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| **Name** | Equation | Notes |
| **Set Theory** | | |
| **Inclusion Exclusion** |  | * Calculate all of the sizes of intersections of sets, Venn diagrams |
| **DeMorgan’s Law** |  | * Both sides of these are equal by DeMorgan’s Law |
| **Probabilities** | | |
| **Factorial** |  | * 4! = (1\*2\*3\*4) * # of order of *n* number of objects |
| **N chose K** |  | * Used to determine subsets of items in a larger set |
| **Binomial Theorem** |  |  |
| **Stirling Approximation** |  |  |
| **Compliment Rule** |  |  |
| **General Probability** |  | * A of Hearts = 1-(51c5/52c5) = .096% * A QUEEN = 1-P(Not a Queen) = 1-(48c5/52c5) * 1 - (1,712,304 / 2,598,960) = 0.341% * A HEART =1-P(Not a Heart)= 1-(39c5/52c5) * 1 - (1,712,304 / 2,598,960) = 0.778% * 4 cards same suit = (4c1) (13c4) / (52c4) |
| **Conditional Probability (Product Rule)** |  | * Simpler way to calculate probabilities |
| **Independent Probability** |  | * Something is considered Independent if the intersection and the product of the two sets are equal |
| **Sequential Probabilities** |  | * (Top Formula) An urn contains one red and one black ball. Each time, a ball is drawn independently at random from the urn, and then returned to the urn along with another ball of the same color. For example, if the first ball drawn is red, the urn will subsequently contain two red balls and one black ball. * A box has seven tennis balls. Five are brand new, and the remaining two had been previously used. Two of the balls are randomly chosen, played with, and then returned to the box. Later, two balls are again randomly chosen from the seven and played with. What is the probability that all four balls picked were played with for the first time? * An urn contains *n* white and *m* black balls. The balls are withdrawn one at a time randomly until all remaining balls have the same color. Find is the probability that: |
| **Total Probability** |  | * 60% of our students are American (born), and 40% are foreign (born). 20% of the Americans and 40% of the foreigners speak two languages. What is the probability that a random student speaks two languages? = 0.6 \* 0.2 + 0.4 \* 0.4 = 0.28 |
| **Bayes Rule** |  | * Helps calculate probabilities that are harder to do directly. |
| **Statistics** | | |
| **Expected Probability** |  | Top formula – General  Bottom formula – for Equiprobable – i.e. Fair die Expected Value |
| **Variance** | **Variance**  **Standard Deviation** | E = Expected Probability  μ = Mean  Standard Deviation = Always Positive |
| **Bernoulli Distribution** |  | The simplest form of distribution |
| **Binomial Distribution** |  |  |
| **Poisson Distribution** |  | * Used when you have very large *n* with a small *p*. |
| **Geometric Distribution** |  | * Determine the first occurrence of a probability * A die is rolled until the number 1 turns up. The expected number of rolls is = 1/p = 6 |
| **Continuous Distributions** | **PDF =**  **P(A) =**  **Mean or E(X) =**  **V(X) =** |  |
| **Uniform Distributions** | **PDF =**  **CDF =** |  |
| **Exponential Distributions** | **PDF**  **CDF** |  |
| **Normal (Gaussian) Distribution** |  |  |
| **Markov Inequality** |  | * In a town of 30 families, the average annual family income is $80,000. What is the largest number of families that can have income at least $100,000 according to Markov’s Inequality? * 80,000/100,000 = 0.8 * 30 \* 0.8 = 24 |
| **Chebyshev's Inequality** |  | * Either of the two formulass work. They will result in the same answer. |
| **Moment Generating Function (MGF)** |  |  |
| **Chernoff Bound** |  |  |
| **Central Limit Theorem** |  | * Let X be a random variable with µ = 10 and σ = 4. If X is sampled 100 times, what is the approximate probability that the sample mean of these 100 observations is less than 9? * P(X^100<=9) = (9-10) / (4/sqrt(100)) = 2.5 * Use Z-Table = 1- .9938 |
| **Bias** |  | * Expected – Mean = Bias |
| **Mean Square Error (MSE)** |  | * Standard Deviation Squared * *n* = Number of Samples taken (not the total population) |
| **S^2 Estimation**  **(Sample Squared Experiments)** | **Sample Mean**  **“Raw Variance”**  **Unbiased Sample Variance**  **Expectation**  **Experiments** | * Figure out the mean, standard deviation for a sub set of the population (the sample) * *n* = number of experiments ran * Mean calculation here is simple – add them up and divide them by the count * X(overline) = Sample Mean * Note: Raw Variance is the same as np.var * Unbiased variance can be calculated by using np.var and multiplying by n/1-n |