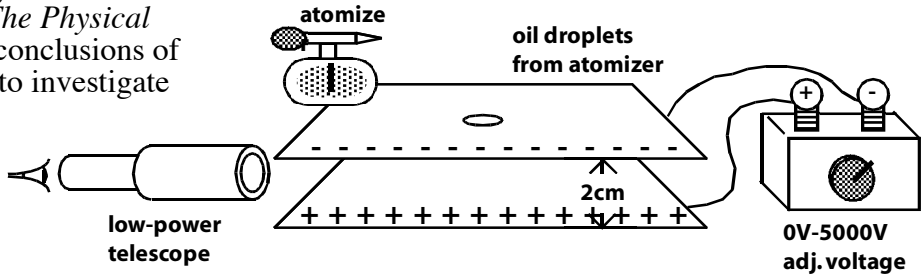
PhyzJob: The Oil Drop Experiment

In December 1909, American physicist Robert A. Millikan wrote an article for *The Physical Review* in which he reported the conclusions of an experiment he had performed to investigate the nature of electric charge.



The **purpose** of Millikan's experiment was to determine whether or not electric charge is *quantized*.

(If something is quantized, it comes in multiples of a definite, indivisible basic unit.)

For example, our monetary system is quantized—all sums of money are multiples of one penny.) If charge was not quantized, it would be considered "continuous," meaning that it could be found in any size—not just multiples of one size.

Procedure

Millikan's procedure involved "balancing" a charged oil droplet in electric and gravitational fields. Here's how it worked:

Oil droplets of very small mass were produced by an atomizer (perfume spray-bottle). These droplets fell through the air slowly (low terminal velocity). A few oil droplets passed through the hole in the top metal plate as shown.

When a droplet was between the plates, Millikan viewed it through a small telescope and measured its terminal velocity. Through a relation called "Stokes' Equation," it is possible to determine an object's mass from its terminal velocity. Knowing the mass of the droplet, Millikan was able to calculate the gravitational force acting on the drop.

By exposing the oil droplets to low-level radiation, Millikan found he could charge the oil droplets (the radiation knocked electrons off the droplet).

Once the droplet was charged, Millikan created an electric field between the plates. By adjusting the voltage between the plates, he could vary the strength of the field and thus balance the charged oil droplet so that it hung motionless between the plates.

Analysis

When the droplet is suspended without motion between the plates, what forces are acting on it?

1._____ and 2. _____ Draw a force diagram to the right.

1. Write an equation for the gravitational force W (weight) of the droplet in terms of its mass m and acceleration due to gravity g.

2. If the oil droplet is suspended between the plates, which force is bigger: gravitational or electrical? Write an equation relating electric force F to gravitational force W under this condition.

3. Write an equation relating the voltage V across the plates, electric field strength E, and the distance d between the plates. Write it solved for E in terms of V and d.

4. Write an equation relating electric field E to electric force F and electric charge q (hint: the definition of electric field). Write it solved for q in terms of E and F.

Concept and layout by Walt Scheider.

Data

Below, you are given the mass of eight oil droplets and the voltage required to balance each droplet between the plates. Complete the data table and compare the charges on the oil droplets. Are they multiples of one value ("quantized") or random, unrelated values ("continuous").

#	MASS x10^{-15} kg	VOLTAGE (V) at "balance"	WEIGHT units=_____	electric FORCE units=_____	electric FIELD units=_____	electric CHARGE units=_____
1	5.8	3553				
2	4.5	1838				
3	3.8	4655				
4	9.4	2303				
5	4.1	2511				
6	6.0	2450				
7	5.6	1715				
8	3.6	4410				

Calculations

Write down the equations (or reasoning) used to calculate the values above (hint: questions 1-5 on the other side).

Weight

Electric Force

Electric Field

Electric Charge

Conclusion

Make a statement of conclusion answering the purpose question of the experiment based on the findings above.

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