Name _____ Date _____ Partners_____

EQUIPOTENTIAL AND THE ELECTRIC FIELD

Statement of Purpose

The purpose of the following experiment is the observation of an electric field by quantitative measurement. By determining the voltage at various points between two electrodes, we are able to map equipotential lines; these lines can be used to map the electric field lines, which are at all points perpendicular to the equipotential.

Notes on the Multimeter

Source: Philips, W.D. "2P: Using a Multimeter." *Design Electronics.* DOCTRONICS Educational Publications. 1999. http://www.doctronics.co.uk/meter.htm.

The multimeter we will be using is the Wavetek Meterman 27XT Digital Multimeter. The multimeter is an extremely useful tool when analyzing electrical circuits because it is able to operate in three distinct modes: by measuring current (as an ammeter), by measuring voltage (as a voltmeter), and by measuring resistance (as an ohmmeter). When the multimeter is functioning as an ammeter, the current passing through it must be identical to the current in the circuit loop for which the measurement is being taken; therefore, the ammeter/multimeter must be connected in series. This function requires a low resistance to avoid modifying the circuit. When the multimeter is functioning as a voltmeter, the voltage drop across the multimeter must be equivalent to that across the circuit branch being examined; therefore, the voltmeter/multimeter must be connected in parallel, as the voltage drop across all branches in a circuit is uniform. This function requires a high resistance to avoid shorting the circuit. The multimeter may additionally function as an ohmmeter when connected across a circuit element which is separate from the circuit. For the purpose of this experiment, we will use the multimeter as a voltmeter.

Experimental Setup

Equipment	Qty
HP 6216A DC Power Supply	1
Wavetek Meterman 27XT Multimeter	1
Brass cylindrical "point" electrodes	2
Aluminum plate electrodes	2
Base and support rod	2
Three finger clamp	2
Stacking banana plugs (black)	2
Banana plugs (one red, one black)	2
Square plastic dish, 8x8 (in.)	1
Waterproofed grid sheet	1
Duplicate grid sheet (not waterproof)	3

Colored markers	5
Water	

I. Two Point Electrodes

1. With the waterproofed grid sheet placed in the bottom of the plastic dish, fill the dish with water to a depth of one to two centimeters. You may want to tape the grid down so it will not slide around as you take data.

2. Turn the Wavetek Meterman Multimeter knob to 20V and select DC mode.

3. With the three-fingered prongs attached to the base and support rods, place the two "point" electrodes in the clamps. Position the holders so that the electrodes are roughly equidistant from their respective sides of the dish. The lower end of each electrode should be submerged in the water. Use a red banana plug to connect one electrode to the positive terminal of the DC Power Supply and a stacking banana plug to connect the other electrode to the negative terminal.

4. Using a second stacking banana plug, connect the black electrode to the COM input of the Wavetek Meterman Multimeter.

5. Plug the multimeter probe lead into the V Ω input of the Wavetek Meterman Multimeter.

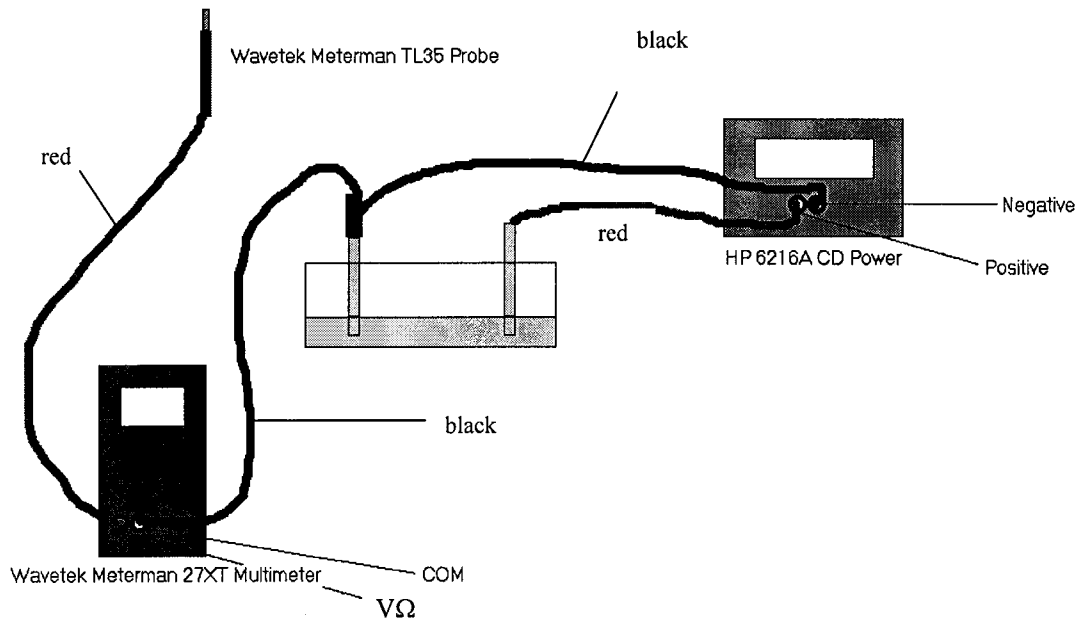

Figure 1

6. **Potential Difference:** Turn on the DC source. Set the input to 5 Volts. This should supply a current and create a potential difference across the electrodes. Bring the probe in contact under water with one of the two electrodes and check the voltage reading with the multimeter.

   Potential (1st Electrode):_____

   Question 1: What voltage reading do you expect to find for the other electrode?

   Use the probe to check your prediction.

   Potential (2nd Electrode):_____

7. **Central Equipotential Line:** Locate a point midway between the two electrodes (as close as possible to the exact center) and measure the potential here by touching the probe to the bottom of the container. Keep in mind that the voltage reading may not stabilize immediately, so you may need to hold the probe still for several seconds before getting an accurate reading. Choose a color to represent this voltage and record the voltage and corresponding color in the table below (Table 1); also record the grid position. Use the marker to mark the position of this first potential on the duplicate grid, which you should label "Grid 1." Now use the probe and multimeter to locate a second point with the same potential. Write this grid position in Table 1 and use the marker to record it on the duplicate grid. Repeat this process until you have located several points on each side of the central point (i.e., the point on the axis of the electrodes). List each grid position in the Table and on the duplicate grid. A line connected through these points should represent your central equipotential line; draw this line on the duplicate grid.

Color	Voltage (V)	Grid Positions

Table 1

8. **Off-Center Equipotential Lines:** Repeat the process described in Step 7, but this time chose an initial voltage point between the electrodes on either side of the center point. Again, locate several points on either side of the electrode axis and record these values in different color ink than that used in Step 7. Remember to record the color, voltage, and grid positions in Table 1.

Prediction 1: What would a connecting line between these points resemble? Sketch your prediction below.

Repeat this process for all five colors, twice on each side of the central equipotential line.

9. **Field Lines:** Electric field lines are perpendicular to equipotential lines at all points.

   Prediction 2: Before drawing the field lines on your data sheet, predict the field line configuration by drawing it below:

Now draw short dashes on the duplicate grid perpendicular to your equipotential lines at several points along each line. Connect these dashes in order to draw electric field lines.

II. Point and Plane Electrodes

1. With the power supply turned off to avoid electrical shock, replace one of the "point" electrodes with a plane electrode. The plane electrode balances on its narrow side on the bottom of the dish, so the base and rod are not needed. Insert the banana plug formerly connected to the "point" electrode into the hole in the corner of the plane electrode.

2. Turn the voltage back on and repeat the procedure outlined above for this configuration. The central electrode axis should now be located between the electrode and the center of the plate.

Prediction 3: How do you expect the equipotential and the field lines to appear with this electrode configuration? Sketch your predictions below.

Test your predictions by following the process described above. Use a new duplicate grid (label it "Grid 2") and record data in Table 2.

Color	Voltage (V)	Grid Positions

Table 2

III. Two Plane Electrodes

1. With the power supply turned off to avoid electrical shock, replace the remaining "point" electrode with a second plane electrode. The apparatus should now contain two parallel planes within the configuration described in the initial laboratory setup.

2. Turn the voltage on and repeat the procedure outlined in Part I for this configuration.

   Prediction 4: How do you expect the equipotential and the field lines to appear with these electrode shapes? Sketch your predictions below.

Test your predictions. Use a new duplicate grid (label it "Grid 3") and record data in Table 3.

Color	Voltage (V)	Grid Positions

Table 3

Grid sheet

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92
93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138
139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161
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1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035
1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058
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1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196
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