Name

Section

Date

26 LABORATORY 26 *Equipotentials and Electric Fields*

PRE-LABORATORY ASSIGNMENT

1. Electric field lines are drawn (a) from positive charges to negative charges (b) from negative charges to positive charges (c) from the largest charge to the smallest charge (d) from the smallest charge to the largest charge.

2. The points where the potential is the same (in three-dimensional space) have the same voltage. (a) True (b) False

3. The points where the potential is the same (in three-dimensional space) lie on a surface. (a) True (b) False

4. The relationship between the direction of the electric field lines and the equipotential surfaces is (a) field lines are everywhere parallel to surfaces (b) field lines always intersect each other (c) field lines are everywhere perpendicular to surfaces (d) field lines always make angles between 0° and 90° with surfaces.

5. Why are the measured equipotentials lines instead of surfaces for this laboratory?

6. If two electrodes have a source of potential difference of 100 V connected to them, how many equipotential surfaces exist in the space between them?

7. Why is it important to center the electrodes on the resistance paper for this laboratory?

8. In the performance of this laboratory, what is the recommended maximum allowed potential difference from one end of an electrode to the other end?

9. On what basis are you to decide how many points to measure for each equipotential for a given electrode configuration?

MAPPING ELECTRIC FIELD LINES FOR VARIOUS CHARGED OBJECTS

Apparatus: DC Power Supply (~20V), Voltmeter w/probes, shallow plastic container with grid on bottom, electrical wires, two alligator clips, two cylindrical brass masses w/banana port, two brass plates, rulers, protractors

Theory: Surrounding any electrically charged object there is a region of space where, **if** there were another charged object present, a force of either attraction or repulsion would exist between the two. The electrical force per unit of charge (N/coul) that would be felt by the hypothetical second object, if it were actually there, is called the ***electric field*** of the real object. The electric field (**E**) is a vector quantity having the direction a positive hypothetical charge would move if released at the location of concern.

When a charge is moved along a path parallel to the direction of the electric field, work is either done by the charge or on the charge. If the positive charge moves in the direction of the electric field work is done by the charge and we say its electrical potential energy is reduced. If the charge is moved opposite the direction of the electric field, work is done on the charge and it gains electrical potential energy. There is no work done by or on the charge if it is moved in a direction perpendicular to the direction of the electric field. This means the electrical potential energy of the charge does not change as the charge is moved perpendicular to the electric field. We define the unit of electrical potential as the ratio of the electrical potential energy of a charge divided by the magnitude of the electrical charge (J/coul). As a charge moves parallel to the electric field there is a change in the electrical potential of the charge. The change in the electrical potential is called the voltage or the potential difference (J/coul) = (Volts).

Obviously, if one moves a charge in a direction perpendicular to the electric field along a line of equal potential, there is no change in the potential difference, but if one moves the charge parallel to the electric field the potential difference does change. This idea will be used in the laboratory to map out the direction of the electric field between two or more charged objects.

In order to map out the electric field we will use a direct current power supply to set a charge on the objects, and a digital voltmeter will be used to measure the voltage or potential difference at various locations in the region between the charged objects.

By immersing the objects in a container of salt water, the lines of equal electric potential may be mapped out using the grid on the bottom of the container. Once these “equipotentials” have been mapped, the electric field lines may also be drawn as they will begin perpendicular to the surface of one charged object and lead to the other charged object crossing the lines of equipotential at right angles. The sign (+ or -) indicated by the voltmeter will show the direction of the vector E field lines. By convention, we say that E field lines point away from a positive charge because an imaginary positive test charge would be pushed away from it. Thus, a positive potential read from the voltmeter indicates that the charged object nearest the red meter probe is the positively charged object and that the E-field is pointing away from it. If the meter indicates a negative potential, the red meter probe is being held closest to the negatively charged object and the E-field is pointing towards that object.

Procedure:

IMPORTANT SAFETY INSTRUCTIONS: To avoid the possibility of a painful electric shock, never put your hand directly in the water, nor touch the charged objects unless the power supply is switched off. Even with power switched off, USE ONLY YOUR RIGHT HAND TO POSITION AND CONNECT THE CHARGE OBJECTS, while keeping your left hand away from the apparatus entirely.

1. Fill the shallow pan half full of tap water.

2. Place brass conducting objects at opposite ends of the pan in the water exactly as shown in the following diagrams. With the power shut OFF and the large voltage control knob turned completely counter-clockwise, connect the black negative lead from the DC power supply's LOW VOLTAGE (0-22V) taps to one of the objects and the red positive lead to the other object. Switch on the power supply and slowly increase its output to 20V.

3. Turn on the digital multi-meter for use as a voltmeter and set to the appropriate DC scale. Use this voltmeter to verify the 20V potential between the objects by placing one probe in firm contact with one of the objects and the other probe with the opposite object. Keep charged objects in exactly the same location throughout all of your data collection. If you are uncertain about any part of this procedure, please ask for assistance.

4. Place one of the voltmeter probes at grid location A1 and position the other probe on grid line 2. Slowly move the probe along 2 until the meter indicates 0 volts. This will be a point on grid line 2 that has the same potential as point A1. *Precisely mark the position of both points on the graph paper.* If the meter does not ever reach 0V when tracing along a grid line, find the minimum reading on that line and then move the probe perpendicular to the line to find the location of the equipotential.

5. Move to grid line 3 and repeat procedure 4.

6. Repeat for each of the numerical grid lines locating the point of equipotential that is the same as that of A1. **SWITCH OFF THE POWER SUPPLY ANYTIME THAT YOU ARE NOT COLLECTING DATA!**

7. Once all of the equipotential points have been located on your graph, draw a smooth curve through the data. If you have difficulty drawing a sharp single curved line through points, then use a ruler to connect the dots. This will be a line of constant potential. Any positive test charge that happens to be located on such a line will have no forces acting on it along the line, only straight away from it (at 90˚ or "normal" to it) in the direction yielding a reduced potential energy (toward the negatively charged object…, like a rock falls straight down to the ground, not at all to the right or left).

8. Move the probe to B1 and do the same as in steps 4, 5, 6 and 7, all recorded on same paper.

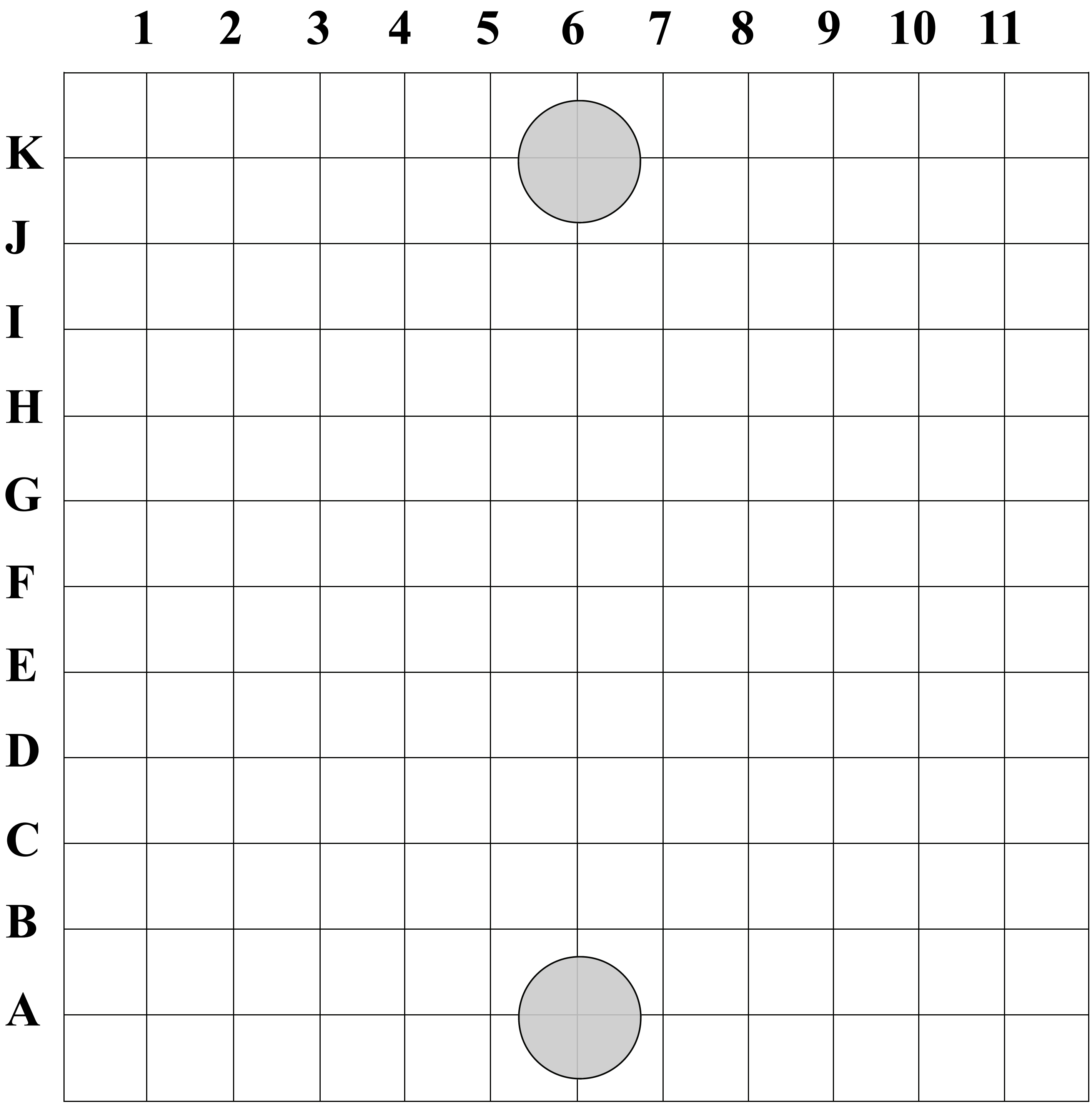
9. Repeat step 8 for each of the Alphabetical points.

10. Use a straight edge to draw several field lines from the positively charged object to the other object. These lines should leave the first object normal to its surface and after crossing each equipotential line be carefully adjusted using a protractor to form a right angle (90˚) with that equipotential. Ideally, the E field line would arrive at the negatively charged object normal to its surface, but an absence of data very near that object may prevent the line from arriving there at all. Clearly label which lines are the equipotentials and which are the E field. Use arrow heads to indicate the direction of the E field.

11. Change to new objects and repeat steps 1 through 10 for each of the four situations depicted on the attached diagrams.

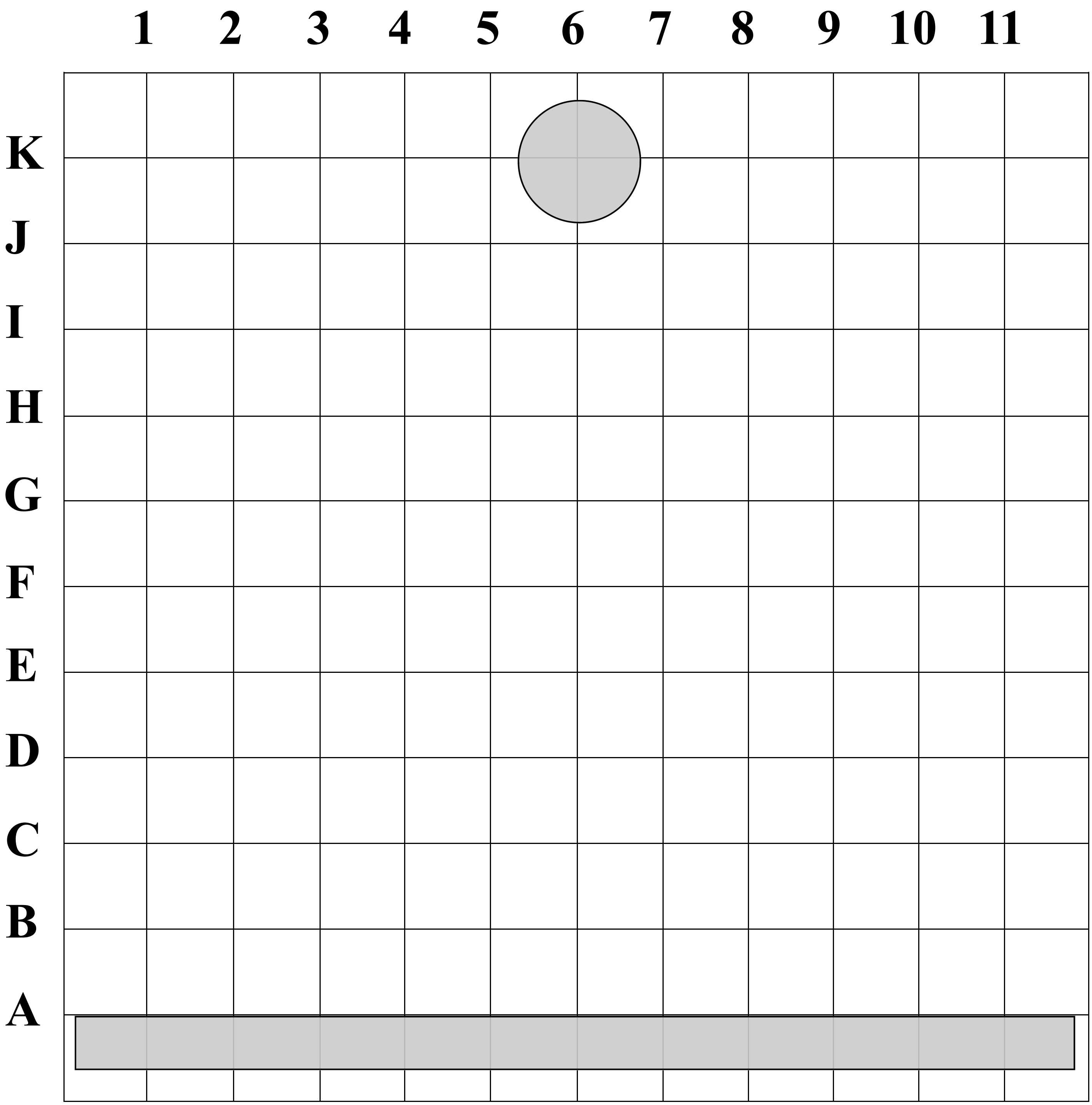
12. Were the resulting E field lines what you expected? Why? (Give a specific and thorough explanation from the point of view of a single test charge in each configuration of charged objects.)

E-Field Lab — Data Collection Sheet



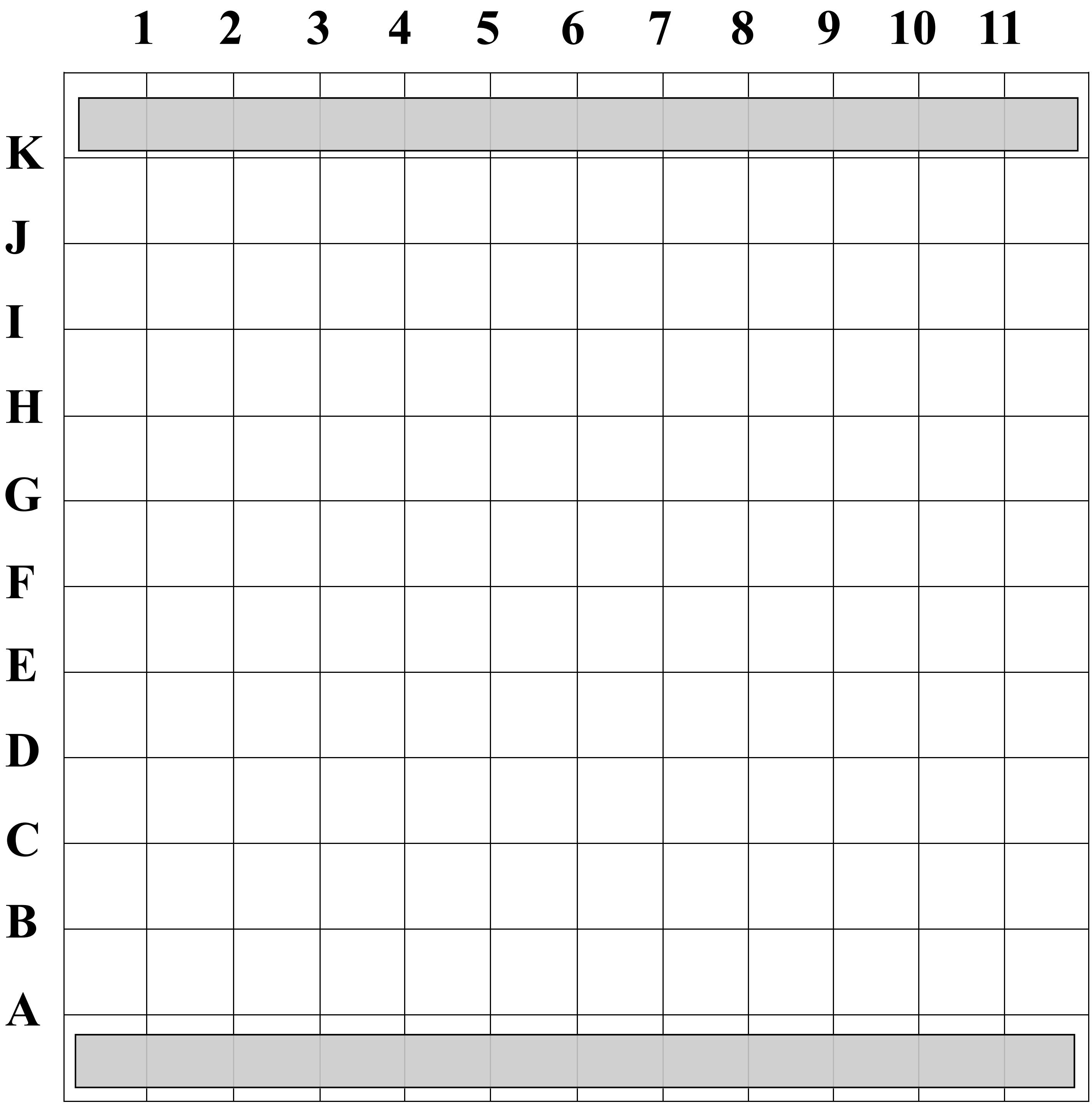
*Grid is not to scale.

E-Field Lab — Data Collection Sheet



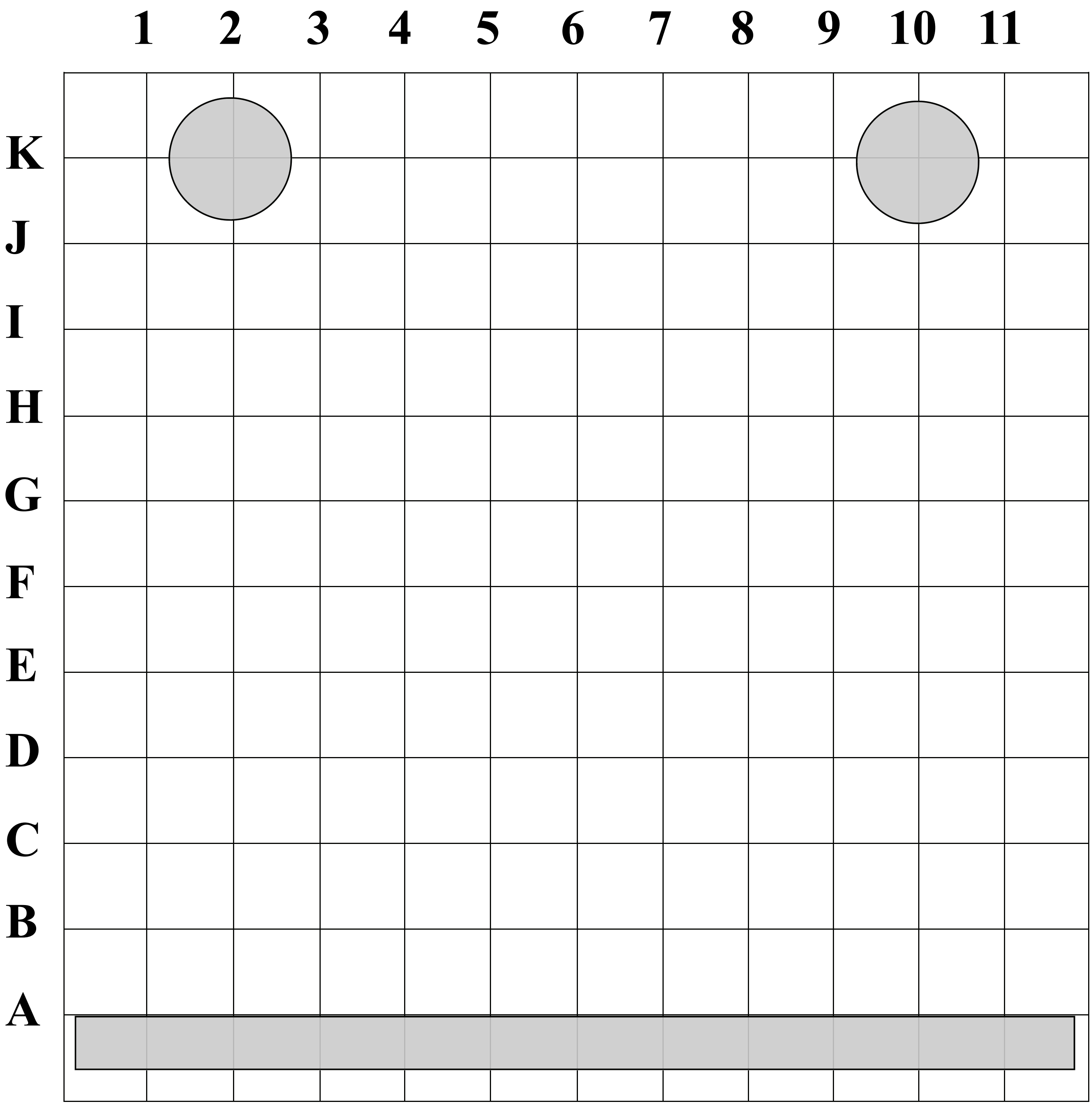
*Grid is not to scale.

E-Field Lab — Data Collection Sheet



*Grid is not to scale.

E-Field Lab — Data Collection Sheet



*Grid is not to scale.