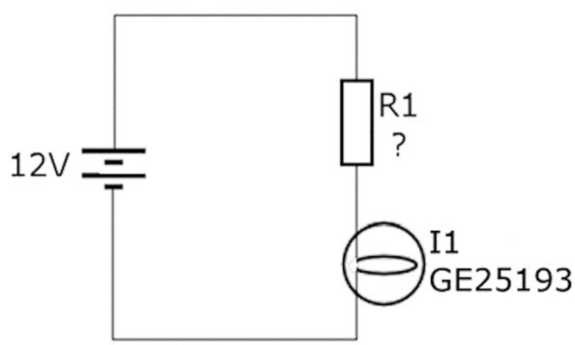
We can now apply some of what we've learned so far to some practical situations.

Some Circuit Examples

Suppose that we need to rig up a pilot light for a piece of camping gear that plugs into our 12-volt car battery using a flashlight bulb that is ordinarily used with two D-type dry cells. The bulb is a GE 25193, which is rated 3.57V and 500mA. We can use this bulb if we connect a resistor in series with it, in order to limit the current to 500mA.



How many ohms should R1 be, and what wattage?

There are a couple of ways to figure out the correct value for *R1*. Pause here, and see if you can come up with an answer.

Here's one solution. Since the current needs to be 1/2-amp (500mA), the total resistance in the series circuit will be…

$$R = \frac{E}{I} = \frac{12}{0.5} = 24\Omega$$

R1 will therefore be 24 ohms, less the resistance of the light bulb. The resistance of the bulb can't be measured, since its cold resistance will be much different (lower) than its resistance when lit. But we can figure it out, given the voltage and current ratings provided in the bulb's specifications:

$$R_{I1=}\frac{3.57}{0.5} = 7.14\Omega$$

$$\therefore R1 = 24 - 7.14 = 16.86\Omega$$

Another way to find an appropriate value for *R1* is to reason that it will have to provide a *voltage drop* equal to the supply voltage minus the rated lamp voltage:

$$E_{R1} = 12 - 3.57 = 8.43V$$

Since the lamp current needs to be 500mA, the value for *R1* can be calculated:

$$R1 = \frac{8.43}{0.5} = 16.86\Omega$$

The next question is the resistors ability to withstand the resulting power dissipation.

We can figure out what the dissipation will be using any one of the power formulas:

$$P = IE = 0.5 \times 8.43 = 4.22W$$

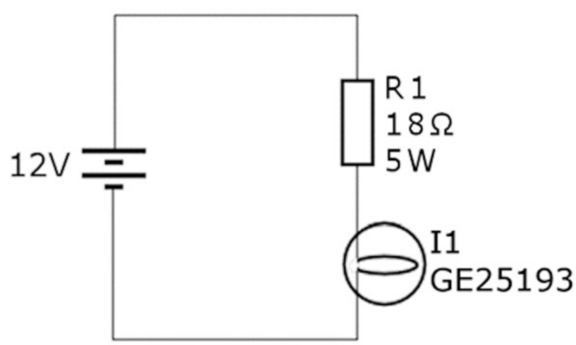
Since this is not a critical application, a 5% or 10% resistor will do. These come in standard sizes ranging from 1Ω to 9.1MΩ in 24-intervals, as shown in the E24 table.

Given those choices, which value would you choose?

E-24 Standard Resistor Series		
1.0	2.2	4.7
1.1	2.4	5.1
1.2	2.7	5.6
1.3	3.0	6.2
1.5	3.3	6.8
1.6	3.6	7.5
1.8	3.9	8.2
2.0	4.3	9.1

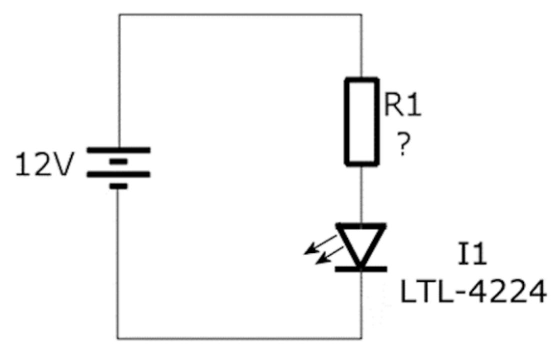
The closest available choices would be 16Ω or 18Ω. Since a small reduction in lamp current results in a significant extension of lamp life, 18Ω would be the better choice.

So the final choice for *R1* would be an 18Ω, 5W power resistor.



From an efficiency point of view, this would not be a good solution to the problem. Besides being wasteful of the battery's energy, the resistor R1 would run very hot; probably hot enough to burn one's fingers.

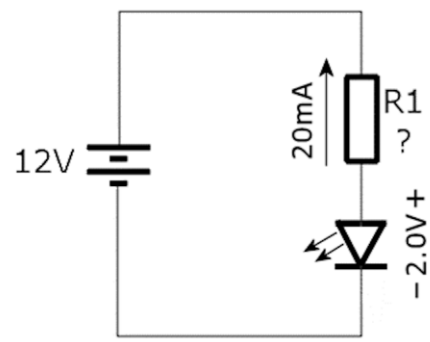
Fortunately, a much better solution is easily available — a high-brightness LED such as the Lite-On LTL-4224:



LEDs are solid state devices, having electrical characteristics that differ from those of a common light bulb. You need to refer to the device's specification sheet to see what those characteristics are. You can find it online, or in the resources for this lecture.

According to its specification sheet, this particular LED will work with *forward currents* up to 30mA. Over the range of zero to 30mA its *forward voltage* drop will vary from 1.6V to 2.4V.

A good operating point is 20mA, at which the forward voltage is given as 2.0V.



Calculating the value needed for *R1* is therefore pretty easy. Pause here for a moment and try to figure it out.

Did you come up with a 500Ω, 1/4W resistor? Great!

Since the voltage drop across the LED will be 2.0V at 20mA, the voltage drop across R1 at 20mA will have to be 10V (12V minus 2V). The resistance needed will therefore be:

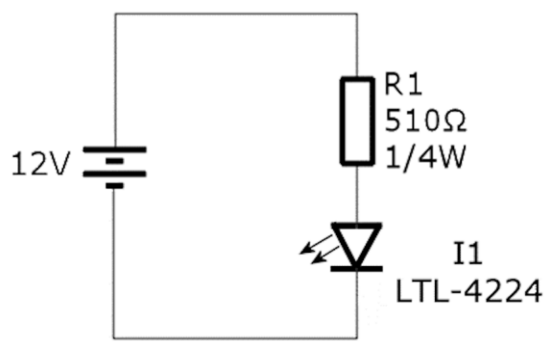
$$R1 = \frac{E}{I} = \frac{12 - 2}{.020} = 500\Omega$$

Using the above table, you can see that the closest available standard value is 510Ω.

Quickly calculating the power rating:

$$P = IE = 10 \times .020 = 0.2W$$

So the application calls for a 510Ω, 1/4W resistor.



This is a much more sensible design than trying to use a flashlight bulb. Besides conserving power, the LED will never burn out.

Variable Resistors

Up to this point, we've been talking about *fixed resistors*. Adjustable resistors are also commonly available in many forms, and are an essential component when …

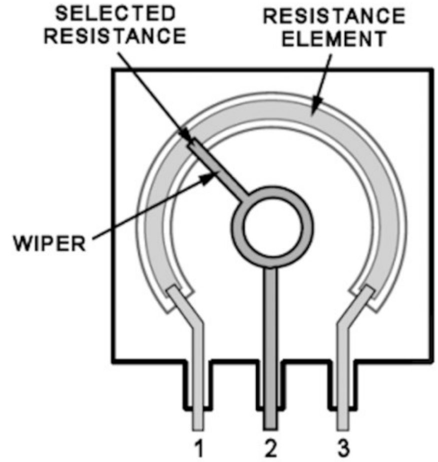
- an exact value of resistance is needed, and isn't commercially available as a fixed resistor,
- where adjustments are apt to be periodically necessary to correct for component drift and aging, or
- equipment operators need to have some way of adjusting the equipment's operating parameters.

Variable resistors are called *potentiometers*, or “pots”, for short.

The large device in the middle of this picture is known as a “control pot”. They are usually user-accessible, serving such purposes as volume controls, brightness adjustments, and so on.

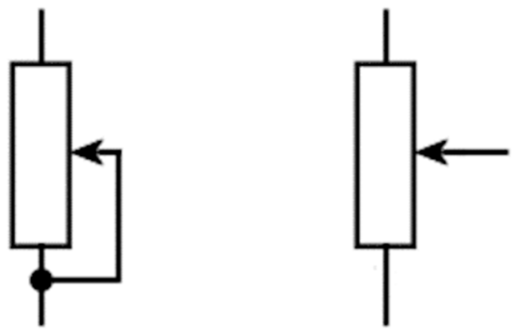
The smaller potentiometers are typically used to adjust circuit parameters to precise values; for example, as a means of calibrating a precision temperature-measuring instrument. These are generally called “circuit trimmers”.

Internally, most potentiometers are all more or less the same, regardless of size or purpose.



They have a circular resistive element with terminals on either end, and a moveable contact, or *wiper*, connected to a third terminal.

They can be connected to perform either as a variable resistance, in which case they're sometimes referred to as *rheostats*, or as voltage dividers. These appear on schematics like this …



RHEOSTAT
(Variable Resistor)

POTENTIOMETER
(Voltage Divider)

Potentiometers are available in a variety of values, depending upon the particular product line. Most provide for linear adjustment, meaning that the resistance changes evenly as the wiper is moved over the resistance element. Pots intended for special purposes, such as volume controls, are available with nonlinear resistive elements.

Perhaps you noticed some new concepts being sneakily introduced here — “series resistance” (is there some other kind), “voltage drop”, “forward current” and “forward voltage” — what’s that all about anyway?

Right now it’s time for a break! We’ll talk about those things in the next lecture.

Please remember to use the discussion panel. When you have a question, I, or one of your fellow course participants, will have an answer. If *you* are able to offer an answer for a question posted by someone else, do feel free to respond.
