2020 Spring ELEC 1100 – Lab Homework

**Complete the lab homework summary sheet and submit to Canvas before the deadline.

****Submission Deadline: upload to your Canvas LA1/LA2/LA3 page before 11:50am (in the morning) on Apr 09 (Thu).**

- 50% penalty mark will be given to a late submission within 3 hours.
- Zero mark will be given to more than 3-hour late submission.

Lab Homework must be submitted as a single **Word document**. It is recommended to follow the scheme given in the summary sheet and directly type in your answers (or draw diagrams, or paste the screenshot of your Tinkercad simulation results). Pasting photos of handwritten steps are acceptable. However, it is your responsibility to ensure that the handwritten parts are readable. Those in cursive handwriting will NOT be graded.

It is allowed to discuss with others regarding the general approaches. It is NOT acceptable to work together on a detailed solution, to copy a solution, or give away a solution.

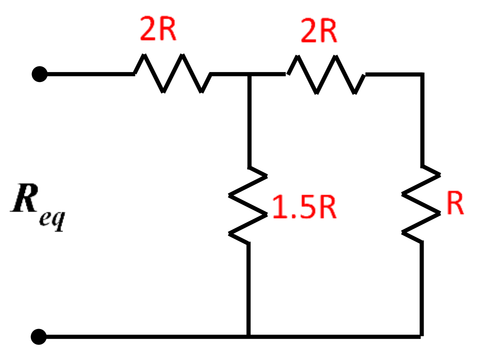
This lab homework accounts for 15% of your overall grade.
Copying from each other will result in zero mark.

Task 1: Resistor Circuit [3 points]

Step 1: Construct the circuit below in Tinkercad. Use multimeter to measure the equivalent resistance R_{eq}.

Let R be the number represented by the last 2 digits of your student ID. For example, if your student ID is 12345678, then R = 78 (kΩ).

If the last 2 digits in your student ID is "00", use "R=50 kΩ" for this question.



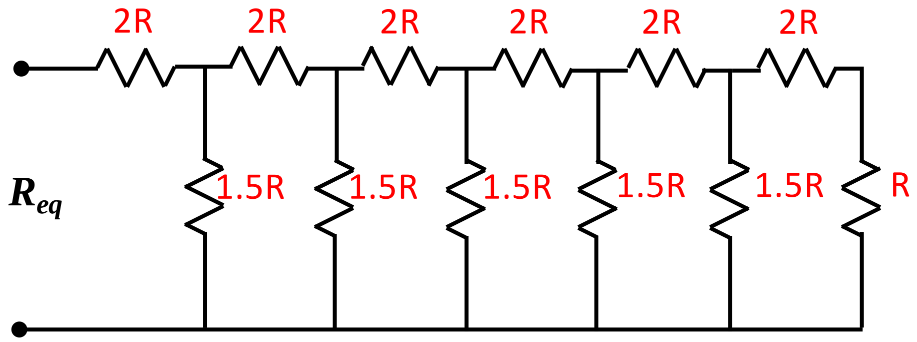
Q1: Write down the value of your R, 1.5R, 2R,

R=______________kΩ; 1.5R=______________kΩ; 2R=______________kΩ

(Use your own student ID!!! Fail to do so will result in a zero mark in Task 1.)

Q2: Include a screenshot of your "Step 1" Tinkercad simulation result below, show clearly the layout of your breadboard and the reading resistance on multimeter.

Step 2: Keep using your own "R" value to construct the circuit below in Tinkercad and measure the equivalent resistance R_{eq}.



Q3: Include a screenshot of your "Step 2" Tinkercad simulation result below, show clearly the layout of your breadboard and the reading resistance on multimeter.

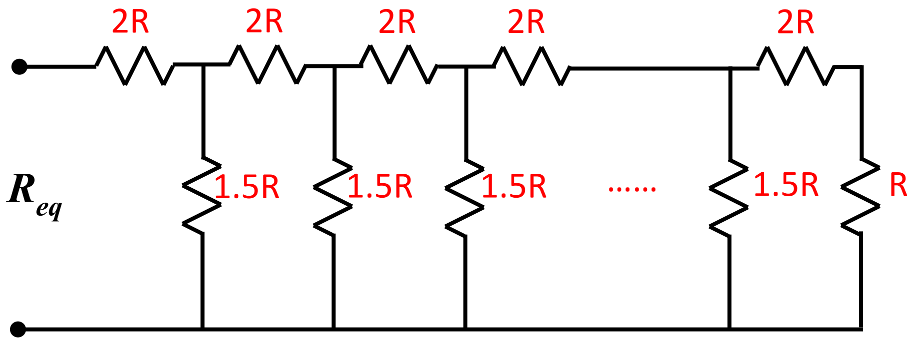
Q4: Include your Tinkercad simulation link of the circuit used in Step 2.

Tinkercad Simulation Link

Task 1:	

Q5: Based on the results you got above, compare the two measured R_{eq} values at Steps 1 & 2. Are the two values the same?

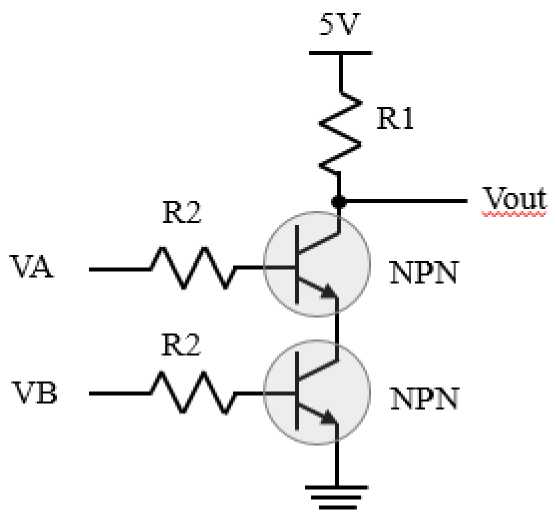
Step 3: Based on what you got above, show calculation steps that for a circuit with infinite modules (R, 1.5R, 2R) as below, the equivalent resistance R_{eq} = 3R.



Q6: Show your steps of obtaining R_{eq} = 3R.

Task 2: Transistor Circuit [5 points]

Step 1: Construct the transistor circuit below in Tinkercad.



Assign resistances to R1 and R2 as below.

R1= (1 + x/100) kΩ, R2= (1 + y/100) kΩ.

Let x be the 3rd and 4th digits of your student ID and y be the 5th and 6th digits of your student ID. For example, if your student ID is 12345678, then your R1 = 1.34 (kΩ) and R2 = 1.56 (kΩ).

Q7: Write down the values of your R1 and R2.

R1=___________kΩ; R2=__________kΩ;

(Use your own student ID!!! Fail to do so will result in a zero mark in Task 2.)

Step 2: Use the given voltage values of V_A and V_B below to run simulation in Tinkercad, while a multimeter measuring the voltage at V_{out}.

Q8: Fill in the table with the measured value of V_{out}.

Case	V_A	V_B	V_{out}
(a)	0V	0V	
(b)	0V	5V	
(c)	5V	0V	
(d)	5V	5V	

Q9: Include **4** simulation screenshots of each case above. Each screenshot should show clearly the layout of your breadboard and the reading voltage of V_{out} on multimeter.

Q10: Include your Tinkercad simulation link below.

Tinkercad Simulation Link

Task 2:	

Q11: Translate the obtained voltage table in Q8 to a binary truth table, i.e. consider high value 5V as binary "1" and low value around 0 as binary "0". Complete the truth table below.

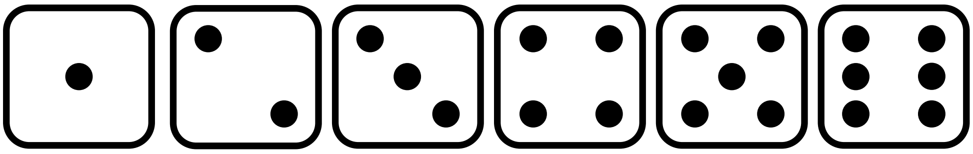
Case	V_A	V_B	V_{out}
(a)	0	0	
(b)	0	1	
(c)	1	0	
(d)	1	1	

Q12: From all the logic gates you learnt in Lecture 11, which one is implemented by this transistor circuit?

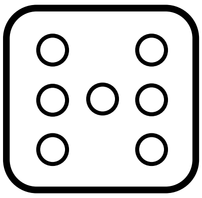
(1) indicate it's name;
(2) indicate it's logic output expression with the two inputs A, B;
(3) draw its' logic gate symbol.

Task 3: Digital Dice Decoder [7 points]

Consider the case of a single dice. On each of its six sides, one of the following patterns appears, representing the numbers 1 to 6.

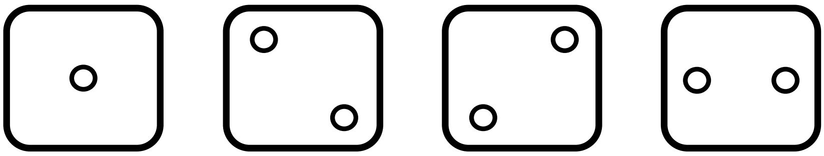


These patterns are traditional. You can think of them as seven lights to be turned "ON" with a given "High" voltage.

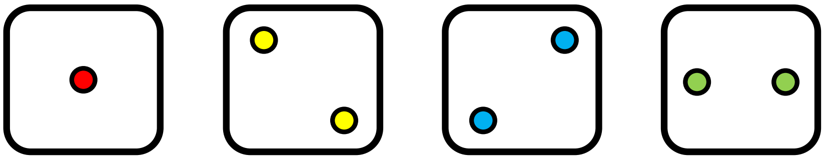


By turning on the appropriate lights, you can create any one of the six patterns on the face of a dice.

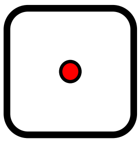
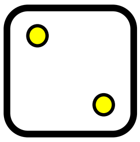
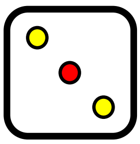
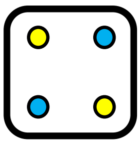
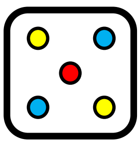
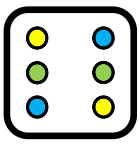
On closer inspection, there are only **four unique patterns** from which the pattern for any face can be formed.



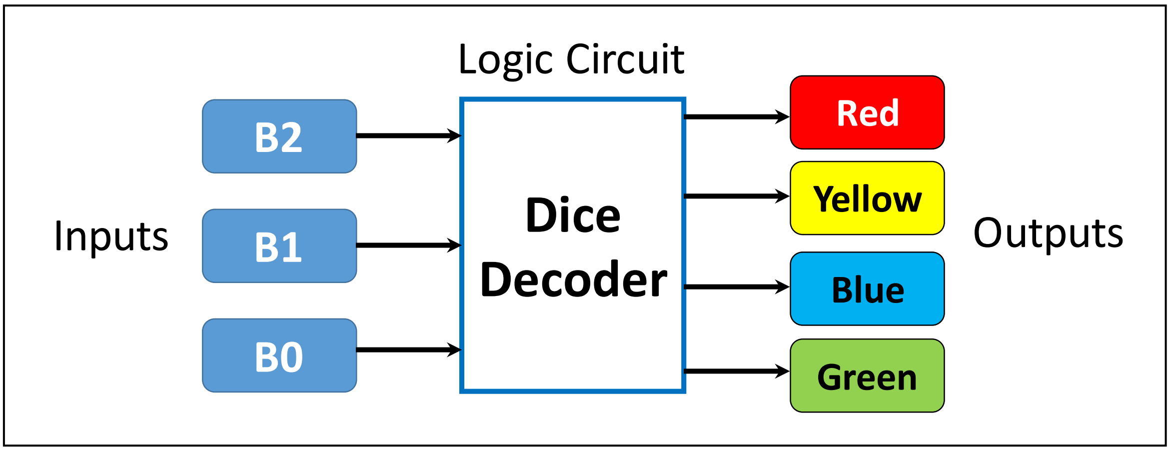
If we use different colors for each of these base patterns, a digital dice display can be made using 4 sets of LEDs: “Red”, “Yellow”, “Blue”, “Green”.



When driven by a 3 bit binary input B2, B1, B0 (where B2 is the MSB and B0 is the LSB) from 1 to 6, the dice display of the **Four Base Patterns** (Red, Yellow, Blue, Green) are as shown in the table.

Dice face	**B2 B1 B0**		**Four Base Patterns**			
			Red	**Yellow**	**Blue**	**Green**
	0 0 0					
1	**0 0 1**		√			
2	**0 1 0**			√		
3	**0 1 1**		√	√		
4	**1 0 0**			√	√	
5	**1 0 1**		√	√	√	
6	**1 1 0**			√	√	√
	1 1 1					

In this task, you need to design a logic circuit to control the four base patterns (Red, Yellow, Blue and Green) displaying the dice face according to the binary input B2, B1, B0 indicating numbers 1 to 6.



Step 1: Complete the truth table of "Red", "Yellow", "Blue" and "Green", respectively.

Q13: Complete the truth table below.

B2	B1	B0	**"Red"**
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

B2	B1	B0	**"Yellow"**
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

B2	B1	B0	**"Blue"**
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

B2	B1	B0	**"Green"**
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Step 2: Draw **K-map** for each of above to obtain the **logic expression** of outputs "Red", "Yellow", "Blue" and "Green" from the inputs B2, B1, B0.

Q14: K-map & logic expression for each of the four base patterns.

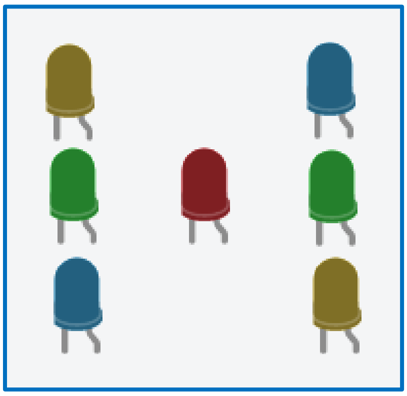
Step 3: Draw logic gates implementation diagram for each of the four patterns.

Q15: logic gates implementation diagram of each of the four patterns.

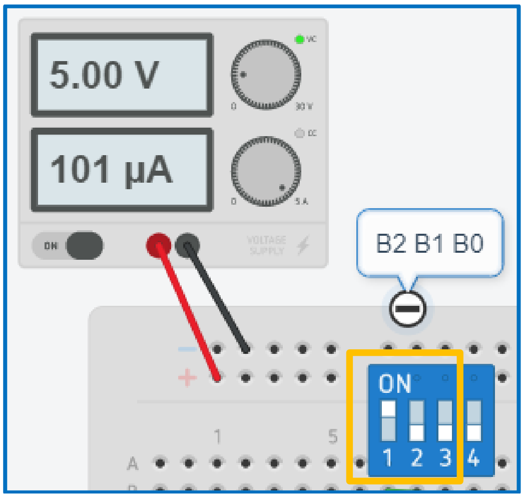
Step 4: Construct the logic implementation circuit in Tinkercad to lightening up LED patterns according to the binary input B2, B1, B0.

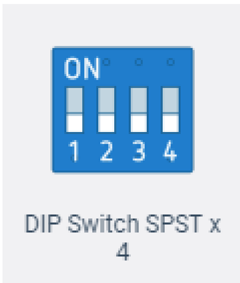
Notes:

1. You may arrange your LED lights as below, remember to connect a 1kΩ resistor to each of them (for protecting the LED from burning out!).



2. You may use a DIP Switch for easily chaning the values of B2, B1, B0 by connecting the Switch to the 5V- row, i.e, "switch on" =5V, "switch off" =0V. Below is using pins 1, 2, 3 = "ON OFF OFF" indicating B2, B1, B0 = 1, 0, 0.





3. The basic logic gates you need to use are listed below. Search the IC number for its pin assignments.

(1) 74HC04: NOT Gates		**6 NOT gates on one IC
(2) 74HC08: AND Gates		**4 AND gates on one IC

(3) 74HC32: OR Gates	 **4 OR gates on one IC
(4) 74HC11: 3-input AND Gates	 **3 gates on one IC

Step 5: Verify your circuit connection by changing DIP Switch input B2, B1, B0 from “001” to “110”, confirm that your LED lights can display the Dice Face number from “1” to “6” accordingly, as shown in the table at page 5.

Q16: Include your Tinkercad simulation link confirmed in Step 5.

Tinkercad Simulation Link

Task 3:	

Step 6: Display Dice Face of number “**y**” by giving corresponding input B2, B1, B0 on DIP Switch.

Where **y**=mod(x, 6) + 1. Note: The MOD function returns the remainder of two numbers after division.

Let x be the last digit of your student ID. For example, if your student ID is 12345678, then your Dice Face number “**y**” = mod(8, 6) + 1 = 3 and you should give B2B1B0=011 to DIP Swich for lighting up the LED patterns.

Q17: Write down the value of your Dice Face number “y” and your input B2B1B0.

y = mod (x, 6) +1 =___________; B2B1B0 =___________;

(Use your own student ID!!! Fail to do so will result in a zero mark in Task 3.)

Q18: Include the simulation screenshot of your Dice Face number “y” displayed by the LED lights. Show clearly the layout of the circuit on your breadboard: including LED lights and DIP Switch ON/OFF setting.