

# Probability Formula Review

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## 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:  $P(\bar{A}) = 1 - P(A)$

## II. Probability rules

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

1. General rule:  $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$
2. Special rule:  $P(A \text{ or } B) = P(A) + P(B)$  is used when events are mutually exclusive.

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

1. General rule:  $P(A \text{ and } B) = P(A) \times P(B | A)$
2. Special rule:  $P(A \text{ and } B) = P(A) \times P(B)$  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.

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

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

## 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.  $P(x) = [x \cdot P(x)]$  is calculated for each value of x.
2. Mean of a probability distribution:  $\mu = E(x) = \sum [x \cdot P(x)]$
3. Variance of a probability distribution:  $V(x) = [\sum x^2 \cdot P(x)] - [E(x)]^2$

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### B. Binomial distributions

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

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

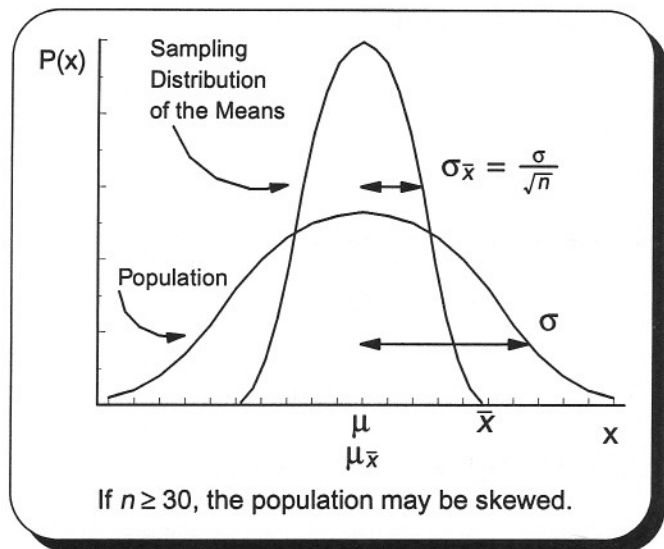
$$P(x) = \frac{\mu^x e^{-\mu}}{x!} \quad \text{where } \mu = np$$

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



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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  $\bar{x} \pm z \frac{s}{\sqrt{n}}$

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

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

**Section VIII Note:** When  $n < 30$  and  $\sigma$  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  $n = \bar{p}(1-\bar{p})\left(\frac{z}{E}\right)^2$