Capacitors

Phet Simulation :
https://phet.colorado.edu/sims/html/capacitor-lab-basics/latest/capacitor-lab-basics_en.html

OBJECTIVES:

- (Capacitor connected to battery): Study the effect of changing the voltage across a capacitor, its plates area and separation distance on the capacitance, charges on plates and electric field between plates.
- (Charged capacitor disconnected from battery): Study the effect of changing the plates area and separation distance of a capacitor on the voltage across the plates, charges on plates and electric field between plates.
- Study discharging of a capacitor through a light bulb.

PART 1: Parallel Plate Capacitor – Battery Connected

Choose "Capacitors" tab. Select all four options in top right corner (Plate Charges, Bar Graph, Electric Field, Current Direction).

1. Note the Capacitance: C = _____ , Plates separation: d = _____ , Plates Area : A = _____
Using "d" and "A", compute the capacitance below. Does it match the value provided?

_____

_____

_____

Part 1 a – "d" and "A" constant – Battery Connected

Connect Voltmeter across the capacitor. Slowly increase the battery voltage to 1.5 V.
Observe changes in following quantities as "d" and "A" are kept constant and voltage is increased.
C : Capacitance, Q : Charge on the capacitor, V : Voltage across the capacitor, **E** : Electric field between the plates of capacitor
Note the observations and provide reasoning in table below.

2. As voltage was being increased, what did you observe about the motion of charges in the external circuit?

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3. After voltage was constant at 1.5 V, what did you observe about the motion of charges in the external circuit?

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	Observations (As voltage is increased, how do these quantities change?)	Reasoning
C		
Q		
V		
E		

Part 1 b – "V" and "A" constant – Battery Connected

Keep the battery connected to the capacitor. With voltage at 1.5 V across capacitor and its area constant at its minimum value of 100 mm^2, slowly decrease the distance between the plates of capacitor to 2.0 mm.
Observe the changes and provide reasoning in table below.

4. As plate separation was being decreased, what did you observe about the motion of charges in the external circuit?

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5. After plate separation was constant at 2.0 mm, what did you observe about the motion of charges in the external circuit?

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	Observations (As plate separation is decreased, how do these quantities change?)	Reasoning
C		
V		
Q		
E		

Part 1 c – "V" and "d" constant – Battery Connected

Keep the battery connected to the capacitor. With voltage at 1.5 V across capacitor and its separation distance constant at its maximum value of 10.0 mm, slowly increase the area of the plates of capacitor to 400 mm^2.
Observe the changes and provide reasoning in table below.

6. As plate area was being increased, what did you observe about the motion of charges in the external circuit?

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7. After plate area was constant at 400 mm^2, what did you observe about the motion of charges in the external circuit?

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	Observations (As plate area is increased, how do these quantities change?)	Reasoning
C		
V		
Q		
E		

PART 2: Parallel Plate Capacitor – Battery Disconnected

Reset to original configuration. Click the refresh button. Select all four options in top right corner (Plate Charges, Bar Graph, Electric Field, Current Direction). Connect Voltmeter across the capacitor and increase the battery voltage to 1.5 V.
After charging the capacitor to 1.5 V, disconnect the battery.

Part 2 a – "A" constant – Battery Disconnected

With area of plates constant at 100 mm^2, slowly decrease the distance between the plates of capacitor to 2.0 mm.
Observe the changes and provide reasoning in table below.

8. Obtain an expression for magnitude of electric field E between the plates in terms of Q, A and ε_0 . Show all work.

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	Observations (As plate separation is decreased, how do these quantities change?)	Reasoning
C		
Q		
V		
E		

Part 2 b – "d" constant – Battery Disconnected

With distance between plates of capacitor constant at 10.0 mm, slowly increase the area of plates to 400 mm^2.
Observe the changes and provide reasoning in table below.

	Observations (As plate area is increased, how do these quantities change?)	Reasoning
C		
Q		
V		
E		

PART 3: Parallel Plate Capacitor – Discharging through a Bulb

Part 3 a – Discharging through a Bulb – Maximum Capacitance

Choose "Light Bulb" tab. Select all four options in top right corner (Plate Charges, Bar Graphs, Electric Field, Current Direction). Select all three options in top left corner (Capacitance, Top Plate Charge, Stored Energy). Decrease the plates separation to minimum and increase the plates area to maximum (this results in maximum capacitance). Connect Voltmeter across the capacitor and increase the battery voltage to 1.5 V.
After charging the capacitor to 1.5 V, toggle the switch to right; thus connecting the capacitor to the bulb.

9. How does the brightness of the bulb change when the switch is moved to right?

10. As capacitor was discharging, what did you observe about Q on its plates and the motion of charges in the external circuit?

11. How V across capacitor and **E** between plates change?

12. What do you observe regarding capacitance of the capacitor? Explain.

13. What happens to energy stored in the capacitor? Explain using energy transformation.

Part 3 b – Discharging through a Bulb – Minimum Capacitance

Reset to a new configuration. Click the refresh button. Select all four options in top right corner (Plate Charges, Bar Graphs, Electric Field, Current Direction). Select all three options in top left corner (Capacitance, Top Plate Charge, Stored Energy). Increase the plates separation to maximum and decrease the plates area to minimum (this results in minimum capacitance).
Connect Voltmeter across the capacitor and increase the battery voltage to 1.5 V.
After charging the capacitor to 1.5 V, toggle the switch to right; thus connecting the capacitor to the bulb.

14. What similarities and differences do you observe when comparing this experiment to part 3b? Explain.

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