Class Time:

Names:

Probability: M and Ms Probability Lab

Student Learning Outcome:

- The student will calculate theoretical and empirical probabilities.
- The student will appraise the differences between the two types of probabilities.
- The student will demonstrate an understanding of long-term probabilities.

Theoretical Table

Color	Quantity
Yellow Y	
Green G	
Blue BL	
Brown B	
Orange O	
Red R	

Empirical Table

With Replacement Table	Without Replacement Table
(,) (,)	(,) (,)
(,) (,)	(,) (,)
(,) (,)	(,) (,)
(,) (,)	(,) (,)
(,) (,)	(,) (,)
(,) (,)	(,) (,)
(,) (,)	(,) (,)
(,) (,)	(,) (,)
(,) (,)	(,) (,)
(,) (,)	(,) (,)
(,) (,)	(,) (,)
(,) (,)	(,) (,)

Directions:

- Count out 40 mixed-color M&M's® which is 1 small bag's worth (some distance learning classes that are using the virtual lab should count out 25).
- **<u>Record the number of each color in the Theoretical Table</u>. Use the information from this table to complete the theoretical probability questions after you have done the experiment (explained in the steps below).**
- Next, put the M&M's in a cup.
- The experiment is to pick 2 M&M's, one at a time. Do NOT look at them as you pick them.
- The <u>first time through</u>, replace the first M&M before picking the second one. Record the results in the "**With Replacement**" column of the **empirical table**. Do this 24 times.
- The <u>second time through</u>, after picking the first M&M, do NOT replace it before picking the second one. Then, pick the second one. Record the results in the "**Without Replacement**" column section of the **empirical table**. After you record the pick, put BOTH M&M's back. Do this a total of 24 times.

- Use the data from the empirical table to calculate the empirical probability questions. **Leave your answers in unreduced fractional form. Do NOT multiply out any fractions.**

	Theoretical Probabilities (USE the Theoretical Table: See ** below)		**Empirical Probabilities (USE the Empirical Tables)**	
	With Replacement	**Without Replacement**	**With Replacement**	**Without Replacement**
P(2 reds):	_____	_____	_____	_____
P(R_1B_2 or B_1R_2):	_____	_____	_____	_____
P(R_1 and G_2):	_____	_____	_____	_____
P(G_2 | R_1):	_____	_____	_____	_____
P(no yellows):	_____	_____	_____	_____
P(doubles):	_____	_____	_____	_____
P(no doubles):	_____	_____	_____	_____

Note: G_2 = green on second pick; R_1 = red on first pick; doubles = both picks are the same color. B_1 = brown on first pick; B_2 = brown on second pick.

**** Optional** (Ask your instructor): Create two trees from the Theoretical Table. One tree is a "With Replacement" tree and the other is a "Without Replacement" tree. Use the trees to fill in the Theoretical Probabilities. Hint: On the first pick for each tree, you have 6 colors to choose from. Hand in your trees stapled to the rest of the lab.

Formulas: C and D are events.

- Multiplication Rule: P(C AND D) = P(C)·P(D|C). If C and D are independent events, then P(C AND D) = P(C)·P(D). Using algebra, P(D|C) = P(C AND D)÷P(C).
- Addition Rule: P(C OR D) = P(C) + P(D) – P(C AND D). If C and D are mutually exclusive events,

then P(C OR D) = P(C) + P(D).

- C' and C are complementary events. P(C) + P(C') = 1.

Questions (ANSWER IN COMPLETE SENTENCES AND WRITE OR PRINT CLEARLY):

1. Why are the "With Replacement" and "Without Replacement" probabilities different?

2. Convert **P(no yellows)** to decimal format for both Theoretical Table "With Replacement" and for the Empirical Table "With Replacement". Round to 4 decimal places.

   - Theoretical Table "With Replacement": **P(no yellows) = _____**
   - Empirical Table "With Replacement": **P(no yellows) = _____**

   Questions

   - Are the decimal values "close"? _____ (YES or NO)
   - Did you expect them to be closer together or farther apart? _____ Why?

3. If you increased the number of times you picked 2 M&M's to 240 times, why would empirical probability values change? (Read #4 before you answer this question. They are different questions).

4. Would this change (See #3 above) cause the empirical probabilities and theoretical probabilities to be closer together or farther apart? How do you know?

5. Explain the differences in what $P(R_1 \text{ and } G_2)$ and $P(G_2 \mid R_1)$ represent. Hint: Think about the sample space for each probability.