DESCRIPTION OF CAPE-tech “Tri-Color LED” APPARATUS

(a) **LED cable** with a 3.5mm (1/8”) phone jack at one end and a Red/Green Bi-color LED (light-emitting diode) lamp at the other end. A current-limiting resistor is incorporated into the cable at the LED end.

(b) **Battery connector** with a 3.5 mm (1/8”) phone plug at one end and two alligator clip leads at the other. The battery connector is intended for use with a 9-volt battery (not supplied).

(c) **120VAC in - 9VAC out transformer** with integral 2-prong polarized plug at the input and a two-conductor cable terminated by a 3.5mm (1/8”) phone plug at the output.

**SUGGESTED USE**

1. To demonstrate the behavior of each of the two individual LED’s within the LED bulb, plug the BATTERY CONNECTOR into the LED CABLE jack. Then, attach an alligator clip to each of the terminals of a 9-volt battery. One of the LED’s within the bulb will light. Note whether the color is red or green and also the location of the light source within the bulb.

2. Now hold the BATTERY CABLE at a convenient distance from the lamp end so that the lamp can be swung in a vertical circle. A circle of light is produced. (Darkening the room enhances the effect.) Observe the color consistency along the circumference of the circle.

3. Now switch the battery leads. The color will shift, and the location of the source within the bulb will change. The LED’s are connected in parallel, with their conducting polarities opposite. The LED that is activated depends on which way the leads are connected to the battery. Again, swing the lamp in a vertical circle.

4. The peak wavelength of the red light is 625nm, and that of the green is 565nm. The red light is brighter in the ratio of 5:4. So far, the third color of the promised “TRI-COLOR LED” has not appeared. It can elicited as follows.

   Unplug the BATTERY CONNECTOR from the LED CABLE, and connect the LED CABLE to the 9-VOLT AC TRANSFORMER. Plug the transformer into an outlet. Behold! The third color appears.

   To explore the source further, swing the lamp in a vertical circle, as before. The contributions of the two individual LED’s are now revealed, each in a segment along the circle. The faster the lamp travels around the circle, the longer the color streak from each of the lamps becomes. They alternate, with a dark region in between each color segment. Each LED is on for the major portion of half a cycle of the alternating current. When the voltage drops below about 2 volts, neither lamp will light.

   With the AC source, each of the two colors produced by the LED is present for less than 1/120th of a second. The colors alternate, repeating the cycle every 1/60th of a second. This is too fast a change for the brain to resolve, and colors are perceived to be concurrent. The third color is the result of the brain-constructed response to a mixture of red and green light signals. Most observers will report a golden hue; however differences in visual acuity for different colors among observers may result in an inability to reach a consensus. They may literally be seeing different colors. This could be the point of departure for a whole new discussion.

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ASSEMBLY NOTES FOR THE CAPE-tech “Tri-color LED” KIT

The bi-color LED has two leads of unequal length. When the longer lead is positive (and the shorter lead negative concurrently), the red LED is illuminated. When the polarity is reversed, the green LED glows.

When the assembly is completed in accordance with the following instructions, the long lead will be connected to the terminal that the tip of the power source plug engages. Thus, whenever the connection is made so that lead is positive, the red LED will be activated.

You will need a soldering iron with a small tip for the assembly of this kit. Overheating the parts can result in an inoperative unit. Since we cannot control assembly skill, we make no warranty as to the operation of the finished product. Please consult your workshop leader(s) for soldering instruction if you have inadequate experience. She, he, or they will be glad to help.

You will also need a heat source capable of activating heat-shrink tubing.

A. PARTS LIST

2 ea 7-inch lead with mini alligator clip (Red, black; White, yellow; White, green; or Yellow, green)
1 ea 3.5 mm (1/8 inch) mono two-lead phone plug with screw-on cover
1 ea 3.5 mm (1/8 inch) mono two-lead phone jack with screw-on cover
1 ea 6-foot 2-conductor line cord (flexible#18)
1 ea bi-color (red/green) LED 1 ea 330-ohm resistor
2 ea piece of 1/8-inch heat shrink tubing
1 ea piece of 1/4-inch heat shrink tubing
1 ea encapsulated AC transformer power supply (120VAC to 9VAC)

B. ASSEMBLING THE BATTERY CONNECTOR (Check off each step as it is completed.)

☐ 1. For each alligator clip lead, strip 1/4" insulation, twist the wire strands, and tin them.
☐ 2. Unscrew the cover from the phone plug, and put the two leads from step one through it from the back, so that the threaded end of the cover points toward the stripped end of the leads.
☐ 3. See the color pair information in the parts list. Connect the capitalized color lead to the center terminal of the phone plug. Connect the other lead to the body terminal.
☐ 4. Check to be sure that the leads are properly separated so they will not short; then, screw the cover onto the phone plug.

C. ASSEMBLING THE LED CABLE (Check off each step as it is completed.)

☐ 1. Separate the leads at one end of the cable for a distance of 1/2 inch. Note that one lead of the cable is smooth, and the other has two or more ribs along it. Cut 1/4 inch off the ribbed end. Remove 3/16 inch of insulation from each lead.
☐ 2. The diameter of wire is too large to fit into the holes in the phone jack terminals. The diameter will be adjusted as follows for each of the cable leads individually. For one lead, collect the strands into two roughly equal groups. Bend the larger (if there is one) group of strands in the same direction, perpendicular to the cable and twist them lightly together. Twist the other group of strands together to form a wire, and tin them. Now, cut off the small group or wind it around the larger, circling the larger group just at the insulation. Apply a small amount of solder to hold the additional strands or remnants in place. Now do the same for the other lead.
☐ 3. Unscrew the cover from the phone jack, and put the cover aside. There are two soldering points for the phone jack. One is large and attaches to the outer body of the jack and has a split metal ring at the end of it. Open up this ring with a pair of pliers until it is almost flattened.
☐ 4. Make a 120 degree (60 degrees short of a U) bend in the wire from the ribbed lead, just past where the small group of strands is severed or wound around it. Thread the lead into the hole in the flattened outer terminal from the inside to the outside. Complete the bend to 180 degrees and crimp in tightly to the terminal. Solder the connection.
☐ 5. Slip the shorter piece of 1/8 inch heat shrink tubing over the remaining wire and slide it down until it is entirely on the insulation. Bend and connect the smooth lead to the center terminal. Solder this connection, making sure no solder makes a bridge to the outer body of the jack. Slide the heat shrink tubing up toward the terminal, leaving 1/8 inch still covering the insulation of the wire. Heat the tubing to shrink its diameter.

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6. Bend the tabs of the ring that were flattened in step C3 back into a curve to hold both of the leads. Be sure that there is no place where the wire from the smooth lead touches any part of the body terminal.

7. Slide the cover for the phone jack along the cable, and screw the cover tightly onto the phone jack.

8. Place the LED in front of you with the long lead toward the right. Use needle nose pliers to bend the long lead of the LED toward you into a U shape just at the crimp mark (about 1/4" below the base). Then, cut off the lead, leaving just enough so that the U can be crimped over another wire in the next step.

9. Make a U bend in one lead of the 330 ohm resistor, about 1/4 inch from the resistor body (either end), using the same technique as in step C8. Again clip off the excess lead, leaving just enough to crimp over the LED lead already prepared in step C8.

10. Hook the two U ends over each other. First crimp the resistor lead so that it clamps around the LED lead. Then, crimp the LED lead so that it clamps around the resistor lead.

11. Secure the connection with solder, keeping the assembly in line parallel to the uncut lead of the LED, and taking care not to overheat the connection. You will need a small soldering tip to make this connection. A soldering gun is NOT recommended.

12. Cut off the remaining LED lead just below the crimp mark. Save this piece of lead for use in subsequent steps.

13. Prepare the remaining end of the two-lead LED cable as follows. Separate the leads for a distance of 1 inch. Place a the remaining piece of 1/8 -inch heat shrink tubing over the ribbed lead, and move it down to where the leads separate.

14. Strip 3/16 inch of insulation from the ribbed lead. Do not twist the strands together. Instead, use the cut-off LED lead from step C12 to create a path among the stands down to the level of the insulation. Save the cut-off LED lead for further use. Into this path, insert the short lead of the LED (the one without the resistor attached) until the lead is just past the level of the insulation or the strands are at the bottom of the LED. The wire should be tight enough to allow you to collect the wire strands along the lead and to have the assembly stay together while you solder it.

15. This process works best if the soldering iron rests on the table, and you control solder and the unit you are soldering. Keeping the heat-shrink tubing protected from the soldering iron, solder the wire connection, letting solder flow until the strands are just integrated into the solder. The larger diameter and heat conductivity of the cable will help protect the LED, but do work as quickly as possible to keep from overheating the LED. If the strands have tended to flare, carefully use needle nose pliers to compress the wires a bit.

16. Slide the piece of heat-shrink tubing along the cable lead so that one end of the tubing is against the bottom of the LED bulb. Use the barrel of the soldering gun, or another approved source, to shrink the tubing at the other end, where it covers the insulation of the cable. When this step is properly done, the unshrunk end of the tubing will be against the bottom of the LED bulb, the shrunk end will be tightly around the cable insulation, and the tubing will not move along the cable lead.

17. The free resistor lead will now be attached to the smooth lead of the cable, using the same general technique employed to attach the LED to the cable in steps C14 and C15. Cut the free resistor lead to a length of 1/4 inch.

18. Next, cut the smooth cable lead so that it ends 1/16 inch from the body of the resistor. Remove 1/8 inch of insulation from the cable lead, and use the cut-off LED lead to make a path among the strands down to the insulation as before. Into the path, and down just below the level of the insulation place the resistor lead. Try to keep the resistor parallel to the ribbed lead attached to the LED as you solder this connection. Again, smooth out the connection with a pair of needle nose pliers so that the wire strands are all contained and reasonably parallel.

19. Slide a piece of 1/4 inch diameter heat shrink tubing over the bulb and cable until the tubing covers the cable connections and just barely covers the ring at the base of the LED bulb. Use an approved heat source (the tip of a match flame or lighter can be used if done with a light touch) to shrink the tubing starting at the end away from the LED, and working up to just below the LED bulb. The tubing has to shrink only enough to hold it in place to provide insulation and protection for the parts and connections.

20. Test the unit with a 9-volt battery via the Battery Connector from part B. Test both polarities (colors). The red LED should be activated when the “capitalized” color is attached to the positive terminal.