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Using Simulations for Students' Online Science Experiments

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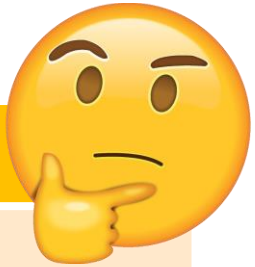
Motivations and Objectives

- Due to pandemic, all courses are delivered online; **science courses with experiments face extra challenges**
- Since science experiments require special apparatus, chemicals, laboratory spaces, etc., it can be **difficult or dangerous for learners to conduct experiments at home in online lessons**
- In this project, we aim

1. To **identify problems encountered by learners** in online science courses with experimental components
2. To **identify strategies**, mechanism or platforms which enable **learners experience experimental components** and acquire experimental skills in online science courses
3. To identify and **devise good practices** of conducting experimental components with learners for non-face-to-face course delivery

Simulations VS Animations/Videos

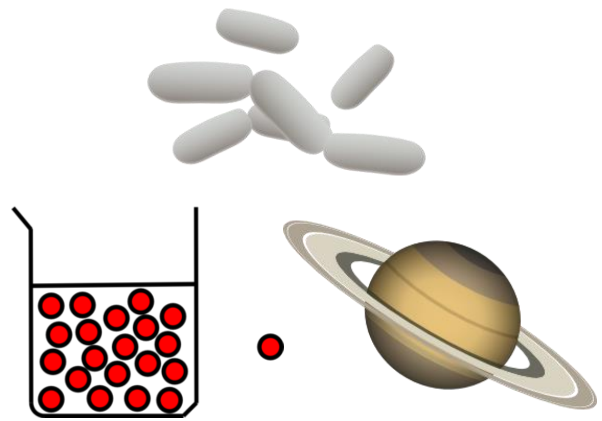
- Although they look similar, there are indeed difference between simulations and animations/videos:



Animations/Videos	Simulations
•	•
•	•
•	•
•	•
•	•

Advantages of simulation in science ed.

- Simultaneous **different representation** of the same concepts (e.g. movie, graph, etc.)
- **Visualize** and **understand** abstract science concepts
- **Replace** dangerous/infeasible/expensive experiments
- Change in **time-scale**, **size-scale**
- Active, hands-on learning
- Group-collaboration



Applications:

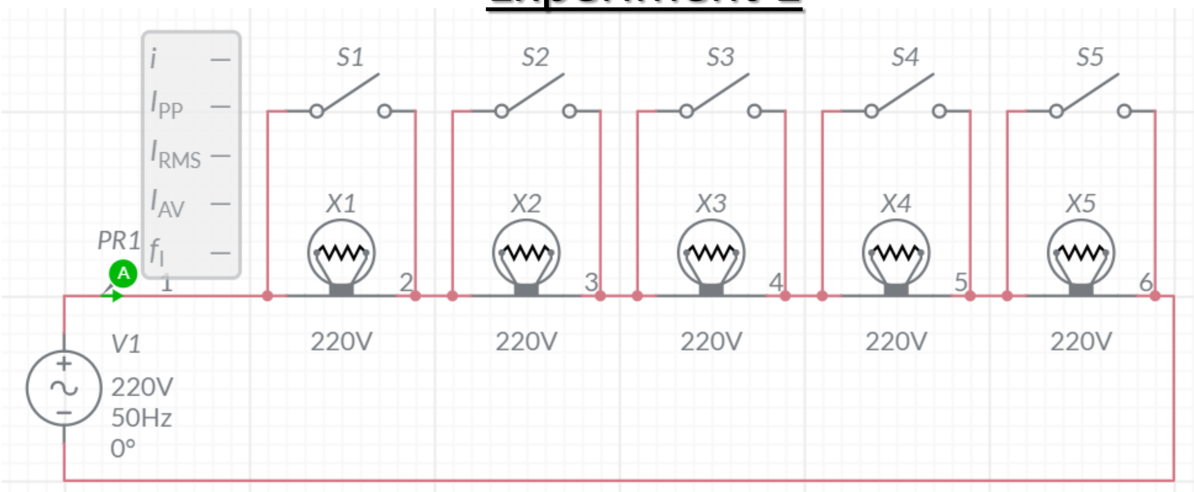
- **Lectures** (visualization, demonstrations, **experiments,** discussions)
- **Pre-lab**
- **Group projects**

Reference
R. Lindgre , Spatial learning and computer simulations in science (2009)
D. Gende, Science Simulations: A Virtual learning environment (2011)

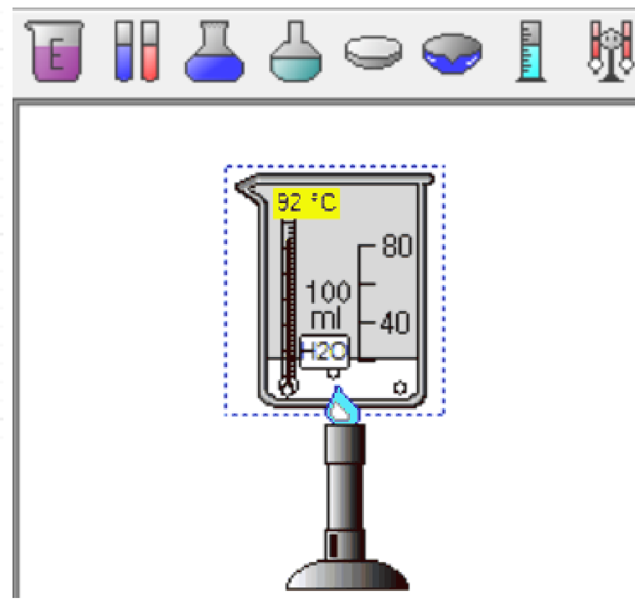
Simulated Science experiments

- Course: **SCP2015 Electricity and Energy**
- Lecturer: Dr YEUNG Chi Ho Bill
- Number of students: 27

Experiment 1



Experiment 2



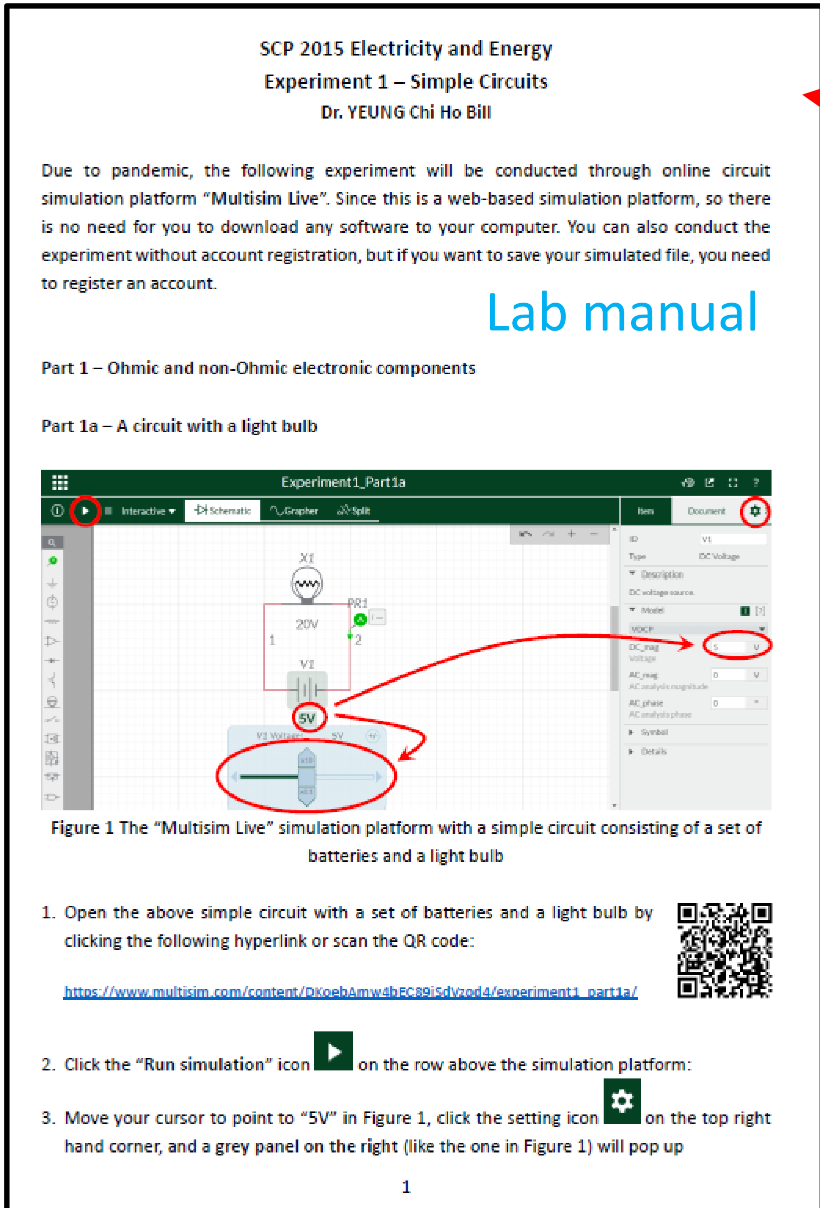
Experiment 1a

Experiment 1b

Experiment 2a

Experiment 2b

Lab manuals and demo videos


SCP 2015 Electricity and Energy
Experiment 1 – Simple Circuits
Dr. YEUNG Chi Ho Bill

Due to pandemic, the following experiment will be conducted through online circuit simulation platform "Multisim Live". Since this is a web-based simulation platform, so there is no need for you to download any software to your computer. You can also conduct the experiment without account registration, but if you want to save your simulated file, you need to register an account.

Part 1 – Ohmic and non-Ohmic electronic components

Part 1a – A circuit with a light bulb

Figure 1 The "Multisim Live" simulation platform with a simple circuit consisting of a set of batteries and a light bulb

1. Open the above simple circuit with a set of batteries and a light bulb by clicking the following hyperlink or scan the QR code:

   https://www.multisim.com/content/DKoebAmw4bEC89iSdVzod4/experiment1_part1a/

2. Click the "Run simulation" icon on the row above the simulation platform:

3. Move your cursor to point to "5V" in Figure 1, click the setting icon on the top right hand corner, and a grey panel on the right (like the one in Figure 1) will pop up

1

Lab manual

Online experiments and Lab reports

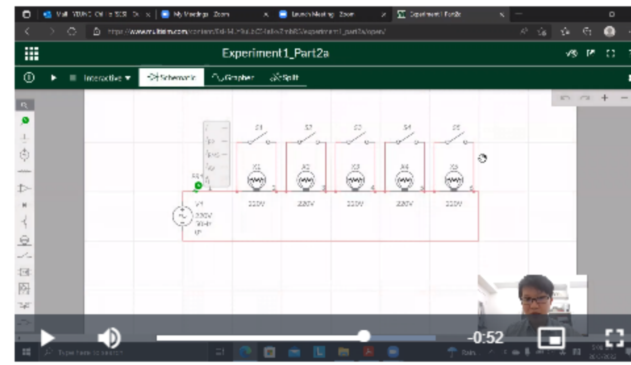
Deadline: 25 April 2022 23:59pm

Experiment 1 - Lab manual (update 25 Apr)

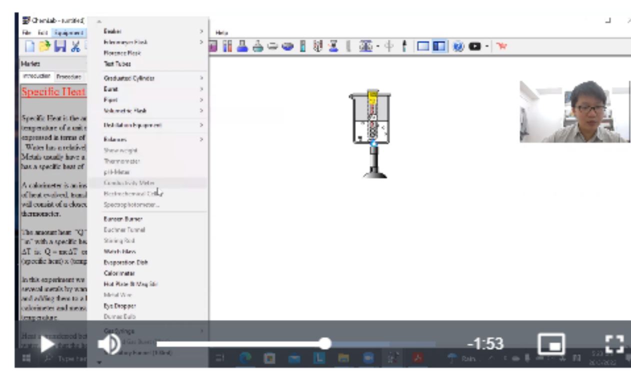
Experiment 2 - Lab manual

Moodle course page

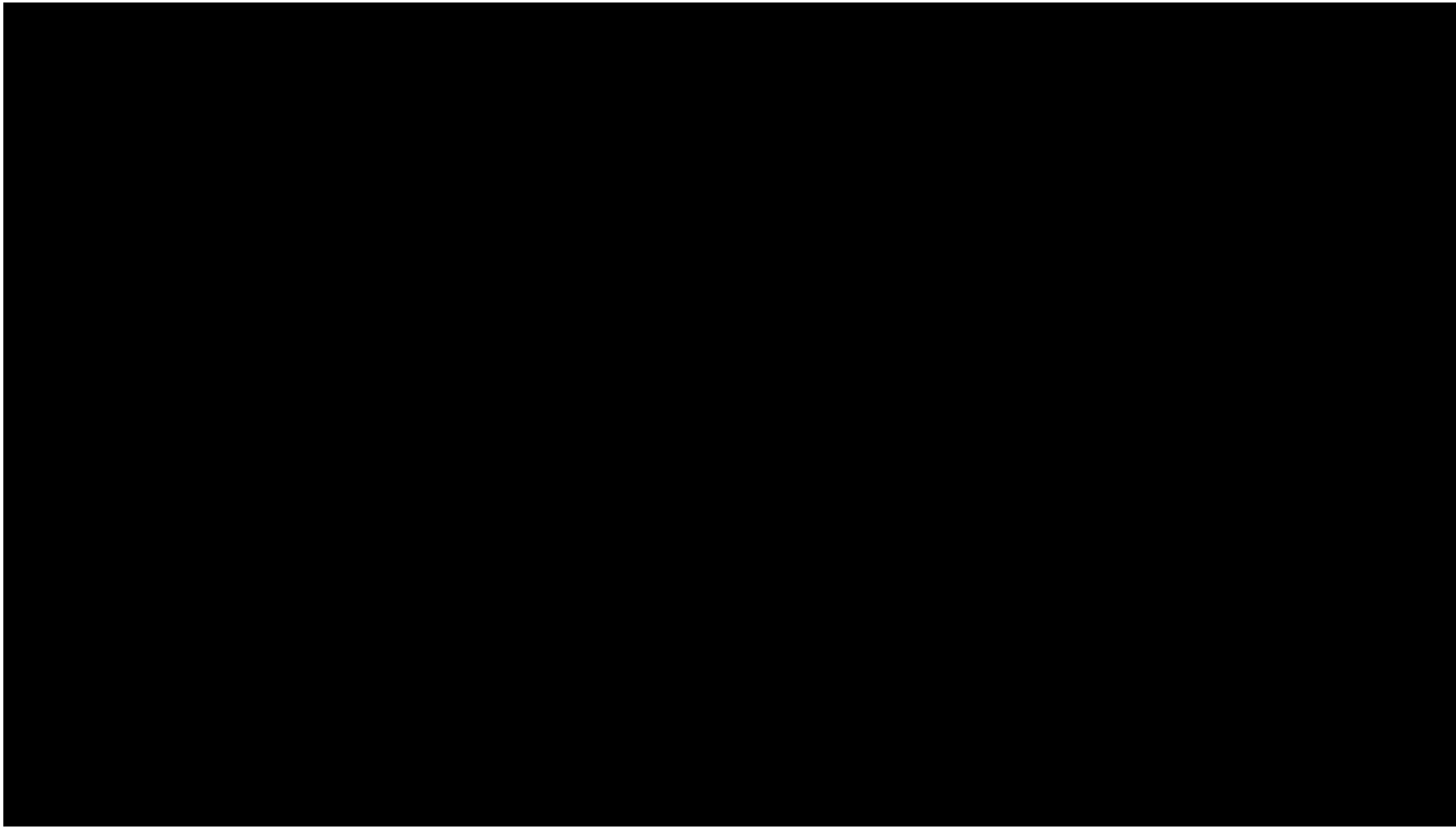
Experiment 1 - Demo



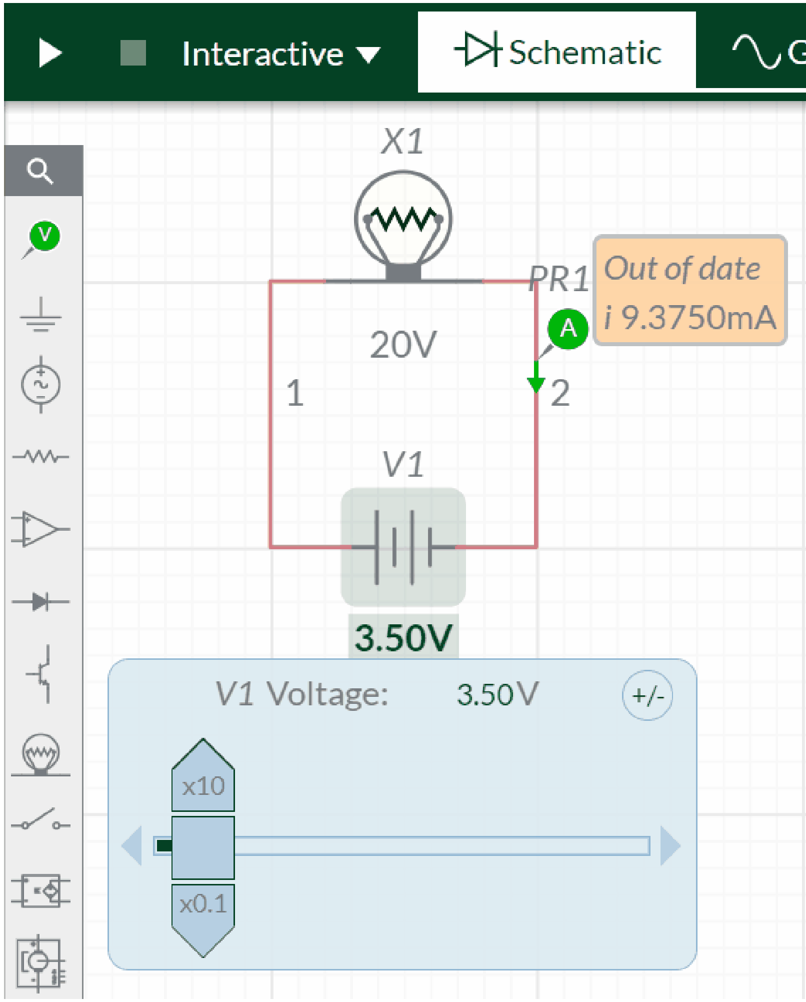
Experiment 2 - Demo

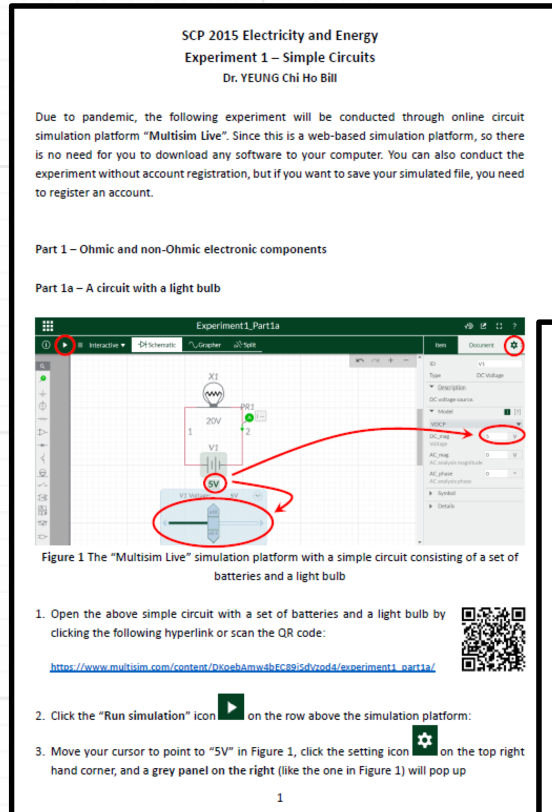


Example of demo video



Simulated Circuit Experiments (1)





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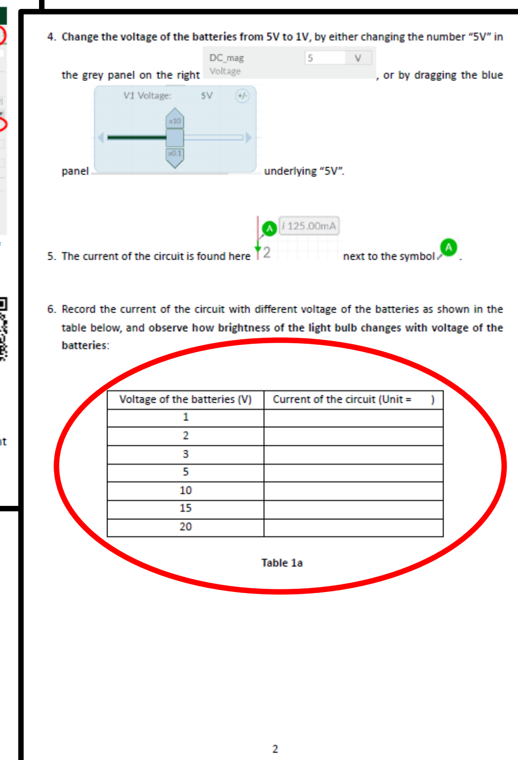
1



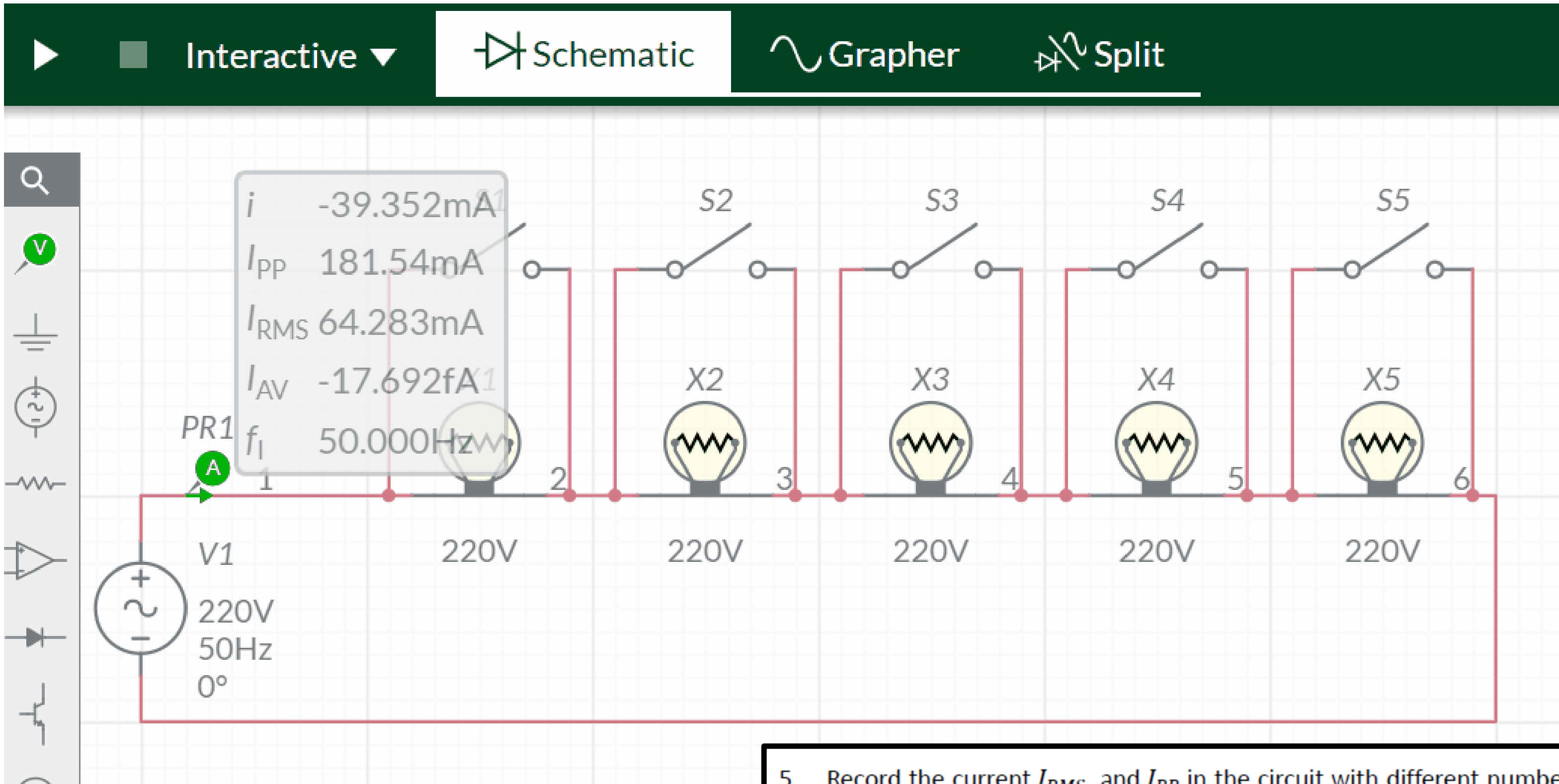
4. **Change the voltage of the batteries from 5V to 1V**, by either changing the number "5V" in the grey panel on the right [DC_mag Voltage 5 V], or by dragging the blue panel [V1 Voltage: 5V] underlying "5V".
5. The current of the circuit is found here [i 125.00mA] next to the symbol [A].
6. Record the current of the circuit with different voltage of the batteries as shown in the table below, and observe how brightness of the light bulb changes with voltage of the batteries:

Voltage of the batteries (V)	Current of the circuit (Unit =)
1	
2	
3	
5	
10	
15	
20	

Table 1a

2

Simulated Circuit Experiments (2)

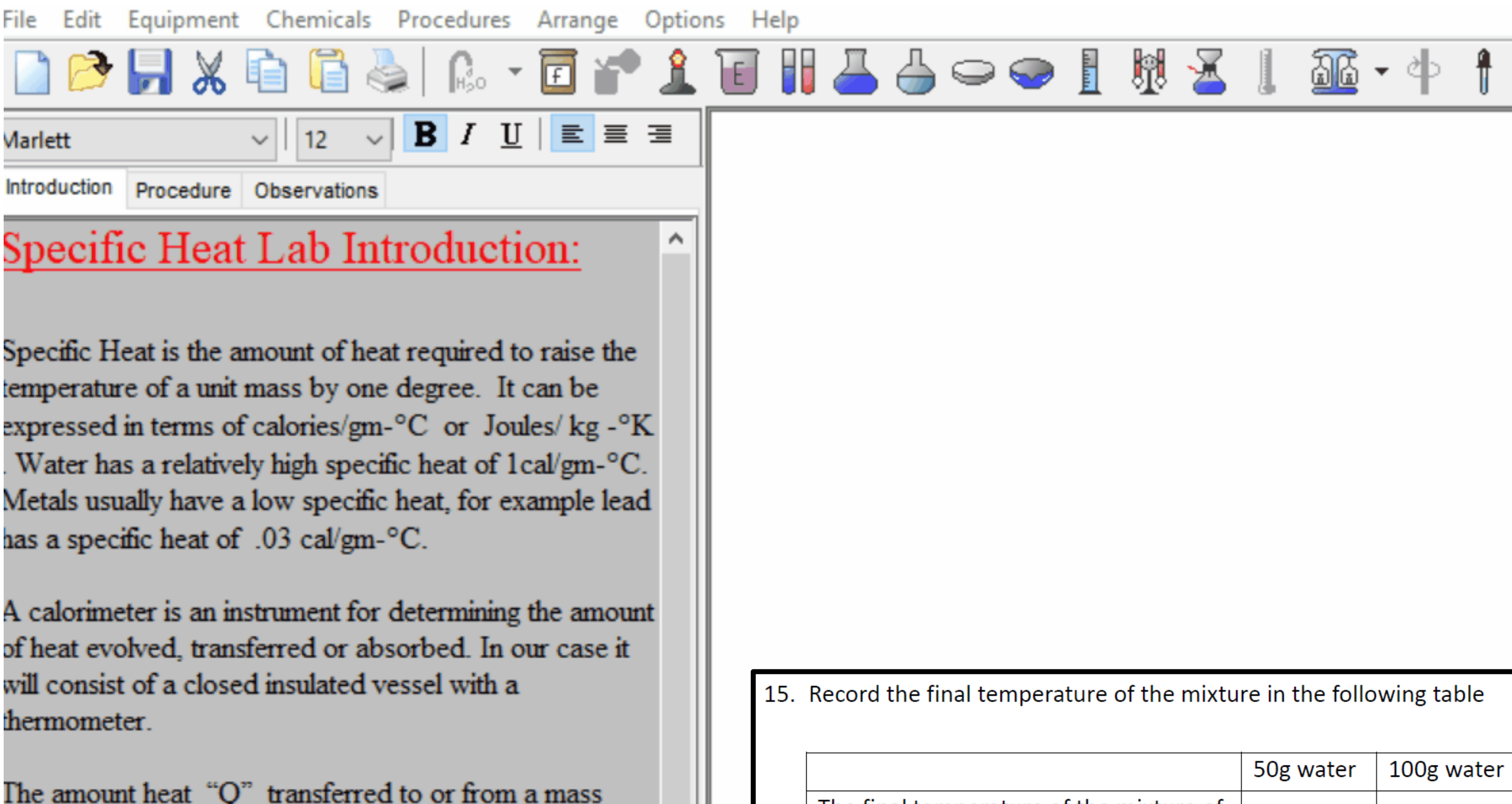


5. Record the current I_{RMS} and I_{PP} in the circuit with different number of closed switches as shown in the table below, and **observe how brightness of the switched-on light bulbs changes with the number of closed switches:**

Number of closed switches	I_{RMS} (Unit =)	I_{PP} (Unit =)
1		
2		
3		
4		
5		

Table 2a

Simulated Physics/Chemistry Experiments (3)



15. Record the final temperature of the mixture in the following table

	50g water	100g water	200g water
The final temperature of the mixture of 100°C iron (100g) + 20°C water (different amount)			

Table 1

Examples of students' lab reports

- Students worked on their lab reports based on the simulated experiment results

Table 1a

Voltage of the batteries (V)	Current of the circuit (Unit=mA)
1	25
2	50
3	75
5	125
10	250
15	375
20	500

Table 1b

Voltage of the batteries (V)	Current of the circuit (Unit=mA)
0.5	2.4634×10^{-3}
1	3.1521
1.5	7.9140
2	12.790
2.5	17.706
3	22.642
4	32.548
5	42.479

Table 2a

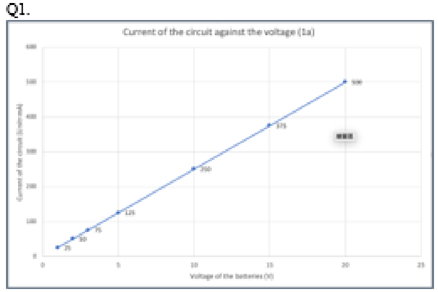
Number of closed switches	I_{RMS} (Unit=mA)	I_{PP} (Unit=mA)
1	80.353	226.93
2	107.14	302.57
3	160.71	453.86
4	321.41	907.72
5	311.03×10^{6}	877.59×10^{6}

Table 2b

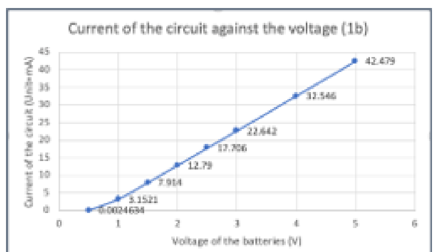
Number of closed switches	I_{RMS} (Unit=mA)	I_{PP} (Unit=mA)
1	321.42	907.73
2	642.83	1815.4
3	964.24	2723.2
4	1285.6	3630.9
5	1607.1	4538.6

Part 1

Q1.



According to the graph of current of the circuit against the voltage of 1a, we found that the current I increase proportionately with the potential difference V of the battery. There exists linear I-V characteristics. Therefore, the light bulb in Part 1a is Ohmic resistors.



The above graph is not a linear graph. According to the graph of the current of the circuit against the voltage of 1b, we found that the current I did not increase proportionately with the potential difference V of the battery, especially can be seen from V=0.5V to V=1.5V. There exists non-linear I-V characteristics. Therefore, the combination of resistor and LED in Part 1b is non-Ohmic resistor.

Q2.

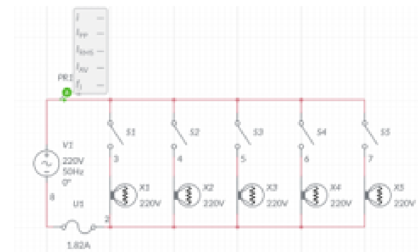
The light bulb in 1a is Ohmic resistor

$$R = \frac{V}{I} = \frac{1V}{25 \times 10^{-3}A} = 40\Omega$$

in Circuit 2a, a large current pass in Circuit 2a, there exists the risk of burnout due to increased circuit temperature.

Q8.

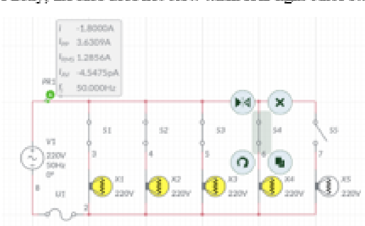
(a)



(b) Since the socket will be overloaded if more than 4 light bulbs are switched on, we aimed to make sure the fuse does not blow when four of the light bulbs work, the value of the fuse should be considered: the circuit used an AC power source, the value and direction will be changing, to make sure four of the light bulbs can work without influences, we should make sure the peak value of I with four closed switches can pass. $I = I_{pp4} \div 2 = 3.6309 \div 2 \approx 1.82A$. Therefore, the value of the fuse I used is 1.82A.

(c)

Firstly, the fuse dose not blow when four light bulbs switch on:



Next, the fuse blows when five light bulbs switch on:

Students' feedback

- Positive comments from students:
  - ✓ It was **interesting** to play with both set of simulated experiments
  - ✓ They can **re-try and repeat** the experiments many times for investigation **without concern on wasting resources**
  - ✓ Some aspects of the experiments are very **realistic**
  - ✓ Given the **pandemic** situation, the simulated experiments **seem to be a good choice** as it allows them to hands-on conduct the experiments; such real experiments would be difficult at home
  - ✓ In terms of learning, they prefer simulated experiments than only watching experimental videos, since they have the **room for exploration and learn-by-doing**
  - ✓ The simulation platforms for both set of experiments work on both **computers** and **tablet computers**, and even mobile phones
- Potential issues:
  - ✗ **Workload** of using simulated experiments may seem **larger** compared to only watching experimental video
  - ✗ **More advanced circuits** can be explored

Can **simulations** replace **hands-on experiments** in teaching science?

	Simulations	Hands-on experiment
Pros	Please refer to the points listed on the last page	• •
Cons	• •	• •

- Simulations are **good complement** to hands-on experiments, **not replacement**

Summary

- **Simulated experiments** have been adopted in an online physics course, these include

1. Simulated circuit experiments
2. Simulated experiments on measuring heat capacity

- Instead of just playing with this online module, **students are required to record data like real experiments**, and submit homework or lab reports
- Students have **mostly positive feedback** on the simulated experiments