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Coursebook answers

Chapter 21

Science in context guidance

There are a number of issues with harnessing lightning:

- It is difficult to predict when the lightning will strike. This makes it an unreliable power source.
- It is difficult to know where the lightning will strike. Where would you put the lightning rods required to harness it?
- Lightning provides (very short) bursts of energy. This energy would have to be somehow stored (giant capacitors?) so the energy can be used appropriately (and over a suitable period of time).

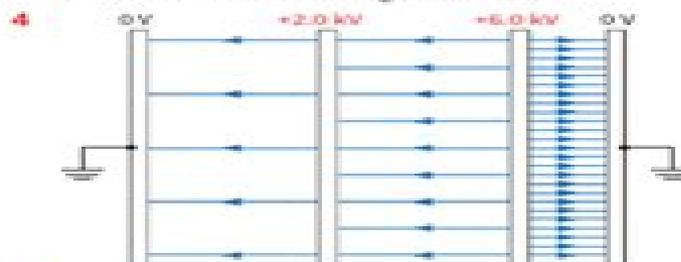
Although the energy released during a lightning strike is huge, it is over in a very short amount of time. 3 000 000 strikes a day would mean around 35 strikes / second on average, or an average power output of 350 MW. Even the smallest nuclear power plants have an output of around 500 MW, so even harnessing all of the lightning on the planet would provide a fairly insignificant amount of electrical energy.

Self-assessment questions

- 1
- Diagram I shows positive charges repelling; the arrow heads point away from the charges.
 - Diagram III shows negative charges repelling; the arrow heads point towards the charges.
 - Diagram II shows opposite charges attracting; the positive charge is on the right.



- 3 The field strength is greatest at the top (pointed) part of the building. The electric field lines are closest together there.



- 5 electric field strength $E = F/Q = 150/20 \times 10^{-3} = 7500 \text{ N C}^{-1}$ downwards
- 6 electric field strength $E = V/d = 1000/0.40 = 2500 \text{ V m}^{-1} = 2500 \text{ N C}^{-1}$
- 7 electric field strength $E = F/Q = 8 \times 10^{-11} / 1.6 \times 10^{-19} = 5000 \text{ V m}^{-1}$ or N C^{-1}
- 8
- Rearrange $E = V/d$ so that voltage to cause sparks is given by $V = Ed = 40\,000 \times 4 = 160\,000 \text{ V}$. This is only an estimate as the formula only really works for parallel plates; using approximations like this is a good way to find a rough estimate.
 - Rearrange $E = V/d$ so that minimum distance is given by $d = V/E = 325/40\,000 = 0.008 \text{ cm} = 0.08 \text{ mm}$.
 - Rearrange $E = V/d$ so that voltage to cause lightning is given by $V = Ed = 40\,000 \times 10\,000 = 400 \text{ MV}$ (remember that the field strength was given in volts per centimetre)

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Table of Contents Mastering Physics Answers Chapter 21

1. Understanding the eBook Mastering Physics Answers Chapter 21
 - The Rise of Digital Reading Mastering Physics Answers Chapter 21
 - Advantages of eBooks Over Traditional Books
2. Identifying Mastering Physics Answers Chapter 21
 - 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 Mastering Physics Answers Chapter 21
 - User-Friendly Interface
4. Exploring eBook Recommendations from Mastering Physics Answers Chapter 21
 - Personalized Recommendations

- Mastering Physics Answers Chapter 21 User Reviews and Ratings
- Mastering Physics Answers Chapter 21 and Bestseller Lists
- 5. Accessing Mastering Physics Answers Chapter 21 Free and Paid eBooks
 - Mastering Physics Answers Chapter 21 Public Domain eBooks
 - Mastering Physics Answers Chapter 21 eBook Subscription Services
 - Mastering Physics Answers Chapter 21 Budget-Friendly Options
- 6. Navigating Mastering Physics Answers Chapter 21 eBook Formats
 - ePub, PDF, MOBI, and More
 - Mastering Physics Answers Chapter 21 Compatibility with Devices
 - Mastering Physics Answers Chapter 21 Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Mastering Physics Answers Chapter 21
 - Highlighting and Note-Taking Mastering Physics Answers Chapter 21
 - Interactive Elements Mastering Physics Answers Chapter 21
- 8. Staying Engaged with Mastering Physics Answers Chapter 21
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Mastering Physics Answers Chapter 21
- 9. Balancing eBooks and Physical Books Mastering Physics Answers Chapter 21
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Mastering Physics Answers Chapter 21
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Mastering Physics Answers Chapter 21
 - Setting Reading Goals Mastering Physics Answers Chapter 21
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Mastering Physics Answers Chapter 21
 - Fact-Checking eBook Content of Mastering Physics Answers Chapter 21

- 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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