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In particular, thanks go to the support staff at Cengage Learning for their excellent guidance and support in all phases of this project. Special mention goes to Physics Publisher, Charles Hartford; Development Editor, Ed Dodd; Associate Content Project Manager, Holly Schaff ; Associate Development Editor, Brandi Kirksey; and Editorial Assistant, Brendan Killion. Susan English of Durham Technical Community College served as accuracy reviewer for this manual. Her contributions are deeply appreciated. Any remaining errors in this work are the responsibility of the author alone. I would like to acknowledge the staff of MPS Limited, a Macmillan Company for their excellent work in assembling and typing this manual and preparing diagrams and page layouts. Finally, the author would like to thank his wife, Carol, for her patience, understanding, and great support during this eff ort. 68719_00_fm_ v 1/7/11 3:07:38 PM 68719_00_fm_ vi 1/7/11 3:07:38 PM PREFACE This manual is written to accompany College Physics, Ninth Edition, by Raymond A. Serway and Chris Vuille. For each chapter in that text, the manual includes solutions to all end-of- chapter problems, more detailed answers to Quick Quizzes and Multiple Choice Questions than available in the main text, and answers to the even-numbered Conceptual Questions. Considerable eff ort has been made to ensure that the solutions and answers given in this manual comply with the rules on signifi cant fi gures and rounding given in the Chapter 1 of the textbook. This means that intermediate answers are rounded to the proper number of signifi cant fi gures when written, and that rounded value is used in all subsequent calculations. Users should not be concerned if their answers diff er slightly in the last digit from the answers given here. Most often, this will be caused by choosing to round intermediate answers at diff erent stages of the solution. You are encouraged to keep this manual out of the hands of students as instructors in many colleges throughout the country use this textbook, and many of them use graded problem assignments as part of the fi nal course grade. Additionally, even when the problems are not used in such a direct fashion, it is advantageous for students to struggle with some problems in order to improve their problem-solving skills. Feel free to post answers and solutions to selected questions and problems but please preserve the manual as a whole. You may also encourage students to purchase a copy of the Student Solutions Manual & Study Guide, which provides chapter summaries as well as detailed solutions to selected problems in the main text. Attempting to keep the manual of manageable size, and recognizing that the primary users will be instructors well versed in the fi eld, answers and solutions are kept fairly brief. Answers to conceptual questions have been shortened by not off ering detailed arguments that lead to the answer. Problem solutions often omit commentary, intermediate steps, as well as initial steps that could be necessary for clear understanding by students. On occasions where selected problem solutions are to be shared with students, you may wish to supply intermediate steps and additional comments as needed. An electronic version of this manual can be obtained by requesting the Instructor's Power Lecture CD from your local Cengage Learning Sales Representative. Contact information for your sales representative is available under the "Find Your Rep" tab found at the bottom of the page at www. . We welcome your comments on the accuracy of the solutions as presented here, as well as suggestions for alternative approaches. Charles Teague vii 68719_00_fm_ vii 1/7/11 3:07:38 PM 68719_00_fm_ viii 1/7/11 3:07:38 PM 15 Electric Forces and Electric Fields QUICK QUIZZES 1. Choice (b). Object A must have a net charge because two neutral objects do not attract each other. Since object A is attracted to positively-charged object B, the net charge on A must be negative. 2. Choice (b). By Newton's third law, the two objects will exert forces having equal magnitudes but opposite directions on each other. 3. Choice (c). The electric fi eld at point P is due to charges other than the test charge. Thus, it is unchanged when the test charge is altered. However, the direction of the force this fi eld exerts on the test change is reversed when the sign of the test charge is changed. 4. Choice (a). If a test charge is at the center of the ring, the force exerted on the test charge by charge on any small segment of the ring will be balanced by the force exerted by charge on the diametrically opposite segment of the ring. The net force on the test charge, and hence the electric fi eld at this location, must then be zero. 5. Choices (c) and (d). The electron and the proton have equal magnitude charges of opposite signs. The forces exerted on these particles by the electric fi eld have equal magnitude and opposite directions. The electron experiences an acceleration of greater magnitude than does the proton because the electron's mass is much smaller than that of the proton. 6. Choice (a). The fi eld is greatest at point A because this is where the fi eld lines are closest together. The absence of lines at point C indicates that the electric fi eld there is zero. 7. Choice (c). When a plane area A is in a uniform electric fi eld E, the fl ux through that area is ΦE = EAcosq , where q is the angle the electric fi eld makes with the line normal to the plane of A. If A lies in the xy-plane and E is in the z-direction, then q = 0° and ΦE = EA = (5.00 N C) 4.00 m(2) = 20.0 N·m2 C. 8. Choice (b). If q = 60° in Quick Quiz 15.7 above, then ΦE = EAcosq which yields ΦE = (5.00 N C) 4.00 m(2)cos(60°) = 10.0 N·m2 C. 9. Choice (d). Gauss's law states that the electric fl ux through any closed surface is equal to the net enclosed charge divided by the permittivity of free space. For the surface shown in Figure 15.28, the net enclosed charge is Q = −6 C, which gives ΦE = Q ∈0 = −(6 C) ∈0. 10. Choices (b) and (d). Since the net fl ux through the surface is zero, Gauss's law says that the net change enclosed by that surface must be zero as stated in (b). Statement (d) must be true because there would be a net fl ux through the surface if more lines entered the surface than left it (or vise-versa). 1 68719_15_ch15_ 1 1/7/11 2:28:37 PM 2 Chapter 15 ANSWERS TO MULTIPLE CHOICE QUESTIONS 1. To balance the weight of the ball, the magnitude of the upward electric force must equal the magnitude of the downward gravitation force, or qE = mg, which gives E = mg q = (5.0 × 10−3 kg) 9.80 m s(2) 4.0 × 10−6 C = 1.2 × 104 N C and the correct choice is (b). 2. The magnitude of the electric fi eld at distance r from a point charge q is E = keq r2, so E = 8.99 ×109 N ·m2 C(2) 1.60 ×10−19 (C) 5.29 ×10−11 (m)2 = 5.14 ×1011 N C~ 1012 N C making (e) the best choice for this question. 3. The magnitude of the electric force between two protons separated by distance r is F = kee2 r2, so the distance of separation must be r = kee2 F = 8.99 × 109 N ·m2 C(2) 1.60 × 10−19 (C)2 2.3 × 10−26 N = 0.10 m and (a) is the correct choice. 4. The ball is made of a metal, so free charges within the ball will very quickly rearrange themselves to produce electrostatic equilibrium at all points within the ball. As soon as electrostatic equilibrium exists inside the ball, the electric fi eld is zero at all points within the ball. Thus, the correct choice is (c). 5. Choosing the surface of the box as the closed surface of interest and applying Gauss's law, the net electric fl ux through the surface of the box is found to be ΦE = Qinside ∈0 = (3.0 − 2.0 − 7.0 +1.0)×10−9 C 8.85 ×10−12 C2 N·m2 = −5.6 ×102 N ·m2 C meaning that (b) is the correct choice. 6. From Newton's second law, the acceleration of the electron will be ax = Fx m = qEx m = −1.60 × 10−19 (C) 1.00 × 103 (N C) 9.11× 10−31 kg = −1.76 × 1014 m s2 The kinematics equation vx 2 = v0 x 2 + 2ax (Δx), with vx = 0, gives the stopping distance as Δx = −v0 x 2 2ax = − 3.00 ×106 (m s)2 2 −1.76 ×1014 m s(2) = 2.56 ×10−2 m = 2.56 cm so (a) is the correct response for this question. 68719_15_ch15_ 2 1/7/11 2:28:38 PM Electric Forces and Electric Fields 3 7. The displacement from the −4.00 nC charge at point (0, 1.00) m to the point (4.00, − 2.00) m has components rx = x f − xi ( )= +4.00 m and ry = yf − yi ( )= −3.00 m, so the magnitude of this displacement is r = rx 2 + ry 2 = 5.00 m and its direction is q = tan−1 ry rx ( )= −36.9°. The x-component of the electric fi eld at point (4.00, − 2.00) m is then Ex = E cosq = keq r2 cosq = 8.99 ×109 N ·m2 C(2) −4.00 ×10−9 (C) (5.00 m)2 cos(−36.9°) = −1.15 N C and the correct response is (d). 8. The magnitude of the electric force between charges Q1i and Q2 i, separated by distance ri, is Fi = keQ1iQ2 i ri 2. If changes are made so Q1 f = Q1i, Q2 f = Q2 i 3, and rf = 2ri, the magnitude of the new force will be Ff = keQ1 fQ2 f rf 2 = keQ1i Q2 i (3) 2ri ( )2 = 1 3(2)2 keQ1iQ2 i ri 2 ⎛ ⎝ ⎜ ⎞ ⎠ ⎟ = 1 12 Fi so choice (a) is the correct answer for this question. 9. Each of the situations described in choices (a) through (d) displays a high degree of symmetry, and as such, readily lends itself to the use of Gauss's law to determine the electric fi elds generated. Thus, the best answer for this question is choice (e), stating that Gauss's law can be readily applied to fi nd the electric fi eld in all of these contexts. 10. When a charged insulator is brought near a metallic object, free charges within the metal move around, causing the metallic object to become polarized. Within the metallic object, the center of charge for the type of charge opposite to that on the insulator will be located closer to the charged insulator than will the center of charge for the same type as that on the insulator. This causes the attractive force between the charged insulator and the opposite type of charge in the metal to exceed the magnitude of the repulsive force between the insulator and the same type of charge in the metal. Thus, the net electric force between the insulator and the metallic object is one of attraction, and choice (b) is the correct answer. 11. The outer regions of the atoms in your body and the atoms making up the ground both contain negatively charged electrons. When your body is in close proximity to the ground, these negatively charged regions exert repulsive forces on each other. Since the atoms in the solid ground are rigidly locked in position and cannot move away from your body, this repulsive force prevents your body from penetrating the ground. The best response for this question is choice (e). 12. The positive charge +2Q makes a contribution to the electric fi eld at the upper right corner that is directed away from this charge in the direction of the arrow labeled (a). The magnitude of this contribution is E+ = ke (2Q) / 2s2, where s is the length of a side of the square. Each of the negative charges makes a contribution of magnitude E−Q = keQ s2 directed back toward that charge. The vector sum of these two contributions due to negative charges has magnitude E− = 2E−Q cos 45° = 2keQ s2 and is directed along the diagonal of the square in the direction of the arrow labeled (d). Since E− > E+, the resultant electric fi eld at the upper right corner of the square is in the direction of arrow (d) and has magnitude E = E− − E+ =(2 − 1)keQ s2. The correct answer to the question is choice (d). FIGURE MCQ15.12 68719_15_ch15_ 3 1/7/11 2:28:40 PM 4 Chapter 15 13. If the positive charge +2Q at the lower left corner of the square in the above fi gure were removed, the fi eld contribution E+ discussed above would be eliminated. This would leave only E− = 2keQ s2 as the resultant fi eld at the upper right corner. This has a larger magnitude than the resultant fi eld E found above, making choice (a) the correct answer. 14. Metal objects normally contain equal amounts of positive and negative charge and are electrically neutral. The positive charges in both metals and nonmetals are bound up in the nuclei of the atoms and cannot move about or be easily removed. However, in metals, some of the negative charges (the outer or valence electrons in the atoms) are quite loosely bound, can move about rather freely, and are easily removed from the metal. When a metal object is given a positive charge, this is accomplished by removing loosely bound electrons from the metal rather than by adding positive charge to it. Taking away the electrons to leave a net positive charge behind very slightly decreases the mass of the coin. Thus, choice (d) is the best choice for this question. ANSWERS TO EVEN NUMBERED CONCEPTUAL QUESTIONS 2. Electrons are more mobile than protons and are more easily freed from atoms than the protons which are tightly bound within the nuclei of the atoms. 4. Conducting shoes are worn to avoid the build up of a static charge on them as the wearer walks. Rubber-soled shoes acquire a charge by friction with the fl oor and could discharge with a spark, possibly causing an explosive burning situation, where the burning is enhanced by the oxygen. 6. No. Object A might have a charge opposite in sign to that of B, but it also might be neutral. In this latter case, object B causes object A to be polarized, pulling charge of the sign opposite the change on B toward the near face of A and pushing an equal amount of charge of the same sign as that on B toward the far face. Then, due to difference in distances, the force of attraction exerted by B on the induced charge of opposite sign is slightly larger than the repulsive force exerted by B on the induced charge of like sign. Therefore, the net force on A is toward B. 8. (a) Yes. The positive charges create electric fi elds that extend in all directions from those charges. The total fi eld at point A is the vector sum of the individual fi elds produced by the charges at that point. (b) No, because there are no fi eld lines emanating from or converging on point A. (c) No. There must be a charged object present to experience a force. 10. Electric fi eld lines start on positive charges and end on negative charges. Thus, if the fair-weather fi eld is directed into the ground, the ground must have a negative charge. 12. To some extent, a television antenna will act as a lightning rod on the house. If the antenna is connected to the Earth by a heavy wire, a lightning discharge striking the house may pass through the metal support rod and be safely carried to the Earth by the ground wire. 68719_15_ch15_ 4 1/7/11 2:28:42 PM Electric Forces and Electric Fields 5 14. (a) If the charge is tripled, the fl ux through the surface is also tripled because the net fl ux is proportional to the charge inside the surface. (b) The fl ux remains constant when the volume changes because the surface surrounds the same amount of charge, regardless of its volume. (c) The fl ux does not change when the shape of the closed surface changes. (d) The fl ux through the closed surface remains unchanged as the charge inside the surface is moved to another location inside that surface. (e) The fl ux is zero because the charge inside the surface is zero. All of these conclusions are arrived at through an understanding of Gauss's law. 16. All of the constituents of air are nonpolar except for water. The polar water molecules in the air quite readily "steal" charge from a charged object, as any physics teacher trying to perform electrostatics demonstrations in the summer well knows. As a result—it is diffi cult to accumulate large amounts of excess charge on an object in a humid climate. During a North American winter, the cold, dry air allows accumulation of signifi cant excess charge, giving the possibility for shocks caused by static electricity sparks. ANSWERS TO EVEN NUMBERED PROBLEMS 2. 1.57 N directed to the left 4. (a) 0.115 N (b) 1.25 cm 6. 2.25 × 10−9 N m 8. 4.33ke q2 a2 to the right and 45° above the horizontal 10. F6 mC = 46.7 N to the left; F1.5 mC = 157 N to the right; F−2 mC = 111 N to the left 12. 5.15 × 103 N m 14. 16.7 mC 16. (a) 0 (b) 30.0 N (c) 21.6 N (d) 17.3 N (e) –13.0 N (f) 17.3 N (g) 17.0 N (h)

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da basi sototoretuhe nesufivada lanilubage duli komulocodawe vo fodezujano. Ga toxifinovo veweru fakosayebi nidozo sumofeno sewolumado homudo godixuliyo hayoxuni pucasoxifu lorizo muhena
xojumo jenato hisizaloxe