Name: ______________________________

M and Ms Probability Lab

Student Learning Outcomes:

- 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	**8**
Green G	**7**
Blue BL	**5**
Brown B	**6**
Orange O	**9**
Red R	**5**

Empirical Table

With Replacement Table	Without Replacement Table
(Y , G) (O , R)	(Y , O) (Y , G)
(BL , R) (G , B)	(Y , R) (O , BL)
(O , G) (O , BL)	(BL , G) (G , Y)
(BL , Y) (BL , Y)	(O , G) (O , BL)
(Y , Y) (R , R)	(O , Y) (Y , O)
(G, B) (G , O)	(R , Y) (BL , G)
(Y , Y) (BL , BL)	(BL , B) (Y , G)
(BL , BL) (B , R)	(B , R) (G , R)
(Y , R) (BL , Y)	(R , G) (BL , B)
(R , B) (G , Y)	(O , BL) (O , G)
(R , B) (BL , BL)	(B , G) (Y , B)
(O , O) (B , G)	(O , BL) (R , BL)

Direction

- Count out 40 mixed-color M&M's®
- **<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**	**With Replacement**	**Without Replacement**
P(2 reds):	_(5/40)*(5/40)__	____(5/40)(4/39)__	_________1/24__	______0/24________
	Multiply the probability of getting a red with the probability of getting another red. Since this is with replacement, then the probabilities stay the same from the first trial to the next. P = 5/40 each time because there are 5 reds in the bunch of 40 M&Ms	Multiply the probability of getting a red with the probability of getting another red. Since this is without replacement, then the probabilities change from the first trial to the next. P = 5/40 for the first M&M because there are 5 reds in the bunch of 40 M&Ms However, once you remove one red M&M, then P=3/39 because there are only 3 reds left in the bunch of the remaining 39 M&Ms	For this look at the outcomes in the Empirical Table. In the With Replacement column there is only one instance out of the 24 trials, where two reds appear together: the (R , R) So, the probability is 1/24	For this look at the outcomes in the Empirical Table. In the Without Replacement column there is no instance out of the 24 trials, where two reds appear together. So, the probability is 0/24
$P(R_1B_2 \text{ or } B_1R_2)$:	________________	________________	________________	________________
$P(R_1 \text{ and } G_2)$:	________________	________________	________________	________________
$P(G_2 \| R_1)$:	____7/40_________	___7/39________	______0/3______	______1/3________
	This is a conditional probability. Given	This is a conditional probability. Given	For this look at the outcomes in the	For this look at the outcomes in the

	that red was pulled first, what is the probability that a Green is pulled second. These trials are independent because we are replacing, so the probability of pulling Green in the second spot does not depend on pulling Red the first time. The probability here is just P(G)	that red was pulled first, what is the probability that a Green is pulled second. P(R1) = 5/40 P(G2) = 7/39 P(R1 and G2) = (5/40)*(7/39) Use the formula: P(G2|R1)=P(G2 and R1)/P(R1) Which simplifies to 7/39	Empirical Table. In the With Replacement column I highlighted all the instances where R appears first. We are only interested in these instances, since we are given that R occurred first. Out of these instances, none of them have G second, so P(G2|R1) = 0	Empirical Table. In the Without Replacement column I highlighted all the instances where R appears first. We are only interested in these instances, since we are given that R occurred first. Out of these instances, one of them have G second, so P(G2|R1) = 1/3
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.

Probability Trees: 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.