

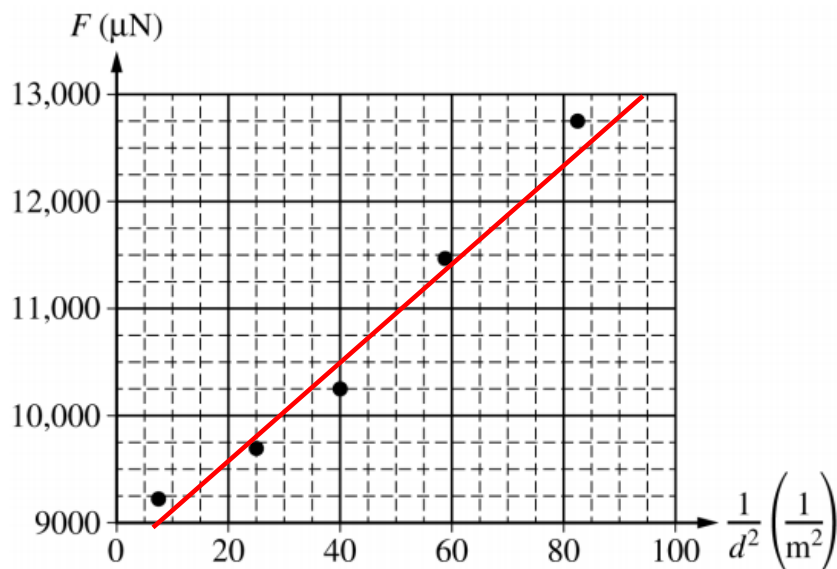
Question 2: Free-Response Question

15 points

- (a) i. For drawing an appropriate best-fit line

1 point

Example response for part (a)(i)



- ii. For calculating the slope using two points from the best-fit line

1 point

$$\text{slope} = m = \frac{\Delta y}{\Delta x} = \frac{(12,000 - 10,500) \mu\text{N}}{(72 - 40) \text{ m}^{-2}} = 4.7 \times 10^{-5} \text{ N}\cdot\text{m}^2$$

For correctly relating the slope to the charge

1 point

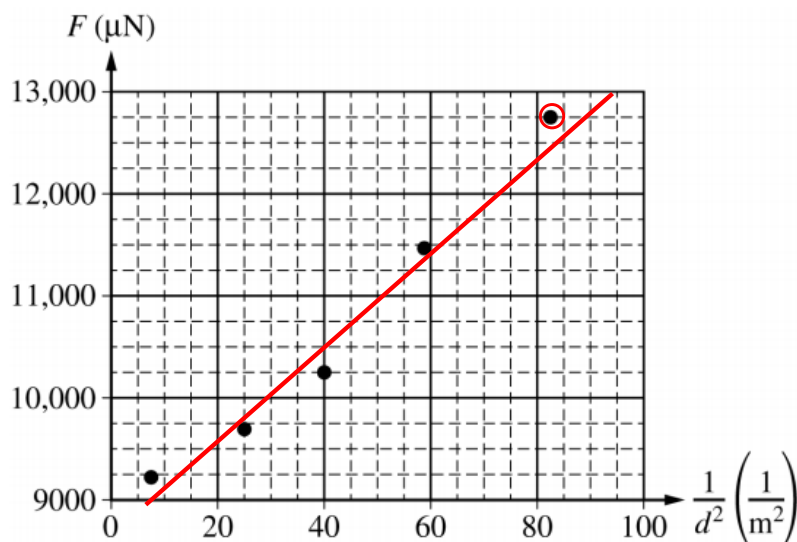
$$F = \frac{kQ^2}{r^2} \therefore \text{slope} = kQ^2$$

For correctly calculating the charge consistent with the slope from the best-fit line

1 point

$$Q = \sqrt{\frac{\text{slope}}{k}} = \sqrt{\frac{(4.7 \times 10^{-5} \text{ N}\cdot\text{m}^2)}{(9 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2)}} = 7.2 \times 10^{-8} \text{ C}$$

- (a) iii. For drawing a circle around the appropriate data point 1 point



- iv. For a correct answer 1 point

From the graph, $\frac{1}{d^2} = 82.5 \text{ m}^{-2}$

$$d = 0.11 \text{ m}$$

- v. For indicating that the y-intercept should be the weight of the conducting sphere and insulating rod 1 point

For a correct justification 1 point

Example responses for part (a)(v).

When the spheres are infinitely far apart, there is no electric force between them. The only force recorded by the balance must be the weight of the lower sphere and insulating rod.

OR

The scale is zeroed before the insulating rod, and lower sphere are placed on it, so the nonzero y-intercept is their weight.

Total for part (a) 8 points

- (b) For selecting “Yes” and providing a correct justification 1 point

Example response for part (b)

Because the later force measurements are lower than the expected values on the best-fit line, then a decrease in charge could explain the discrepancy seen in the data.

(c) i.	For correctly indicating the position of the excess positive charges	1 point
	For correctly indicating that the net charge is positive	1 point

Example response for part (c)(i)



ii.	For a correct justification	1 point
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Example response for part (c)(ii)

On a conductor, excess charges are free to move and will repel each other. The excess charges in the sphere will rearrange themselves until they are as far apart from each other as possible; thus, the repelling force decreases.

Total for part (c) 3 points

(d) i.	For appropriately indicating the position of the excess charges on both spheres	1 point
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ii.	For selecting “Less than” and attempting a relevant justification	1 point
	For a correct justification	1 point

Example response for part (d)

Because the opposite charged spheres will attract each other, this will decrease the upward normal force exerted by the scale on the lower sphere; thus, the reading on the scale will be less than when the spheres had the same charge.

Total for part (d) 3 points

Total for question 2 15 points