

GRIFFITHS ELECTRODYNAMICS SOLUTIONS

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Problem 2.1

a) Twelve equal charges, q are situated at the corners of a regular 12-sided polygon (for instance, one on each numeral of a clock face.) What is the net force on a test charge Q at the center?

The force on Q must be 0 by symmetry. The x , y , and z components of the fields due to each charge cancel, so the force vanishes.

b) Suppose one of the 12 q 's is removed (the one at "6 o'clock"). What is the force on Q ? Explain your reasoning carefully.

Now it is like 10 of the charges cancel, the only one that doesn't cancel being the one directly opposite the missing charge. Thus, the force is

$$F = \frac{1}{4\pi\epsilon_0} \frac{qQ}{r^2} \quad \square \quad (1)$$

pointing in the direction of the missing charge. Here, r is the distance from the center to each charge.

c) Now 13 equal charges, q , are placed at the corners of a regular 13-sided polygon. What is the force on a test charge Q at the center.

Again, by symmetry, the answer is still 0.

d) If one of the 13 q 's is removed, what is the force on Q ? Explain your reasoning.

The same answer as in part b, equation 1, and for the same reason.

Problem 2.2

a) Find the electric field (magnitude and direction) a distance z above the midpoint between two equal charges, q , a distance d apart. Check that your result is consistent with what you'd expect when $z \gg d$.

The force would not have components in the y or x direction, if we put the charges in the $x - z$ plane, there is no y -component of the field at the point in question, and the x -components cancel. The z -component of the field is

$$\mathbf{E} = \frac{1}{4\pi\epsilon_0} \frac{2q}{z^2 + (d/2)^2} \sin(\theta) \hat{\mathbf{z}} = \frac{1}{4\pi\epsilon_0} \frac{2qz}{(z^2 + (d/2)^2)^{3/2}} \hat{\mathbf{z}} \quad \square \quad (2)$$

where the factor of 2 comes from adding up the two charges. When $z \gg d$, the electric field becomes

$$\mathbf{E} = \frac{1}{4\pi\epsilon_0} \frac{2q}{z^2} \hat{\mathbf{z}} \quad (3)$$

which is what you would expect, since the system acts like a point charge of charge $2q$.

b) Repeat part (a), only this time make the right hand charge $-q$ instead of $+q$.

Now the z -components cancel and the x -components don't. Mathematically, this means replacing $\sin(\theta)$ with $\cos(\theta)$.

$$\mathbf{E} = \frac{1}{4\pi\epsilon_0} \frac{2q}{z^2 + (d/2)^2} \cos(\theta) \hat{\mathbf{x}} = \frac{1}{4\pi\epsilon_0} \frac{qd}{(z^2 + (d/2)^2)^{3/2}} \hat{\mathbf{x}} \quad \square \quad (4)$$

where the 2 has canceled out with the $d/2$ that comes from the cosine. If $z \gg d$, then from far away it looks like a dipole, and the field reduces to that of a dipole:

$$\mathbf{E} = \frac{1}{4\pi\epsilon_0} \frac{qd}{z^3} \hat{\mathbf{x}} \quad (5)$$

Griffiths Electrodynamics Solutions Manual

Hussin A.Rothana



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Table of Contents Griffiths Electrodynamics Solutions Manual

1. Understanding the eBook Griffiths Electrodynamics Solutions Manual
 - The Rise of Digital Reading Griffiths Electrodynamics Solutions Manual
 - Advantages of eBooks Over Traditional Books
2. Identifying Griffiths Electrodynamics Solutions Manual
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Griffiths Electrodynamics Solutions Manual
 - User-Friendly Interface
4. Exploring eBook Recommendations from Griffiths Electrodynamics Solutions Manual
 - Personalized Recommendations
 - Griffiths Electrodynamics Solutions Manual User Reviews and Ratings
 - Griffiths Electrodynamics Solutions Manual and Bestseller Lists
5. Accessing Griffiths Electrodynamics Solutions Manual Free and Paid eBooks
 - Griffiths Electrodynamics Solutions Manual Public Domain eBooks
 - Griffiths Electrodynamics Solutions Manual eBook Subscription Services
 - Griffiths Electrodynamics Solutions Manual Budget-Friendly Options
6. Navigating Griffiths Electrodynamics Solutions Manual eBook Formats

- ePub, PDF, MOBI, and More
- Griffiths Electrodynamics Solutions Manual Compatibility with Devices
- Griffiths Electrodynamics Solutions Manual Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Griffiths Electrodynamics Solutions Manual
 - Highlighting and Note-Taking Griffiths Electrodynamics Solutions Manual
 - Interactive Elements Griffiths Electrodynamics Solutions Manual
- 8. Staying Engaged with Griffiths Electrodynamics Solutions Manual
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Griffiths Electrodynamics Solutions Manual
- 9. Balancing eBooks and Physical Books Griffiths Electrodynamics Solutions Manual
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Griffiths Electrodynamics Solutions Manual
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Griffiths Electrodynamics Solutions Manual
 - Setting Reading Goals Griffiths Electrodynamics Solutions Manual
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Griffiths Electrodynamics Solutions Manual
 - Fact-Checking eBook Content of Griffiths Electrodynamics Solutions Manual
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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