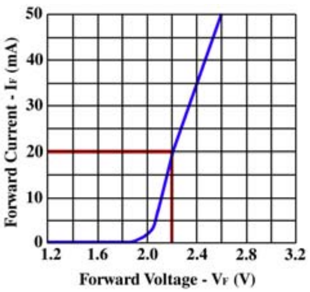
Thanks for purchasing this **Hansen Hobbies Chutelight Kit**! Please make sure you have everything:

- Chutelight pcb	(1)	- coin cell holder	(1)	- switch	(1)
- **LED**	(1)	- 20Ω resistor	(2)	- clear heat shrink	(1)
- lithium coin cell	(1)				

Circuit Explanation:

LED's, like other types of diodes, have the unique characteristic of holding a fairly constant voltage drop from **anode** to **cathode** when powered. When ground (zero voltage) is applied to the **cathode** and positive voltage is applied to the **anode** the diode is "forward biased" and current will flow, given that the voltage across the diode is high enough. If you know anything about P-N junction diodes then you'll recall that after the voltage reaches a certain level, the diode becomes completely conductive and current will flow unchecked. Unlike your typical P-N junction diode, however, the **Current Voltage (IV) Graph** for **LED**'s has a fairly usable slope as shown in blue (silicon rectifiers would have a near-vertical line at about .7V).



To the left is the **IV Graph** for the **RL5-8030 Super-Red AlGaInP LED** included with this kit. The graph was obtained from the **LED** supplier and shows the expected **Current** through the **LED** for a given **Voltage** across its leads. Also specified by the supplier was the suggested operating current and voltage – shown on our graph with red lines. **Note: this graph doesn't represent all LED's – different color LED's will have very different IV graphs – you should always get operating specifications from the manufacturer when buying LED's.**

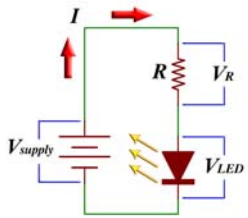
If we had a 2.2V battery on hand to match our **LED**, then we'd be set, but that's hardly the case. We have a common 3.0V lithium coin cell, so we need a way to limit the current through the **LED** to the manufacturer's recommended operating current of 20mA.

To limit the current we put a resistor in series with the diode. Here's how to calculate what **Resistance** (**R**), to use for a given **Supply Voltage** (V_{supply}), to achieve a certain **Current** (**I**): We know from Ohm's law that for any resistor $V = (I)(R)$ We won't think of the diode as a resistance in the circuit, but rather as a voltage drop. The voltage across the resistor (V_R) is simply the **Supply Voltage** minus the voltage drop across the **LED**, so:

$$V_R = V_{supply} - V_{LED} = (I)(R)$$

Moving things around:

$$R = \frac{(V_{supply} - V_{LED})}{I}$$



Now we can plug in our known values and solve for the needed resistor value. The **Supply Voltage** from the lithium coin cell is 3.0V, the **Voltage** drop across the **LED** is 2.2V, and we want a **Current** of 20mA. We plug in these numbers and find

$$R = \frac{(3.0V - 2.2V)}{.02A} = 40\Omega$$

The included circuit board is designed for two resistors in series (for symmetry & appearance reasons only), so two 20Ω resistors are included.

FAQ:

Q: *What happens if my supply voltage is beyond the maximum recommended voltage and I don't use a current limiting resistor?*

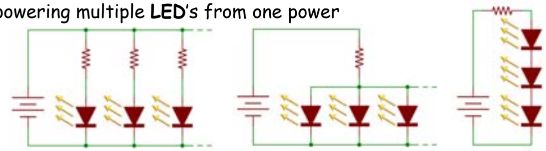
A: With a power supply capable of sourcing a lot of current (like a car battery), the current flow through the **LED** would soar and the **LED** would burn up soon after. The included **Lithium CR2032** isn't capable of sourcing that much current (the chemicals in the battery simply cannot react fast enough) so the battery voltage would actually drop to a level where it could satisfy the **LED**'s current demand. This isn't good for the life of the battery, but for lighting purposes sometimes it's worth the simplicity and extra brightness to not use a current limiting resistor. That's why you won't find a current limiting resistor in one of those Photon flashlights. Having said that, you might decide to replace the resistors in this kit with solid wires to make the **LED** slightly brighter while reducing battery life.

Q: *How much current can I really run through a super bright* ***LED*** *before it burns out?*

A: All **LED**'s are going to be different, but usually you can get away with as much as 100mA. Running the **LED** 'hot' will reduce its life, but since they're usually rated in the tens of thousand of hours, it might be worth it. Check the **Current – Relative Brightness Graph** for your **LED** to see how you can expect the brightness to increase with added current. You'll probably find that increasing the current doesn't benefit brightness all that much – you're better off using more **LED**'s.

Q: *How can I safely power multiple* ***LED's*** *from one power source?*

A: There are three basic options for powering multiple **LED**'s from one power source as shown:



The leftmost circuit is exactly what we did to power the **LED** for this kit, except additional resistor/**LED** 'rungs' have been chained onto the power source. Current limiting resistors are calculated the exact same way as before and each **LED**'s current can be individually controlled by changing the resistor value.

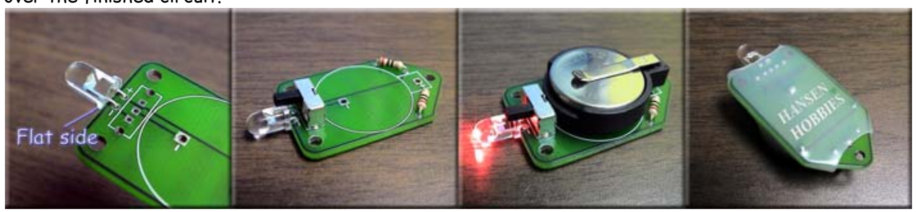
The middle circuit uses one current limiting resistor for multiple **LED**'s. To calculate this value use our original equation and multiply **I** by the number of **LED**'s in the circuit. This eliminates components which is good, but relies on all the **LED**'s having identical **IV** graphs – because all the **LED**'s have common (connected) anodes and cathodes they will all share the same voltage drop. You could never use this setup with, say, an AlGaInP red **LED** and an InGaN blue **LED** because the blue **LED** needs 3.5V to run at 20mA and the red **LED** would fry at that voltage. This circuit is generally considered bad practice.

The rightmost circuit is probably the best choice for powering multiple **LED**'s. It only uses one resistor which simplifies things and the **LED**'s are stacked in series which means they will all share the same current flow. Each **LED** can have a different voltage drop which means you can power different types of **LED**'s this way. The same equation that we used before to calculate the resistor value can be used here – we simply need to use the sum of all the **LED** voltage drops as our V_{LED} value. Another advantage over the leftmost circuit is that we're not wasting as much power. For example, if we had a 20V power source and used the left circuit to power **9 LED**'s then **89%** of the power would be dissipated from the resistors in the form of heat; only **11%** goes to powering the **LED**'s. Using the rightmost circuit to power 9 **LED**'s we would have a total V_{LED} of $9 \times 2.2V = 19.8V$ and would use a tiny 10Ω current limiting resistor and the **LED**'s get to use **99%** of the power. Given that, why don't we just take the resistor out completely and run the **LED**'s at 2.22V? This is just slightly above the recommended operating voltage and current and eliminates the need for a resistor! When powering **LED**'s in this fashion, you'll often find that you can get away with not using a current limiting resistor and still operate the **LED**'s at a safe current.

Assembly Instructions:

Use the pictures below to place and solder your components. Start by bending the legs of the **LED** so that the base of the **LED** fits snugly against the edge of the circuit board when inserted. Make sure you have the **LED** oriented correctly - the pcb is marked "+" and "-". There are two ways to tell the orientation of a **LED**: the longer leg of the **LED** is the anode (positive), the cathode (negative) is marked by a flat side on the **LED** bulb.

After soldering the **LED** in place, solder the resistors and the switch (note that the mounting legs of the switch can also be soldered to increase mechanical strength) – the switch will fit snugly against the base of the **LED**. Clip the component leads flush to the pcb as you go. Finally, solder the battery holder in place. Check your work to make sure that you haven't bridged any solder pads. When you're satisfied that everything is ok insert the lithium coin cell and check for proper operation. If something isn't working then recheck your circuit for errors. Last, you can protect the circuit in clear heat shrink tubing. You'll need a heat gun, or some reasonably hot heat source to carefully shrink the tubing evenly over the finished circuit.



Operation:

If you're planning on using your finished circuit for rocket night launches then you'll likely need to clip some of the heat shrink away from the mounting holes (or tie the parachute lines before covering the circuit with heat shrink). The lines from the parachute should tie directly to the two holes on either side of the switch. Swivel clips (found in fishing supplies) are very helpful here, as they swivel freely taking any twists out of the lines, and can be easily unclasped.

Next, the shock cord (connected to the rocket) gets attached to the hole on the bottom of the pcb. Use your favorite folding method and make sure the parachute and **Chutelight** are well protected from the ejection charge with tissue – don't forget to turn the **Chutelight** on before launching!

When the rocket ejects the parachute the **Chutelight** will be suspended between the parachute and the rocket, and will point up into the parachute, making it glow a brilliant red.

If you have need, we can supply extra CR2032 coin cells, as well as 2-cell battery holders as a direct replacement for the 1-cell holder (this will give the **6V** necessary for some **LED**'s). If you want to experiment with different color LED's we recommend you check out www.superbrightleds.com. On their web site you can find all the data you need for powering their super bright **LED**'s.

If you have any questions or comments about
this kit please email chris@hansenhobbies.com.