(N)(O).

B. **Factorial rule** for arranging all of the items of one event: N items can be arranged in N! ways.

C. **Permutation rule** for arranging some of the items of one event: (order is important: a, b, c and c, a, b are different)

$${}_{N}P_{R} = \frac{N!}{(N-R)!}$$

D. **Combination rule** for choosing some of the items of one event: (order is not important: abc and cba are the same and are not counted twice)

$${}_{N}C_{R} = \frac{N!}{(N-R)!(R!)}$$

## IV. Discrete probability distributions



A. **Probability distributions**

1. $P(x) = [x \bullet P(x)]$ is calculated for each value of x.

2. Mean of a probability distribution: $\mu = E(x) = \Sigma[x \bullet P(x)]$

3. Variance of a probability distribution: $V(x) = [\Sigma x^2 \bullet P(x)] - [E(x)]^2$

B. **Binomial distributions**

$$P(x) = \frac{n!}{x!(n-x)!} p^x q^{n-x}$$ where

| | |
|---|---|
| n is number of trials | x is number of successes |
| p is probability of success | q, the probability of failure, is 1 - p |
| $\mu = np$, $\sigma^2 = npq$ and $\sigma = \sqrt{npq}$ | |

C. **Poisson distributions**

$$P(x) = \frac{\mu^x e^{-\mu}}{x!}$$ where $\mu = np$

Poisson approximation of the binomial requires $n \geq 30$ and $np < 5$ or $nq < 5$.

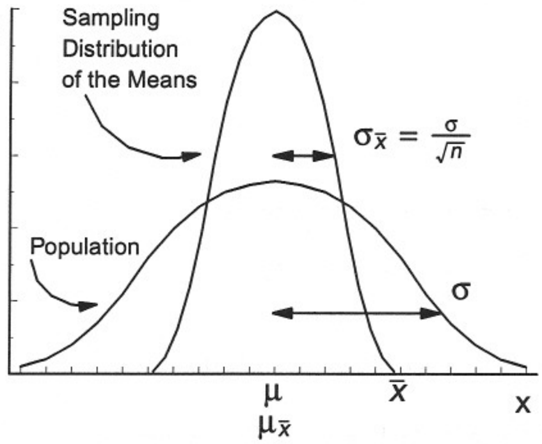
## V. The continuous normal probability distribution

A. To find the probability of x being within a given range: $z = \frac{x-\mu}{\sigma}$

Normal approximation of the binomial requires $n \geq 30$ and both np and nq are $\geq 5$. The continuity correction factor applies.

B. To find a range for x given the probability: $\mu \pm z\sigma$

## VI. Central limit theorem




If $n \geq 30$, the population may be skewed.

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## VII. Point estimates

A. $\bar{x}$ for $\mu$ B. $s$ for $\sigma$ C. $\bar{p}$ for $p$ D. $S_{\bar{x}}$ for $\sigma_{\bar{x}}$ where $S_{\bar{x}} = \frac{s}{\sqrt{n}}$ and $\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$

## VIII. Interval estimates when n $\geq$ 30

A. For a population mean $\bar{x} \pm z\frac{\sigma}{\sqrt{n}}$ or $\bar{x} \pm z\frac{s}{\sqrt{n}}$

**Note:** Use the finite correction factor in section VIII formulas when n/N $\geq$ .05. $\sqrt{\frac{N-n}{N-1}}$

B. For a population proportion $\bar{p} \pm z\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$ where $\bar{p} = \frac{x}{n}$

**Section VIII Note:** When n < 30 and σ is unknown, the t distribution, to be discussed in chapter 16, must be substituted for the z distribution when making interval estimates. Many statistics software programs do all interval calculations, regardless of sample size, using the t distribution.

## IX. Determining sample size

A. When estimating the population mean $n = \left(\frac{z\sigma}{E}\right)^2$

B. When estimating the population proportion $n = \bar{p}(1-\bar{p})\left(\frac{z}{E}\right)^2$