Lab – Understanding Capacitance Name:

Purpose: To investigate the relationships and properties of capacitors
Materials: Multimeter with Capacitance function, aluminum foil, textbook

Part I – Capacitance versus plate separation distance

Procedure:
1) Obtain two equal sized sheets of aluminum foil and a large textbook.
2) Place one of the sheets at page 200, for example, and the other at page 260 (this is 30 pages!).
3) Place the red probe on one sheet and the black on the other and close the book.
4) Turn the knob to the symbol that looks like -||- (The capacitance setting)
5) Use the capacitance meter to measure and record the capacitance in nanoFarads (you should see a "nF" on the right side indicating it is measuring in nanoFarads).
6) Repeat the steps above, except change the # of pages each trial by 30 pages up to 150 pages.
7) Graph the data

Pages	Pages^{-1}	Capacitance (nF)
30	1/30	
60	1/60	
90	1/90	
120	1/120	
150	1/150	

Looking at the graphs, which plot is linear? Pages vs Capacitance Pages^{-1} vs Capacitance

A linear plot indicates the quantities are directly proportional. Which of the following is the correct statement of proportionality (where C is capacitance and d is the separation distance)?

$C \propto \frac{1}{d}$ $C \propto d$

Part II – Capacitance versus Area of the Plates

1. Measure and record the Capacitance for your homemade capacitor with a page separation of about 50 pages.
2. Carefully fold each aluminum foil plate in half. Measure and record the capacitance.
3. Repeat each step below by folding the plates in half again 3 more times.
4. Graph the data.

Area	Area^{-1}	Capacitance (nF)
A	A	
0.5Area	2 Area	
0.25Area	4 Area	
0.125Area	8 Area	
0.0625Area	16 Area	

Looking at the graphs, which plot is linear? Area vs Capacitance Area^{-1} vs Capacitance

A linear plot indicates the quantities are directly proportional. Which of the following is the correct statement of proportionality (where C is capacitance and A is the area of the plates)?

$C \propto \frac{1}{A}$ $C \propto A$

$C \propto$

Combine the two statements of proportionality from the front into one statement

To turn a statement of proportionality into an equation, you have to add a constant of proportionality. In the case of capacitance, it is ε_o, called the vacuum permeability of free space. It has a magnitude of 8.85 x 10^{-12} C^2/ N m^2.

$$C = \varepsilon_0 \; \frac{\qquad}{\qquad}$$

Show the complete formula in the box provided.

This is the equation for the capacitance of a parallel plate capacitor.

In general, equation for capacitance of any shape capacitor is $C = \frac{Q}{\Delta V}$ where C is the capacitance measured in Farads (F), Q is the magnitude of charge on each plate of the capacitor (in C), and ΔV is the potential difference between the plates of the capacitor in Volts (i.e. if each side of the capacitor was connected to the sides of a 12 V battery ΔV would be 12 V).

Using the equation you found from the lab and the general equation given above, find the equation for the amount of charge on the plate of a parallel capacitor.

The potential energy stored in a capacitor can be given by the following three equations:

$$PE_{electric} = \frac{1}{2} Q\Delta V$$

$$PE_{electric} = \frac{1}{2} C(\Delta V)^2$$

$$PE_{electric} = \frac{Q^2}{2C}$$

Check your equations in the book and then work the following problems.

1. Calculate the capacitance of a capacitor whose plates are 20 cm x 3.0 cm and are separated by a 1.0 mm gap. What is the charge on each plate if the capacitor is connected to a 12 V battery? What is the electric field between the two plates?

2. A camera flash unit stores energy is a 150μF capacitor at 200 V. How much electric energy can be stored?