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Cranking Up

Purpose

To observe and compare the work done in a series circuit and the work done in a parallel circuit

Required Equipment/Supplies

4 lightbulbs, sockets and clip leads
Genecon hand-crank generator
parallel bulb apparatus

voltmeter
ammeter

Procedure

Part A: Qualitative Investigation

Step 1: Assemble four bulbs in series as shown in Figure A. Screw all the bulbs into their sockets. Connect the sockets with clip leads.

Connect one lead of a Genecon to one end of the string of bulbs and the other lead to the other end of the string. Crank the Genecon so that all the bulbs light up. Now, disconnect one of the bulbs from the string and reconnect the Genecon. Crank the Genecon so that the three remaining bulbs are energized to the same brightness as the four-bulb arrangement. How does the crank feel now? Repeat, removing one bulb at a time and comparing the cranking torque each time.

Assemble the circuit and crank the Genecon as you unscrew bulbs in series.

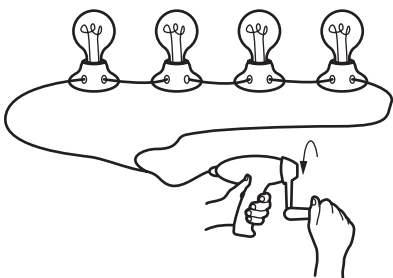


Fig. A

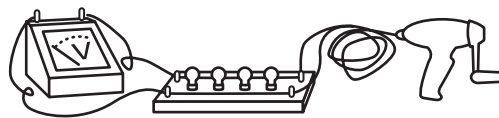


Fig. B

Step 2: Assemble the circuit with the parallel bulb apparatus, as shown in Figure B. Each end of the bulb apparatus has two terminals. Connect the leads of a voltmeter to one pair of terminals on one end of the apparatus. Connect the leads of the Genecon to the terminals on the other end of the apparatus. Crank the Genecon with all the bulbs unscrewed in the sockets so that they don't light. Then, have your partner screw them in one at a time as you crank on the Genecon. Try to keep the bulbs energized at the same brightness as each bulb is screwed into its socket.

Assemble the parallel circuit and crank the Genecon as you screw in the bulbs.

1. What do you notice about the *torque* required to crank the Genecon at a constant speed as more bulbs are added to the circuit?

2. How would you describe the amount of torque required to crank the Genecon to energize four bulbs in series compared with that required for four bulbs in parallel?

3. If all the bulbs in the series and parallel circuits are glowing equally brightly, is the energy expended (the work you are doing to crank the Genecon) the same?

Part B: Quantitative Investigation— Resistors in Series

Now repeat Part A in a quantitative fashion using a voltmeter and an ammeter.

Assemble the circuit in series.

Step 3: Assemble four bulbs in a series circuit and connect the meters, as shown in Figure C. Connect the voltmeter in parallel with all four bulbs so you can measure the total voltage applied to the circuit. Then you will connect it in parallel with single bulbs to measure the voltage across each bulb. Connect the 3-volt lead from the voltage supply to one terminal of the bulbs and the ground connection to one lead of an ammeter. Connect the other lead of the ammeter to the second terminal of the bulbs. The ammeter will measure the *total* current in the circuit.

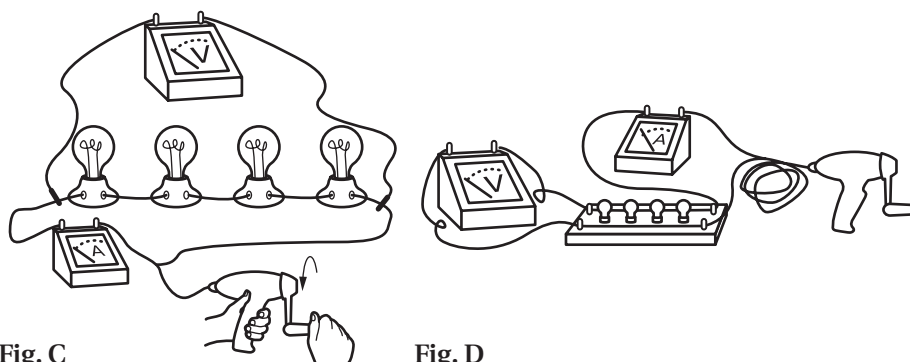


Fig. C

Fig. D

Note: If you are not using digital meters, you may have to reverse the polarity of the leads if the needle of the meter goes the wrong way (–) when power is applied.

Close the switch, apply power to the circuit, and measure the current in the circuit, the voltage applied to the circuit, and the voltage across each bulb. Record your results in Data Table A.

Step 4: Now remove one of the bulbs from the string, close the gap in the circuit, and repeat your measurements for three bulbs. Then remove the other bulbs one at a time, closing the gap in the circuit each time, and repeat the measurements. Record your data in Data Table A.

Number of Bulbs	Total Current (A)	Total Voltage (V)	Voltage Across Each Bulb (V)			
1						
2						
3						
4						

Data Table A

Number of Bulbs	Total Current (A)	Total Voltage (V)	Voltage Across Each Bulb (V)			
1						
2						
3						
4						

Data Table B

Step 5: Repeat using the 4.5-volt terminal of the voltage supply instead of the 3-volt terminal. Record your data in Data Table B.

Repeat using a different voltage.

4. Is there any change in brightness as the number of bulbs changes?

5. Does the voltage applied in the circuit change as you add more bulbs?

6. How are the voltages across each bulb related to the applied voltage?

7. How does the current supplied by the battery change when more bulbs are added?

8. Did any of the rules you discovered relating voltages and currents change when you applied 4.5 volts instead of 3 volts?

Part C: Quantitative Investigation—Resistors in Parallel

Step 6: Assemble the circuit and connect the meters, as shown in Figure D. Connect the voltmeter in parallel with the bulbs by connecting the voltmeter to two terminals on one end of the parallel bulb apparatus. Connect the 3-volt lead from the voltage supply to one terminal of the parallel bulb apparatus. Connect the ground lead from the voltage supply to one lead of an ammeter; connect the other lead of the ammeter to the second terminal of the parallel bulb apparatus. The ammeter will measure the total current in the circuit.

Assemble the circuit in parallel.

Make sure the bulbs are not loose in their sockets. Close the switch and apply power to the circuit. Observe the brightness of the bulbs, then unscrew the bulbs one at a time.

Record your measurements of current and voltage.

Step 7: Screw the bulbs back in, one at a time, each time measuring the current in the circuit, the voltage applied to the circuit, and the voltage drop across each bulb. Record your data in Data Table C.

Number of Bulbs	Total Current (A)	Total Voltage (V)	Voltage Across Each Bulb (V)			
1						
2						
3						
4						

Data Table C

Number of Bulbs	Total Current (A)	Total Voltage (V)	Voltage Across Each Bulb (V)			
1						
2						
3						
4						

Data Table D

Repeat using a different voltage.

Step 8: Repeat Steps 3 and 4 using the 4.5-volt terminal of the voltage supply instead of the 3-volt terminal. Record your data in Data Table D.

9. Is there any change in brightness as the number of bulbs changes?

10. Does the voltage across each bulb change as more bulbs are added to or subtracted from the circuit?

11. Does the applied voltage to the circuit change as you add more bulbs?

12. How does the current supplied by the battery change as the number of bulbs in the circuit changes?

13. Did the ratio of voltage and current change when you applied 4.5 volts instead of 3 volts?
