Electrostatics lab report answers

APPAREIL Heat Lamp Minutery Two stems lucites Raw plastic Stem Silk Fur Cat Stand with stirrup carries pith balls on Electroscope Electrophorus Coulomb's Law (no-needed load pads) INTRODUCTION This experiment consists of many short demonstrations in electrostatic. In most exercises, you don't take data, but record a short description of your observations. If high humidity conditions prevent you from completing certain parts, you can try them again next week with the Van de Graaff experiments. THEORY The fundamental concept in electrostatic is electrical charge. We are all familiar with the fact that rubbing two materials together - for example, a rubber comb on cat fur - produces a static charge. This process is called friction loading. Surprisingly, the exact physics of the friction loading process is poorly understood. However, it is known that the capture and rupture of contact between the two materials transfers the load. The charged particles that make up the universe come in three kinds: positive, negative and neutral. Neutral particles do not interact with electrical forces. Charged particles exert electrical and magnetic forces on each other, but if the charges are stationary, the mutual force is very simple in form and is given by Coulomb's law: 'begin eqnarray' F_'s textrm E kqQ/r-2, 'end-eqnarray' where 'F_'s 'textrm') is the electrical force between two stationary charged particles with charges (q) and 'Q' (measured in coulombs), is the separation between the charges (measured in meters), and (k) is a nature constant (equal to 9×109 Nm2/C2 in SI units). The study of Coulomb forces among the arrangements of stationary charged particles is called electrostatic. Coulomb's law describes three properties of electrical force: the force is inversely proportional to the square of the distance between the charges, and is directed along the straight line that connects their centers. The force is proportional to the product of the magnitude of the loads. Two particles of the same charge exert a repulsive force on top of each other, and two particles of opposite charge exert an attractive force on each other. Most of the common objects we process in the macroscopic (human-sized) world are electrically neutral. They are composed of atoms that consist of negatively charged electrons moving in quantum motion around a positively charged nucleus. The total negative charge of the electrons is normally exactly equal to the total positive charge of the nuclei, so that the atoms (and thus the whole object) have no charge Net. When we load a material by friction, we transfer some of the electrons from one material to another. Materials such as metals are conductors. Each metal atom brings one or two electrons that can move relatively freely through the A driver will carry an electric current. Other materials such as glass are insulators. Their electrons are closely related and cannot move. Load the sticks onto an insulator, but do not move freely through it. A neutral particle is not affected by electrical forces. Nevertheless, a loaded object will attract a neutral macroscopic object through the electrical polarization process. For example, if a negatively charged rod is brought near an insulated and neutral insulator, the electrons in the insulation atoms will be slightly removed from the negative stem, and the positive nuclei will be slightly attracted to the negative stem. We say that the stem has induced polarization in the insulation, but its net load is still zero. The polarization of the load in the insulation is low, but now its positive load is a little closer to the negative stem, and its negative load is a little further. Thus, the positive load is attracted to the stem more strongly as the negative load is pushed back, and there is an overall net attraction. (Don't confuse electrical polarization with the polarization of light, which is a totally different phenomenon.) If the negative rod is brought near an isolated and neutral conductor, the driver will also be polarized. In the conductor, the electrons are free to move through the material, and some of them are pushed back to the opposite surface of the conductor, leaving the surface near the negative rod with a net positive charge. The driver has been polarized, and will now be attracted to the loaded rod. Now, if we connect a conductive wire or any other conductive material of the polarized conductor to the ground, we provide an ie through which electrons can move. The electrons will actually move along this path to the ground. If the wire or path is subsequently disconnected, the driver as a whole ends up with a net positive load. The driver was charged without being hit by the loaded rod, and his load is opposite to that of the rod. This procedure is called induction charge. The ELECTROSCOPE An electroscope is a simple instrument to detect the presence of electrical charge. The old electroscopes consisted of a box or cylinder with a front glass wall for the experimenter to look inside, and an insulating top through which a conductive rod with a ball or disc (called an electrode) on top entered the box. At the bottom of the stem, very fine gold leaf was folded on hanging leaves, or perhaps a gold leaf hanging next to a fixed weather vane. Gold has been used because it is a good driver and very ductile; it can be made very thin and When the load has been transferred upwards, the gold leaves become loaded and repel each other. Their discrepancy indicated the presence of a charge. A modern electroscope like the one used in your experiments consists of one of a attached to a delicately balanced moving weather vane or needle. When the load is brought near the upper electrode, the moving weather vane moves outwards, being pushed back by the fixed weather vane. ELECTROSTATICS AND HUMIDITY We are all familiar with the fact that cold, dry days are hot for electrostatics, and we get small shocks after walking on a mat and touching a door button, or sliding on a car seat and touching the metal from the car door. If the humidity is low enough on the day of your lab, the experiments will be easy. If the humidity is extremely low, as is often the case in Southern California, you probably won't escape the lab without direct experience with electrostatic! If humidity is high, as is sometimes the case in summer, experiments are more difficult, and some may be impossible. If the experiments are difficult on the first week of the electrostatic lab, they will be left in place so you can try some of them with the Van de Graaff experiments in the next lab. When the air is moist, a thin, invisible film of water forms on all surfaces, especially on the surfaces of the insulators of the experiment. This film leads away the accusations before they have a chance to build. You can improve this effect a little by shining a heat lamp on the insulation of the device. Do not get too close to the heat lamp, or the insulation will be melted. HUMIDITY EFFET EXPERIENCE Equipment Lucite stem silk fabric Timer Procedure Electroscope Record your observations in writing either on the computer (for example, in Microsoft Word) or on your own paper. If you write by hand, write clearly, clearly and cleanly so that anyone, especially your TA, can read it easily. Start each observation with the section number and the stage number (e.g., I-2 for the step below). You don't need to repeat the question. Not all steps have observations to record. Record in your notes the relative humidity in the room (of the wall counter) and the temperature inside and outside. For this experience, do not make the flood lamp shine on the electroscope. Get ready to start your timer. You can use the stopwatch function of your wristwatch. Rub the lucite stem vigorously with the silk fabric. Use a small whipping motion at the end of the friction. Touch the lucite rod to the top of the electroscope. Move the rod along and around the top to touch as much of its surface to the electroscope metal as possible. Given The rod is an insulator, the load will not drain from all parts of the rod on the electroscope; you must touch all the parts (except when you hold it) to the electroscope. Start your timer immediately after uploading the electroscope. Record how long it takes the electroscope needle to completely drop to 0 degrees. Time up to five minutes, if necessary. If the needle has not fallen to 0 degrees after five minutes, record an estimate of its angle at the Brand. As a general rule, after the charge, the needle can be at 80 degrees. If the electroscope needle drops to 0 degrees in a few minutes, the heat lamp will help in the experiments below. If the needle drops to 0 degrees in about 15 seconds, as it does on some summer days, you will probably have trouble completing the experiments, even with the use of the heat lamp. If so, you can try again next week. IN this section, you will observe the characteristics of both types of loads, and experimentally verify that the opposite loads attract and as the charges repel. Equipment Two lucite rods A rough plastic rod Stand with silk fabric brace Procedure of the fur Of the cat Load a stalk of lucite by rubbing it vigorously with silk. Place the stem in the stirrup holder as shown in Figure 7. Rub the second stalk of lucite with silk, and bring it near the first stem. What is going on? Record the observations in your notes. Rub the rough plastic stem with the cat's fur, and bring this rod near the lucite stem into the stirrup. Record your observations. For reference purposes, according to the convention originally chosen by Benjamin Franklin, the lucite stems rubbed with silk become positively charged, and the rough plastic rods rubbed with the cat's fur become negatively charged. Hard rubber rods, which are also commonly used, become negatively charged. PITH BALLS In this section, you will observe the induced polarization of a neutral insulator and the transfer of load by contact. Equipment hanger with balls of marrow stem stem raw plastic silk fabric Cat fur Procedure (The heat lamp can help minimize moisture near the marrow balls.) Touch the marrow balls with your fingers to neutralize any charge. Load the stalk of lucite by rubbing it with silk. Bring the lucite stalk close (but don't touch) the marrow balls. Observe and record what happens to the balls. Explain your results. (See the theoretical section, if necessary.) Touch the marrow balls with your finger to unload them. Recharge the lucite stem with silk. Touch the marrow balls with the lucite stem. (Sometimes it is necessary to touch different parts of the rod to the balls.) Then bring the rod near one of the balls. What is going on? Save and explain your results. Load the rough plastic rod with the cat's fur. How does the plastic rod affect the marrow balls after they have been loaded with the lucite stem? Record your results. Load INDUCTION Equipment Electroscope Lucite Stem Rough Plastic Silk Fabric Fur Procedure Cat Load the lucite stem by rubbing it with silk. Bring the lucite rod close (but don't touch) the top of the electroscope, so that the electroscope is deflected. Remove the stalk of lucite. What is going on? Record the results of your notes. Use several sentences and perhaps a diagram or two to explain the behavior of the accusations in the electroscope. Bring the lucite stem near the again so that it is deflected. Hold the rod in this position and briefly touch the top of the electroscope with your other finger. Keep the stem in position. What is going on? Record the results in your notes. Now remove the lucite stem. If you have done everything correctly, the electroscope must have a permanent deviation. Chart in your notes what happened with the loads. (See the theoretical section, if necessary.) With the electroscope deflected as a result of the above operations, bring the charged lucite rod near the electroscope again. Remove the lucite rod and bring a loaded raw plastic rod near the electroscope. What happens in each case? Record the results in your notes. ELECTROPHORUS Electrophore is a simple electrostatic induction device invented by Alessandro Volta around 1770. Volta called it an inexhaustible source of burden. In its current form, the electrophore consists of a plate of lucite on which rests a flat metal plate with an insulating handle. The lucite plate is positively charged by being rubbed with silk. Because lucite is an insulator, it stays charged until the load flows slowly. The metal plate does not capture this positive load, even if it rests on the lucite. The plate comes into contact with lucite in only a few places; and because lucite is an insulator, the load does not easily transfer from it. Instead, when you touch the metal plate, the electrons in your body (attracted by the positive lucite plate) flow onto the metal plate. Your body acts like an electric field. The metal plate is negatively charged by induction. As the positive load is not used, the metal plate can be charged several times by induction. Equipment Electrophorus Silk Fabric Electroscope Neon tube Procedure (The thermal lamp that shines on the equipment can improve its operation.) Load the electrophore lucite plate by rubbing it with silk. A whipping motion towards the end of the friction can help. Usually, lucite should be loaded only once for the entire experience. Place the metal plate in the center of the lucite plate, and touch it with your finger. (You may feel a slight shock.) Hold the metal plate by its insulating handle as far away from the metal as possible. Bring the metal within 2 cm of your joint, then slowly come closer until a (painless) spark jumps. Recharge the metal plate by placing it on the lucite, touching the lucite, then lifting the plate with its insulating handle. Bring it near your lab partner's joint. procedure until you have experienced several sparks. What is the average distance that a spark will jump? Record this distance in your notes. Reload the metal plate and slowly bring it near the top of the electroscope. Watch what happens with the electroscope needle. Keep the plate away from the electroscope and record with the electroscope needle. Is it still deflected? Why not? Recharge the metal plate and touch it at the top of the electroscope. Set the metal plate aside. Watch what happens with the electroscope needle. Is there a difference in the behavior of the needle compared to the results of Procedure 6? If so, how do you explain the difference? Record this explanation in your notes. Once again, reload the metal plate. Hold one end of the neon tube with your fingers, and slowly move the metal plate closer to the other end. Watch what happens with the neon tube. The induced current should create a brief flash of light. By grinding the end of the tube with your fingers, you provide a pathway for loads to move. In this section, you loaded the lucite plate by rubbing it at the beginning, and were then able to load the metal plate several times. Where does the load on the metal plate come from? Where does the energy that brings in the sparks and lights from the tube? Comment in your notes. COULOMB LOI You will test the reverse dependence of Coulomb's law with a very simple device. There is a large box containing a suspended marrow ball covered with a conductive surface, and similar marrow balls on the sliding blocks. A mirror ladder allows you to determine the position of the balls. (The purpose of the closed box is to minimize the effects of drafts.) The movement of the suspended ball from its equilibrium position depends on the electrical force that pushes it away from the sliding ball. Figure 10's triangle of strength gives 'begin'eqnarray' and 'tan' F/mg, 'end-eqnarray' while the physical triangle of the suspended ball gives 'begin'eqnarray' 'sin'phi 'and 'l' 'end'eqnarray' if the angle is low, then 'tan'phi 'sin-phi', and '') is proportional to 'F'. Therefore, to demonstrate the inverse dependence of Coulomb's law, we must measure the displacement according to the separation between the centers of the balls. The purpose of the mirror is to minimize parallax errors in reading the scale. For example, to measure the position of the front of the suspended ball, align the front edge of the ball with its image. Your eye is now perpendicular to the scale, and you can read the position. Figure 11 below shows the situation where your eye is still too high and right. Coulomb's Law Equipment Electrophorus Silk cloth Procedure Take a moment to check the position of the suspended ball in your Coulomb device. Look out the side plastic window. The suspended ball must be at the same height as the sliding ball (i.e. the of the mirror ladder must pass behind the center of the suspended marrow ball, as in Figure 12 below). Lift the top cover and look down on the ball. The suspended ball must be centered on a line with sliding balls. If necessary, carefully adjust the fine wires that hold the ball suspended to position it correctly. Load the metal plate of the electrophore in the usual way by rubbing the plastic base with silk, placing the metal plate on the base, and touching it with your finger. Lift the metal plate with its insulating handle and touch it carefully with the ball on the left sliding block. Slide the block into the Coulomb without touching the sides of the box with the ball. Slide the block until it is near the hanging ball. The suspended ball will be attracted by polarization, as in Section III of this laboratory. After he touches the sliding ball, the suspended ball will pick up half the load and be pushed back. Repeat if necessary, pushing the sliding ball until it touches the suspended ball. Recharge the sliding ball to produce maximum force, and experiment with pushing it towards the hanging ball. The suspended ball must be pushed back strongly. You will measure the movement of the suspended ball. You don't need to measure the position of its center, but will record the position of its inner edge. Remove the sliding ball and record the balance position of its inner edge that faces the sliding ball, which you subtract from all other measurements to determine the movement. Put the sliding ball in it, and test measurements of the inside edge of the sliding ball and the inside edge of the hanging ball. The difference between these two measurements, plus the diameter of one of the balls, is the distance between their centers. Practice taking measurements and compare your readings with those of your lab partner until you are sure you can do them accurately. Try to estimate the measurements at 0.2 mm. Take measurements and record the diameter of the balls (seeing on the ladder). Remove the sliding ball and double-check the balance position of the inside edge of the hanging ball. You can save and graph data in Excel or by hand (although if you work by hand, you will lose the opportunity for 2 additional credit mills below). Recharge the balls as in steps 1-4, and record a series of measurements of the inner edges of the balls. Move the sliding ball in 0.5 cm steps for each new measurement. Calculate the columns of the moves (position of the suspended ball minus the equilibrium position) and the separations (difference between the two measures recorded plus the diameter of a ball). Chart (by hand or with Excel) vs. (1/r-2). Is Coulomb's law verified? an additional credit of 2 mills, use Excel to adapt a power law curve to the data. What is the exhibitor of the force dependency? (Theoretically, it should be 2,000, but what does your curve produce?) For your recordings, you can print your Excel file using a table and your digital observations and all the other electronic files you have generated. SUPPLEMENTARY CREDIT (3 mills) You can modify the load on the sliding ball by factors of two, touching it to the other unloaded sliding ball (the ground with your finger first). The balls will share their load, and half of the load will remain on the first ball (assuming the balls are the same size). This way, you can get a fee on the first ball of 'Q', 'Q/2'), '(Q/4'), and so on. Design and run an experiment to verify the dependence of Coulomb force on the value of one of the charges. (That is, we want to show that force is proportional to one of the charges.) The method is yours; explain your plan and the results of your notes. What do you have to plot against what? Is something to be held all the time? Constant?