L04 - Coulomb's Law Examined Graphically

Remember this lab? 

Physics 20 - Lab - Gravitational Forces and Fields

Students will:

(a) Use the data table provided to graph the relationship between radius (*r*) and force of gravity (*Fg*) by hand.

(b) Manipulate the x-variable to linearize the graph. Graph inverse radius squared ($1/r^2$) versus force of gravity (*Fg*) by hand.

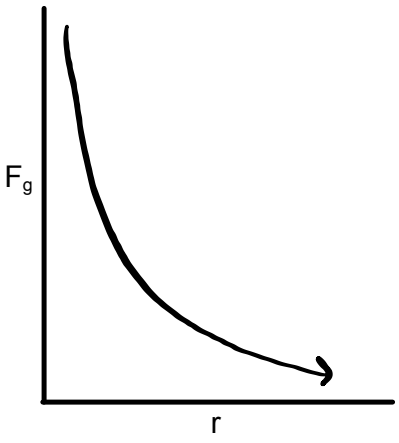
Radius (r) [meters]	Force of Gravity (Fg) [Newtons]
0.1	20×10^{-7}
0.2	5.0×10^{-7}
0.3	2.2×10^{-7}
0.4	1.3×10^{-7}
0.5	0.8×10^{-7}

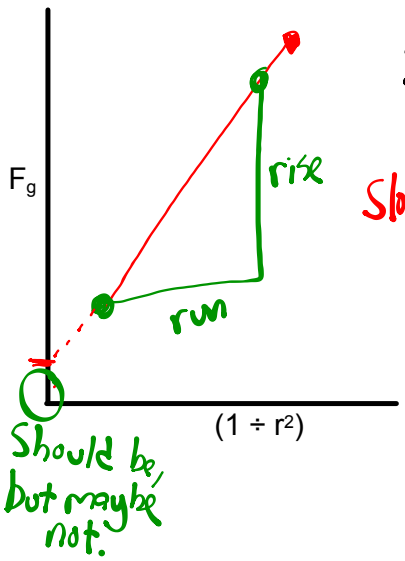
$1/r^2$

$1 \div (0.1)^2 = 100$

$1 \div (0.2)^2 = 25$

(c) Given: $m_1 = 10kg$ and $m_2 = 30kg$. Use your graph to calculate the Gravitational Constant *G*.





$F_g = (Gm_1m_2)\frac{1}{r^2} + 0$

$y = (\text{Slope})\,x + b$

$\text{Slope} = \frac{\text{rise}}{\text{run}} = Gm_1m_2$

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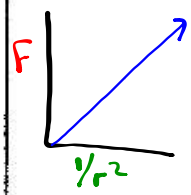
Coulomb's Law - Graphing - Pg 1

A student performed an experiment that verified Coulomb's Law of Electrostatics by measuring the repulsion between two charged spheres, A and B, as a function of the separation of the spheres. The spheres were identical in size and mass. The measurements are shown in the table of values and plotted on the graph below.

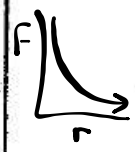
Separation (m)	Force (N)	$1/r^2$
0.10	0.790	$1/0.1^2 = 100$
0.13	0.480	
0.20	0.200	
0.40	0.050	
0.60	0.022	



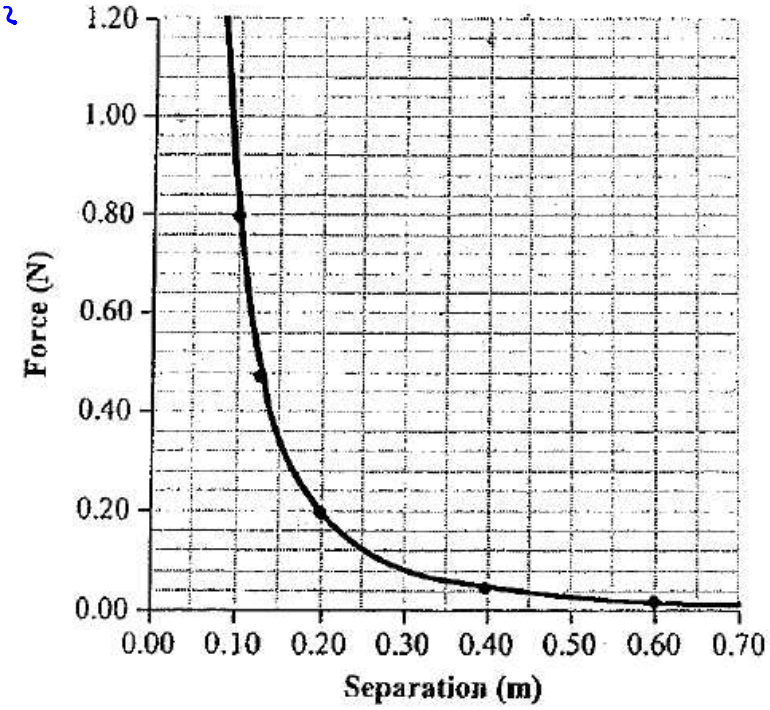
$F = (kq_1q_2)\frac{1}{r^2} + 0$

$y = (m)x + b$

Slope = kq_1q_2



Force of Repulsion as a Function of the Separation



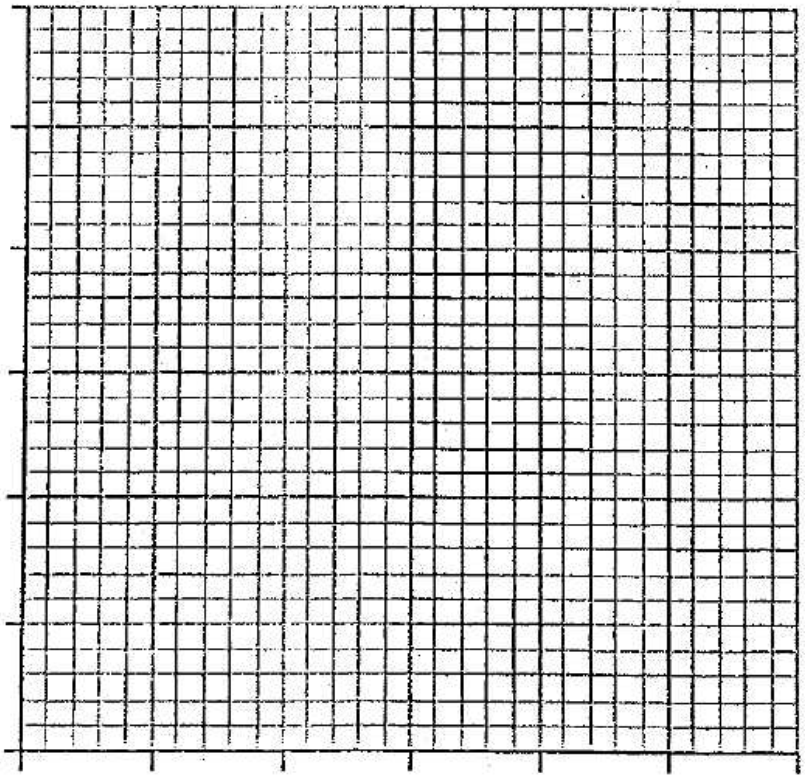
Coulomb's Law - Graphing - Pg 2

2.

- Show that the results verify Coulomb's Law by manipulating the data and providing a new table of values that, when plotted, will produce a straight-line graph.
- Plot the new data with the responding variable on the vertical axis.
- Calculate the slope of your graph.
- Using the slope value, or another suitable averaging techniques, determine the charge on sphere B if the charge on sphere A is 3.08×10^{-7} C.
- Determine the magnitude of the force between spheres A and B when they are at a distance of 2.00 m apart. Use the hypothetical value of 3.00×10^{-6} C for the charge on sphere B if you were unable to determine the actual value.

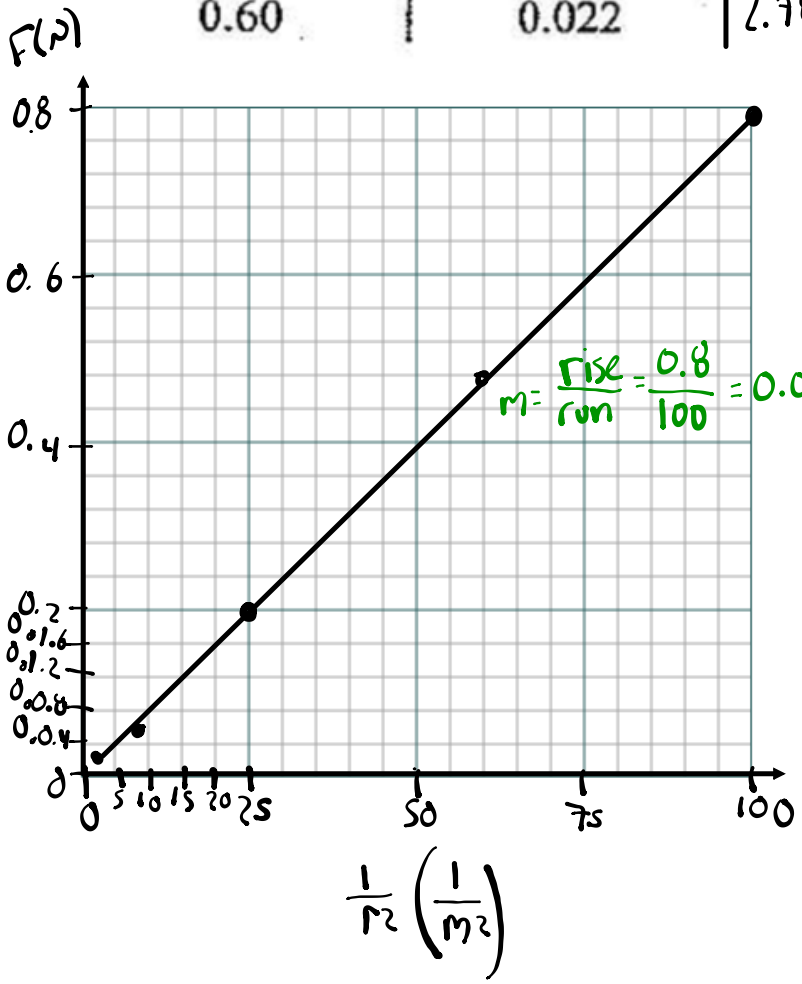
Clearly communicate your understanding of the physics principles that you are using to solve this question. You may communicate this understanding mathematically, graphically, and/or with written statements.

_____ (Title)



Coulomb's Law - Graphing - Pg 3

Separation (m)	Force (N)	1 ÷ r² (1/m²)
0.10	0.790	100
0.13	0.480	59.2
0.20	0.200	25
0.40	0.050	6.25
0.60	0.022	2.78



$m = \frac{rise}{run} = \frac{0.8}{100} = 0.008$

$F = (kq_1q_2)\frac{1}{r^2} + 0$

$y = (m)x + b$

$m = kq_1q_2$

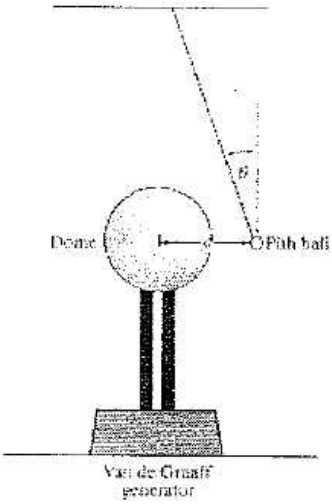
$0.008 = (8.99\times10^{9})(3.08\times10^{-7})q_2$

$q_2 = 7.89\times10^{-6}\,C$

Coulomb's Law - Graphing 2 - Pg 1

Use the following information to answer this graphing-skills question.

An experiment is performed to determine Coulomb's constant, k. The experimental apparatus is illustrated below.



The charge on the dome of the Van de Graaff generator is -2.0×10^{-6} C, and the charge on the graphite-coated pith ball is -3.0×10^{-8} C.

As the separation distance, d, between the dome and the pith ball is varied, the angle, θ, at which the pith ball is hanging is measured.

Then the electrostatic force is calculated.

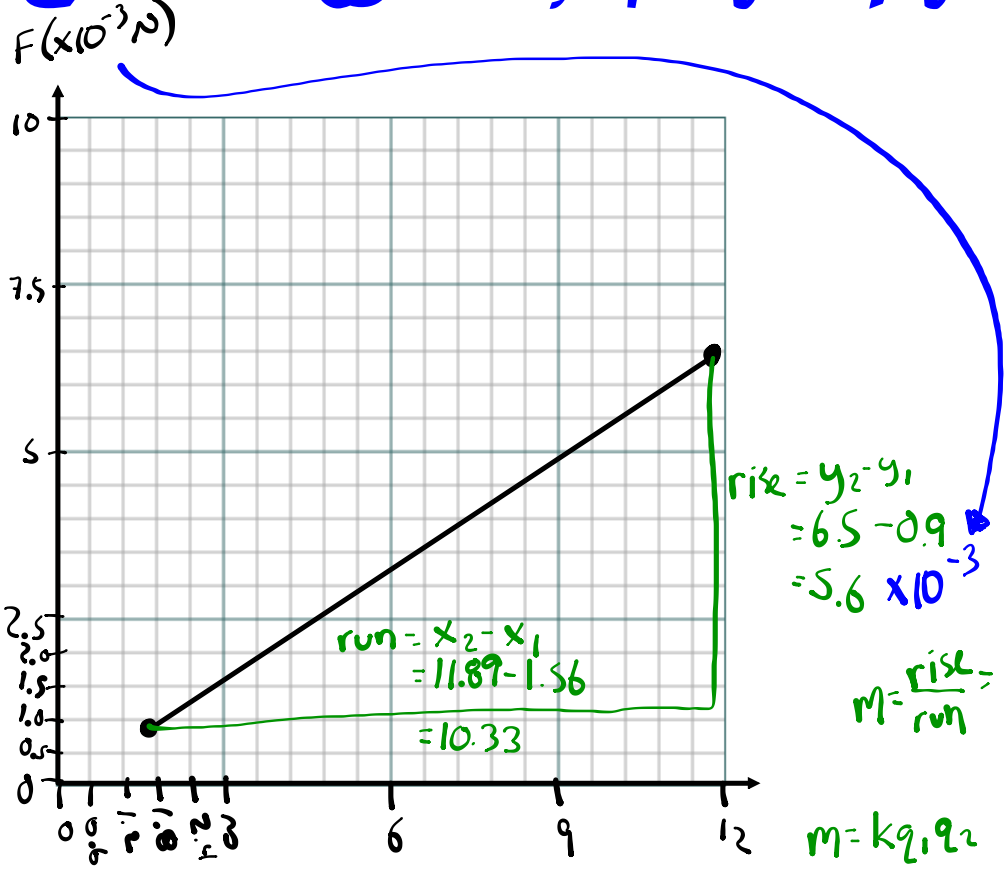
The table below contains the data.

Observations		Analysis	
Separation Distance (m)	Angle (°)	Reciprocal of the Square of the Distance (m^{-2})	Electrostatic Force (10^{-3} N)
0.29	19.0	11.89	6.5
0.38	11.0	6.93	3.7
0.50	6.0	4.00	2.0
0.66	4.0	2.30	1.2
0.80	2.0	1.56	0.9

Written Response—10 marks

1. Using graphical analysis, **determine** the experimental value of Coulomb's constant, k. As part of your response, **complete** the data table, **provide** a graph of the electrostatic force as a function of the reciprocal of the square of the separation distance, **determine** the slope of your graph, and **relate** the slope algebraically to a physics equation. **State** all necessary physics principles and formulas.

Coulomb's Law - Graphing 2 - Pg 2



rise = $y_2 - y_1$
= 6.5 − 0.9
= 5.6×10^{-3}

run = $x_2 - x_1$
= 11.89 − 1.56
= 10.33

$m = \frac{rise}{run} = 5.4211 \times 10^{-4}$

$m = kq_1q_2$

$(5.4211 \times 10^{-4}) = k(2 \times 10^{-6})(3 \times 10^{-8})$

$k = 9.04 \times 10^{9} \frac{Nm^2}{C^2}$