|  |  |  |  |
| --- | --- | --- | --- |
| **M&M Color** | **Frequency of Plain** | **Frequency of Peanut** | **Total** |
| **Brown** | 112 | 36 | 148 |
| **Yellow** | 105 | 63 | 168 |
| **Red** | 109 | 40 | 149 |
| **Orange** | 327 | 60 | 387 |
| **Green** | 314 | 57 | 371 |
| **Blue** | 288 | 66 | 354 |
| **Total** | **1255** | **322** | **1577** |

Table : Contingency Table for Color and Type of M&M

**Note:** Each example below involves drawing one M&M and using the frequencies in the above contingency table to calculate the probabilities.

|  |  |
| --- | --- |
| **Essential Rules and Definitions of Probability** | |
| **Any probability is a number between 0 and 1** | All possible outcomes together must have probability 1 |
|  | , where S = sample space |
| **Mutually Exclusive Events** | Complement Rule |
| Question What is the probability of drawing a blue and green M&M? | Question What is the probability of drawing any color except red? |
| **Define** **events** A and B as follows…  A = draw a blue M&M B = draw a green M&M | **Define event** A as follows…  A = draw a red M&M |
| Procedure Recognize that you cannot draw one M&M that is both blue and green. Colors of M&Ms are mutually exclusive, which means the events A and B do not share any common outcome. | Procedure Find the probability of drawing a red M&M and subtract that probability from 1. |
| Answer | Formula |
|  | Answer |

|  |  |
| --- | --- |
| **Calculate Marginal Probabilities (Total Row or Column)** | |
| **Question**  What is the probability of drawing a blue M&M? | **Question**  What is the probability of drawing a peanut M&M? |
| **Define** **event** A as follows…  A = draw a blue M&M | **Define event** B follows…  B = draw a peanut M&M |
| **Procedure**  Divide the number of blue M&Ms by the total number of M&Ms. | **Procedure**  Divide the number of peanut M&Ms by the total number of M&Ms. |
| **Formula**  P(A) = | **Formula**  P(B) = |
| **Answer**  P(A) = = 0.22 | **Answer**  P(B) = = 0.20 |

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| --- | --- |
| **Calculate Probabilities with the Addition Rule** | |
| **Non-Overlapping Events** | **Overlapping Events** |
| **Question**  What is the probability of drawing a blue or a green M&M? | **Question**  What is the probability of drawing a blue or a peanut M&M? |
| **Define** **events** A and B as follows…  A = draw a blue M&M B = draw a green M&M | **Define events** A and B as follows…  A = draw a blue M&M B = draw a peanut M&M |
| **Procedure**  Add the probability of drawing a blue M&M to the probability of drawing a green M&M. | **Procedure**  Add the probability of drawing a blue M&M to the probability of drawing a green M&M and subtract the overlapping amount because it was counted twice, i.e., subtract the joint probability of drawing an M&M that is both blue and peanut. |
| **Formula** | **Formula** |
| **Answer** | **Answer** |

|  |  |
| --- | --- |
| **Calculate Joint Probabilities from a Contingency Table** | |
| **Question**  What is the probability of drawing a blue and peanut M&M? | **Question**  What is the probability of drawing a plain and red M&M? |
| **Define** **events** A and B as follows…  A = draw a blue M&M B = draw a peanut M&M | **Define events** A and B as follows…  A = draw a plain M&M B = draw a red M&M |
| **Procedure**  Divide the number of blue peanut M&Ms by the total number of M&Ms. | **Procedure**  Divide the number of red plain M&Ms by the total number of M&Ms. |
| **Formula**  P(A and B) = | **Formula**  P(A and B) = |
| **Answer**  P(A and B) = = 0.04 | **Answer**  P(A and B) = |

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| **Calculate Conditional Probabilities from a Contingency Table** | |
| **Question**  What is the probability you drew a blue M&M if you know you drew a peanut M&M? | **Question**  What is the probability you drew a plain M&M if you know you drew a red M&M? |
| **Define events** A and B as follows…  A = draw a blue M&M B = draw a peanut M&M | **Define events** A and B as follows…  A = draw a red M&M B = draw a plain M&M |
| **Procedure**  Recognize that the probability you drew a blue M&M without knowing the type might be different from the probability you drew a blue M&M with knowing the type.  If you know the type, there is no reason to use the total number of M&Ms to calculate the probability. The denominator now becomes the total number of peanut M&Ms, because you know the M&M is peanut. | **Procedure**  Recognize that the probability you drew a plain M&M without knowing the color might be different from the probability you drew a plain M&M with knowing the color.  If you know the color, there is no reason to use the total number of M&Ms to calculate the probability. The denominator now becomes the total number of red M&Ms, because you know the M&M is red. |
| **Independent or Dependent?**  Events A and B are independent events if the following statement is true: | **Independent or Dependent?**  Events A and B are independent events if the following statement is true: |
| **Dependent**  4 | **Dependent** |

|  |  |
| --- | --- |
| **Calculate Joint Probabilities with the Multiplication Rule** | |
| **Independent Events** | **Dependent Events** |
| **Question**  If you rolled a 5 on the first roll of a die, what is the probability of rolling a 3 on the second roll? | **Question**  What is the probability you drew a blue M&M if you know you drew a peanut M&M? |
| **Define** **events** A and B as follows…  A = roll a 5 on the first roll B = roll a 3 on the second roll | **Define events** A and B as follows…  A = draw a blue M&M B = draw a peanut M&M |
| **Procedure**  Recognize these are independent events and multiply the probability of rolling a 5 by the probability of rolling a 3. The probability of rolling a 5 on the first roll does not affect the probability of rolling a 3 on the second roll.  . | **Procedure**  Recognize these are dependent events (see previous table) and multiply the following two probabilities together:   * The probability you drew a blue M&M **given** you know you drew a peanut M&M * The probability you drew a peanut M&M. |
| **Formula** | **Formula** |
| **Answer** | **Answer** |

|  |  |
| --- | --- |
| **Calculate Conditional Probabilities with the Conditional Probability Formula** | |
| **Question**  What is the probability you drew a blue M&M if you know you drew a peanut M&M? The probability of drawing a blue peanut M&M is 0.0419 and the probability of drawing a peanut M&M is 0.2042. | **Question**  What is the probability you drew a plain M&M if you know you drew a red M&M? The probability of drawing a red plain M&M is 0.069 and the probability of drawing a red M&M is 0.094. |
| **Define events** A and B as follows…  A = draw a blue M&M B = draw a peanut M&M | **Define events** A and B as follows…  A = draw a red M&M B = draw a plain M&M |
| **Procedure**  Organize what is given in the problem… | **Procedure**  Organize what is given in the problem… |
| **Formula** | **Formula** |
| **Answer** | **Answer** |
| **Compare to Contingency Table Solution…** | **Compare to Contingency Table Solution…** |