

# Series/Parallel Bulb Board

P6-1120



## BACKGROUND:

The Series/Parallel Bulb Board is used to quickly arrange and rearrange circuits in series and parallel. Each “arm” of the apparatus creates an electrical connection between neighboring bulbs. To break the connection, partially unscrew the red or black knob and pull the arm so that it swings out.

## SETUP:

The board can be arranged to create any combination of parallel and series circuit combinations.

Designed to be used with a maximum of 6V DC. Do not exceed 6V.

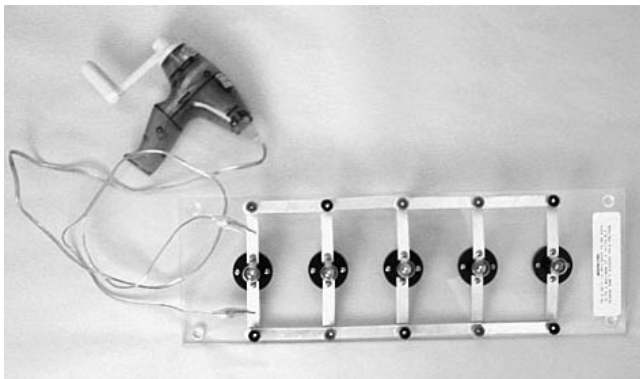


Figure 1: Parallel Circuit. All arms are connected.

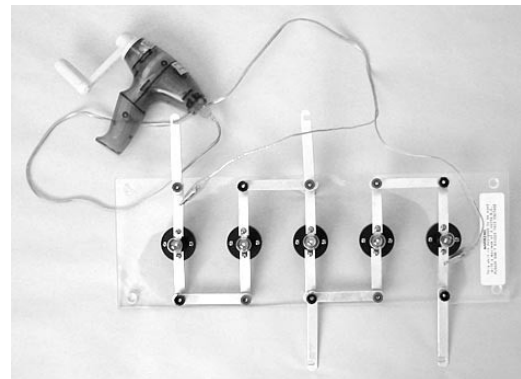


Figure 2: Series Circuit. Arms are opened to allow current to pass through each bulb in line.

## RELATED PRODUCTS:

**Genecon** (P6-2631). Hand-crank generator, ideal as a battery replacement for a wide variety of basic electricity experiments.

**Miniature Bulbs** (P6-1407). 3.2V, 0.3A screw-base bulb. Pack of 10.

**Energy Ball** (P6-2300). Fun demonstration of open and closed circuits!?



# Instruction Sheet for Lamp Boards

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With figures created in Crocodile Physics simulation software

**Purpose:** The lamp board is a device for showing the effect of different kinds of series, parallel, and series-parallel circuit hook-ups via the brightness of light bulbs acting as resistances. The board's convenient strap-connectors allow a combination of two to five lights to be arranged in series, parallel, or series-parallel mixes. By using the light board alone, the user can optically see how electrical energy is being distributed due to a particular hookup. By using electrical meters, it is possible to make quantitative measurements of the distribution of energy, but such measurements are only recommended for advanced students (see below).

**Set-up Instructions:** The suggested bulbs to be used with the lamp boards are 3.2V light bulbs. (It is always a good idea to teach safety while teaching electricity. With this goal in mind, students should be taught to keep the power to the circuit off when they change configurations of the strap-connectors.) The light bulbs should not be over-tightened in their sockets, but they have a tendency to loosen as the board is used, and so should be checked for tightness with each configuration. While 6 volts is recommended, the filaments of the bulbs will still glow at lower voltages. On the other hand, if a 12 volt source needs to be used, a single #40 bulb (6.3V, 0.15A) can be placed in series with any other bulbs to insure that no bulb will have more than 6 volts supplied to it (see Figure 1).

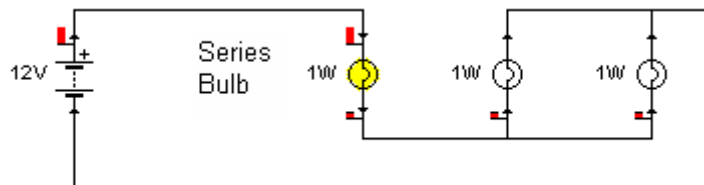


Figure 1: Using 12 Volts

**Care and Storage Instructions:** The light board is very rugged in its construction, but it can, of course, be damaged. It should not be dropped and/or bent out of shape. The knurl screws should be tight on the strap connectors, but they should never be over-tightened. The strap-connectors and mounting posts should be kept clean at all times. When too much power is applied to these bulbs, they will quickly burn out, so be careful with them.

**Background:** Since  $\text{Power} = \text{Voltage} \times \text{Current} = (\text{Voltage})^2 / \text{Resistance}$ , the smaller a given resistor, the greater the power it will draw from a constant voltage source. The best qualitative difference between series and parallel hookups of resistances is in the way they draw power from a voltage source. A parallel configuration of two resistors is effectively a smaller resistance than either resistor alone. A series configuration of the same two resistors is effectively a greater resistance than either resistor alone. So parallel combinations will tend to cause the bulbs to glow brighter than series combinations. Mixed configurations are just extensions of this same basic idea.

**Suggested Uses:** A few of the many possible series/parallel circuit combinations are shown schematically in Figures 2 through 4 below. Have students carefully note the relative brightness of the different bulbs in a few simple cases, then see if they can predict the relative brightness of the various bulbs prior to powering up a new circuit configuration.

A basic, but important, point that can easily be seen with the light boards is the need for all bulbs to be operating when a series circuit is connected whereas the bulbs act independently of one another in parallel configurations. In the circuits of Figures 2 and 3, have students loosen single bulbs, and then loosen various combinations of bulbs. Then, using the circuit of Figure 4, you can verify the students' comprehension by having them predict what would happen if one or more bulbs were loosened (or burned out). (You might want to keep some burnt-out bulbs around. These can be inserted in various board combinations along with good bulbs to see how students go about finding the bad bulbs (other than by filament inspections!) One bad bulb is relatively easy to locate, but 2 or more bad ones in the circuits of Figures 2 or 4 can be a pretty good challenge (further demonstrating the convenience of the circuit in Figure 3).

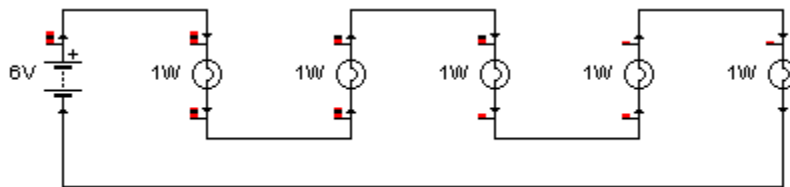


Figure 2: Series Connections

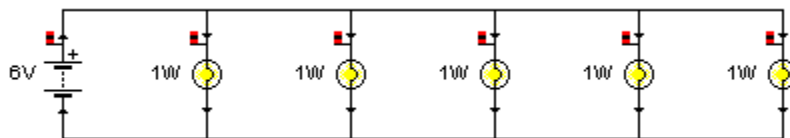


Figure 3: Parallel Connections

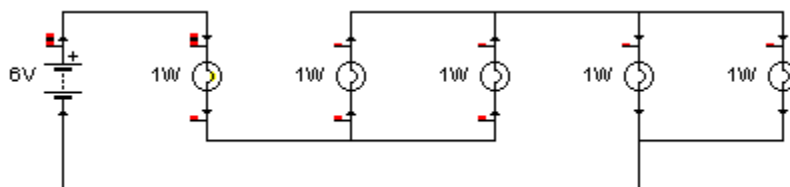


Figure 4: A Series-Parallel Connection

## ADVANCED TEACHERS NOTES FOR LAMP BOARDS

Quantitative measurements are easy to make with the lamp board, but difficult to understand. The reason is that the bulbs are an example of a non-ohmic resistance. In other words, the basic Ohm's law relation  $V=IR$  is not accurate for a light bulb (it is still qualitatively correct). In fact, a plot of resistance vs. current for a bulb would be expected to look something like Figure 5 (with  $V$  changing in order to change  $I$ ).



**Figure 1**

Since the curve is not a horizontal straight line, the incandescent bulbs will NOT maintain a constant resistance as the current varies. Due to heating effects, the resistance of the filament of each bulb will vary as the current passing through it is changed. The only way to quantitatively verify the series and parallel relationships for resistors is to first generate a plot like the one above for each of the bulbs. Then, for a particular configuration, the current passing through each bulb will have to be measured. By using  $R$  vs.  $I$  plots, the measured current value can be used to determine the resistance of each bulb for that configuration. Then the series resistance relation

$$R_T = R_1 + R_2 + R_3 + \dots$$

the parallel resistance relation

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$

and any mixed combination of series and parallel can be verified. Clearly, this activity will be time-consuming and intellectually demanding. Also note that the internal resistances of the meters used for such measurements must be taken into account.