Investigation of a parallel plate capacitor

Theory

The capacitance of a parallel plate capacitor is given by the equation:

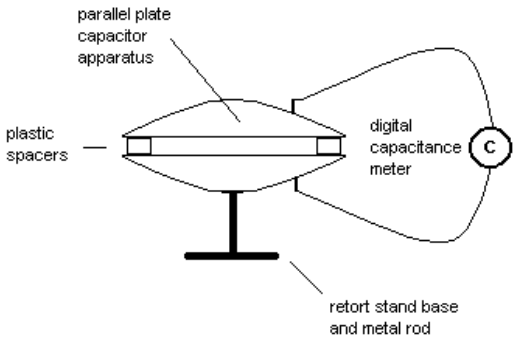
$$C = \frac{\varepsilon_r \varepsilon_0 A}{d}$$

where A is the area of the plates
d is the distance between them
ε_0 is the permittivity of free space
ε_r is the relative permittivity of any material between the plates (~ 1 for air).

A number of investigations can be carried out:

- Variation of C with distance (constant A and air spaced capacitor).
- Effect of a material medium. The capacitance can be found for a capacitor made with a plastic sheet separating the plates, and for an air spaced capacitor separated by spacers cut from the same sheet. You can see from the parallel plate capacitor equation that the relative permittivity is the ratio of the two capacitances.
- Variation of C with area of overlap (constant d)

The diagram shows a commercial apparatus of circular cross section, which can be used for the first two investigations. To vary the area of overlap it is easier to use a homemade capacitor made from rectangular metal sheets. You will also need a micrometer to measure the thickness of the spacers.



Method

For the first investigation, a number of thin acetate spacers should be used, which can be piled up to vary the separation of the plates. To find the thickness of the acetate spacers, measure the thickness of a pile with a micrometer. (Why not a single spacer?) Calculate the value of d for each capacitance arrangement. The capacitance is to be found from a direct reading capacitance meter, which is simply connected across the plates.

For the second investigation, measure the capacitance for a capacitor made with a plastic sheet separating the plates, and for an air spaced capacitor separated by spacers cut from the same sheet.

For the third investigation, make your own capacitor out of rectangular metal plates separated by a large acetate sheet. You will need to place boards on top of the arrangement to keep the layers in contact, and use crocodile clips to connect to the exposed edges of the plates. Obtain a series of values for the capacitance for different areas of overlap.

Processing of results

For the first investigation, the equation can be written as:

$$C = \varepsilon_0 A \times \frac{1}{d}$$

A graph of C against 1/d can be plotted and ε_0 found from the gradient ($\varepsilon_0 A$).

For the second investigation calculate a single value for the relative permittivity of the plastic sheet.

For the third investigation, the equation can be written as:

$$C = \frac{\varepsilon_r \varepsilon_0}{d} \times A$$

A straight line should be produced if C is plotted against A. In this case you should be able to measure the gradient ($\varepsilon_r \varepsilon_0 / d$) and calculate the permittivity ($\varepsilon_r \varepsilon_0$) of the acetate sheet.

Discussion and Conclusion

Do your graphs support the equation?

For the air-spaced capacitor in the first investigation, look up the standard value of ε_0 to compare with your value. Remember to reference the source of your value.

Also calculate the relative permittivity (ε_r) for each of the plastic sheets and see if you can find any reference values to compare these with (use the accepted value of ε_0 to calculate a value of ε_r for the acetate sheet in the third investigation).

Can you account for any discrepancies from the uncertainties in your experimental measurements?