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|  |  | |  |  | | --- | --- | | Aluminum Pan, radius = 10 cm | Paintbrush (2), watercolor | | Balance, accuracy = 0.0001 g | Pipets (2), 1 mL | | Balance, accuracy = 0.05 g | Resistors (2), 12 Ω | | Bell wire (609.6 m), 16 gauge | Resistors (9), 10 Ω | | Brick, 30 cm x 10 cm | Ruler, metric | | Buckets (2), thick white plastic, 40 cm x 29 cm | Safety goggles | | Caliper, micrometer | Scissors | | Cardboard container | Screw driver (small) | | Drill | Seeds (200), *Brassica rapa* | | Drill bits, 1/8 in., 5/16 in. | Soil (14 L), potting mix | | Duct tape | Soil container, 1.00 L, plastic | | Electricity, 60 Hz, 120 V | Solder | | Extension cord wire, 555 cm | Soldering Iron | | Felt (4), 23 cm x 30 cm | Surge protector (1) | | Fluorescent lights (4), 400 watts, 4 feet | Table, 1.36 m x 0.75 m x 0.99 m | | Foam (2), 27 cm diameter | Tags (64), for plants | | GR plug (3) | Thermo-Hygro Meter | | Greenhouse | Thermometer, Celsius | | Hand saw | Transformer, AC, 22 volts, w/fuse | | Heat gun | Trays (2), 35.6 cm, clear plastic | | Leather gloves | Tubing, heat shrinkable (20 cm) | | Leveler, 18 in. | VOM Meter and current probe | | Liners (2), plastic, 18 cm x 27.5 cm | Water container, aluminum | | Masking tape | Wire cutter | | Oscilloscope and b-dot loop | Wisconsin Fast Plant lighting fixture |   ***Procedure***  ***1. Preparing the buckets***  With a hand saw, cut the bottom off both buckets. Each bucket should then be 35 cm in height and 29 cm in diameter. Remember to wear gloves and safety goggles.                      Remove the handles from both of the buckets.  With a Sharpie, near the bottom of the buckets, label one bucket "Control" and another "Experimental."  ***2. Winding the Coils on the Buckets***  Take 152.4 m (500ft) of red 20 AWG wire and wrap Control Bucket.   * 1. Pull 10 cm of wire through one of the handle holes. The handle hole will be the starting point of the wrapping. Gently, bend the wire at the hole to one side and use duct tape to secure.   2. Wrap red wire tightly coiled clockwise around bucket. One person should help uncoil wire off reel, another should push down on the coils to make sure there is no gap between the windings, while the third pulls hard on the wire and rotates the bucket. The third person should wear a leather glove for safety.   3. Continue wrapping until all the wire is used. Leave about 45 cm of wire at the top of the bucket. (Make sure that the wire ends on top are long enough to reach the bottom of the bucket.) Remember that the ending point should be above the starting point. Softly, bend the wire over the rim of the bucket. KEEP THE WIRE TIGHT. Count the number of loops from the starting point to the endpoint.   4. Wrap duct tape along edge of bucket, once. Also, wrap duct tape over the wires near the bottom along with the starting point.   5. Repeat a-d using 152.4 m of 20AWG white wire on the same bucket.   Repeat the above on the Experimental Bucket. Make sure that the number of loops for the red wire on both buckets and the white wire on both buckets are the same. Very carefully, use the wire cutter to cut into the plastic that protects the wire exposing 2 cm of copper on both ends of the wires. Do this for both buckets. BE CAREFUL NOT TO CUT INTO WIRE!  Both these buckets are now solenoids. On both buckets, there should be a red and white wire hanging from the top and a red and white wire hanging from the bottom.  ***3. Connecting the Coils***:  *Control: Connecting the coils in parallel bucking*   * 1. Connect top red wire to bottom white wire by twisting ends together. Label "A1" using masking tape.   2. b. Connect bottom red wire to top white wire by twisting ends together. Label "A2" using masking tape.   *Experimental: Connecting the coils in parallel aiding*   * 1. Connect bottom red wire and bottom white wire by twisting ends together. Label "B1" using masking tape.   2. b. Connect top red wire and top white wire by twisting ends together. Label "B2" using masking tape.   By connecting the coils in parallel bucking the magnetic field of both layers of wire will cancel each other to produce a net 0-G field in the control.  By connecting the coils in aiding, the net magnetic field will double. In this way, the control lacks an artificial magnetic field, while the experimental still retains it.  ***4. Setting up the Circuit***  Observe safety precautions. Make sure transformer is not plugged in. (For a diagram of the circuit, see page 16.)  *Setting Up the Experimental Circuit:*   * 1. Cut 1.85 meters of extension cord.   2. Prepare both ends of the wire. (See note below: Preparing the Wire.)   3. On one end, attach a GR plug. (See note below: Attaching the GR Plug.)   4. On the opposite end, attach one strand of the wire to the experimental wires labeled "B1" and the other strand to the wires labeled "B2."   *Note: Preparing the wire*   * 1. Separate the two strands along the seam 3 cm from end.   2. Strip the plastic of the wire 2 cm from the end of both strands.   *Note: Attaching the GR Plug*   * 1. Prepare the wire (see note below).   2. Unscrew the GR plug.   3. Insert the wire into GR plug holes.   4. Screw the GR plug tightly into place.   *Note: Attaching the Wire*   * 1. Twist the wires together clockwise.   2. Solder the wires together.   3. Fit a shrinking tube over wires, cut, and blow dry.   *Setting Up the Control Circuit:*   * + - 1. Create resistor chain          1. Take two pieces of copper wire 20 cm in length and strip of all the plastic.          2. On a brick, place 9-10 Ω resistors and 2-12 Ω resistors in a straight line approximately 0.5 cm apart from each other.          3. Place both copper wires parallel to each other 13 cm apart on the leads of the resistors.          4. Solder the copper wires onto the leads.          5. Allow time to cool. Re-solder if necessary.          6. Tape down all the resistors horizontally (perpendicular to leads).       2. Cut a new extension cord into two pieces of 3.2 meters and .5 meters.       3. Prepare both ends of both wires. (See note above: Preparing the Wire.)       4. Attach one end of one piece of extension cord to one of the copper wires on the resistor chain.       5. Attach the other end of the cord on the same side to the other copper wire.       6. Attach one strand on the opposite side of the above cord to one end of a GR plug.       7. Attach one end of the remaining extension cord into the remaining hole in the GR plug.       8. Attach the other strand on the same side to the remaining resistor strand.       9. On the opposite side of the control cord, connect one strand to "A1" and the other end to "A2."   *Plugging in the GR Plugs*   * 1. Insert the control GR plug into right-most banana jack on the transformer. Insert the experimental GR plug into the other end of the control GR plug.   2. Prepare secondary GR plug      1. Cut 3 cm of 18 AWG wire.      2. Strip the plastic off the wire 1 cm from the end of both strands.      3. Fasten both ends of this wire onto two ends of a single GR plug.      4. Insert this GR plug into the left-most GR jack.   ***5. Testing the Setup***  *Testing the Buckets*   * 1. Plug in transformer into surge protector and turn on surge protector and transformer.   2. Wait ten minutes while observing to make sure that there is no malfunction and that the wires on both buckets are warm.   3. Turn off transformer.   *Testing the field produced*   * 1. Connect the oscilloscope to the outlet. Connect the b-dot loop to the oscilloscope. Set the oscilloscope to 60 Hz and set the scale to the more sensitive setting.   2. Insert the loop into the center of the control solenoid so that the loop is parallel to the ground.   3. Record the measurement of the oscilloscope.   4. Repeat for the experimental solenoid.   *Testing the Current*   * 1. Separate the middle of the control extension cord into two strands on the control solenoid.   2. Clamp the current probe onto each strand.   3. Record the measurement of the VOM meter.   4. Repeat for the experimental solenoid.   ***6. Preparing the Foams***   * 1. Draw a 19-cm square in the center of the foam.   2. Draw four lines parallel to and 3.2 cm from each other and the sides.   3. Draw four more such lines perpendicular to the first four lines.   4. Drill holes using a 1/8 inch drill bit where lines intersect each other and the sides of the 19-cm square, excluding four corners, for a total of 32 holes.   5. Use scissors to enlarge holes to about 1.5-cm diameter.   ***7. Preparing the Liners***   * 1. Place one liner inside the other and make sure that they fit.   2. On the center of the bottom draw circles with radii of 5, 10, 15, 20, and 25 cm.   3. Drill 5/16-inch holes 3 cm apart from each other along each circle. Important: Make sure that the liners don’t move relative to each other. Also, make sure that the drill goes through both liners.   ***8. Germinating the Seeds***   * + - 1. Soak 200 Wisconsin Fast Plant Seeds (*Brassica rapa*) in water.          1. Moist two paper towels.          2. Place one paper towel on the aluminum pan and pour 10 mL of water into the center.          3. Scatter the seeds onto the paper towel.          4. Cover the seeds with another paper towel.          5. Wait six hours, checking after three hours to make sure that the paper towel is still moist.   ***9. Warming up the Wires***   * + - 1. Turn on transformer and wait three hours.       2. After three hours, check the temperature.   ***10. Planting the Seeds***   * + - 1. Place two trays on table equidistant from two sides and .45 m apart from each other       2. Center two pieces of felt on each tray and place them perpendicular to each other.       3. Center the liner on felt.       4. Fill liner with 7 L of topsoil.          1. Pour dirt out of bag into cardboard container, break up soil, and pour back into bag.          2. Pour dirt into 1-L container, making sure not to overfill while pouring from the same height (this makes sure that the dirt is packed down the same each time).          3. Pour the dirt from this container into the liner.          4. Repeat this step 7 times.       5. Repeat for the second liner.       6. Label each hole with an (x,y) coordinate so that the origin is at the lower left corner of the square.       7. Place the foam inside each liner       8. Place 3 seeds in each hole.       9. Using two 1-mL pipets, pipet four mL of water into each hole. Use the force of the water to push the seeds into the dirt.       10. Place buckets on top of each liner.       11. Fill each tray to the top with water.   ***11. Setting up the Lighting***   * + - 1. Create a light fixture, such that the distance from the light to the top of the buckets is 30 cm for both buckets.       2. Plug in the light fixture.   ***12. Taking Daily Data***   * + - 1. Move the light fixture and take buckets off.       2. Fill the tray to the top with water.       3. Record the date, temperature, and humidity.       4. Take data describing when plants germinate.       5. Starting Day 5 of development, use scissors to cut seedlings such that only one seedling is allowed to grow from each hole.       6. After germination, measure the height of the plants, the number of leaves, and the number of flowers for the first fifteen days (i.e. until the plants are too tangled to take any further measurements). Be very careful while taking the bucket off and putting it on and taking measurements, so as not to injure the plant.       7. Take any observations that are of interest.       8. Replace the bucket and the light fixture.       9. Level the light using a leveler.       10. Repeat a through i until Day 43.   ***13. Pollination***   * + - 1. Between Day 17 and Day 22, in the control bucket, touch the flowers with a paintbrush to pollinate them.       2. Use a different paintbrush for the experimental bucket and repeat.   ***14. Taking Final Data***   * + - 1. On Day 43, carefully empty the control liner, and gently uproot the plants, and weigh each of them on a balance.       2. Tag them according to their (x,y) coordinate.       3. Using a ruler measure the plant height, leaf width and length, and root length.       4. For the seedpod width measurements, take a random sample to choose three living plants.       5. Using a micrometer caliper, measure seedpod width of the two largest seedpods on each of these plants and their stem diameters.   ***15. Drying Experimental Seeds***   * + - 1. Dry the rest of the experimental plants to collect the seeds from the seedpods.       2. These seeds can be used for the second generation. |