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Baffled Snoot Design

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1 Introduction



Figure 1: Front view of a baffled snoot.

A snoot is a simple light modifier, commonly used in photography and cinema, that restricts a light source to a narrower beam. Commonly, it's little more than a cylinder or cone placed on the front of the light source.

This document describes the design of a simple do-it-yourself snoot that incorporates baffles to more-carefully control the restricted light beam, eliminating internal snoot reflections and color casts. In use, this snoot provides higher-contrast and a crisper edge to the beam, a useful set of attributes for some lighting applications.

The number of baffles, their aperture sizes, and placement within the snoot, are determined by the geometry of the snoot and light source. Two approaches to the method of designing the baffles are described here. First, a careful scale drawing of the snoot can be made, and techniques used to geometrically define baffle size and locations. Second, the same principles can be applied mathematically. The first approach is a good approximation, the second provides more precision. The scale drawing is useful in either case so that is the starting point.

2 Scale Drawing

A scale drawing of the baffled snoot to be constructed is the best starting point in order to carefully determine the overall dimensions of the snoot and baffles. It will also be used as a guide in actual construction to be sure each piece is placed precisely to achieve the results we want.

2.1 Starting Assumptions

The first step in designing the snoot is to make a few basic design decisions that will guide the rest of the process.

First we will assume, for simplicity, the light beam we wish to manage is circular in cross section. It doesn't have to be but it's the simplest case and the principles applied here can be used for other shapes. If the snoot is to be used with a small portable camera flash, the flash's rectangular light output will be immediately restricted to a circle of roughly 3 cm (the vertical dimension of most common flash heads).

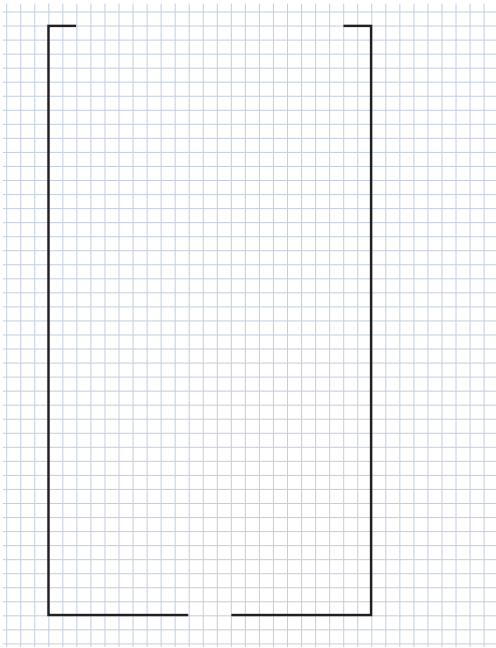
Second, the angular diameter of the snooted flash should be determined. Obviously it can't exceed the angular diameter of the light source itself. For common flashes, 25° is the approximate practical maximum that you would want to use.

Third, the overall snoot length should be fixed. The longer the snoot, the more crisp the light edge will be for a given distance from the light. The length and stability of the available materials for the construction of the snoot are often practical limitations on snoot design.

Glance at the mounting tip in section 4.2 on page 10 to design with easy flash-mounting in mind.

2.2 Basic Layout

Graph paper is a great help in laying out your snoot design. Once you've settled on your overall dimensions, lay them out to scale on your graph paper.



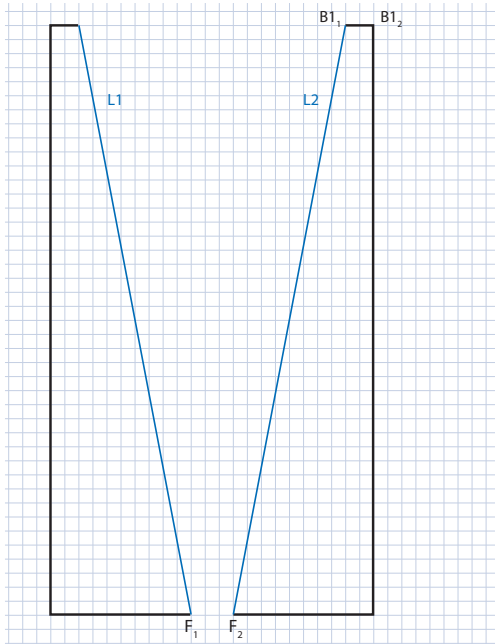
Light enters the bottom entrance baffle and exits the top exit baffle.

For our example here, the drawing shows our snoot's outside dimensions to be 23 units wide by 42 units high. The light entrance baffle has an aperture 3 units wide. The exit aperture at the top is 38 units wide.

Figure 2: A cross-section view of the snoot box shell is drawn to scale.

2.3 Light Cone

Draw two lines delimiting the cone-shaped light going through the snoot.



$L1$ and $L2$ are lines defining the light path through the entrance and exit baffles. $F1$ and $F2$ are the points on either side of the light source entrance baffle aperture. $B1_1$ and $B1_2$ are the points representing baffle $B1$'s line segment end points.

Note how the lines $L1$ and $L2$ also delimit the aperture size in the baffles we'll be adding inside our scale drawing. That is, no baffle aperture can be any narrower than the horizontal distance between these two lines at any given vertical position within the snoot walls.

Figure 3: Snoot box with edges of light path shown as limited by the baffles.

2.4 First Internal Baffle

Now we need to determine the position of the internal baffles. The overall objective is to make sure that no illuminated portion of the inside snoot side walls is visible from the outside. We'll start by blocking the light source's ability to illuminate the wall toward the exit end of the snoot. The inside walls can be illuminated by light rays from any part of the entrance aperture but we'll just focus on the extreme case.

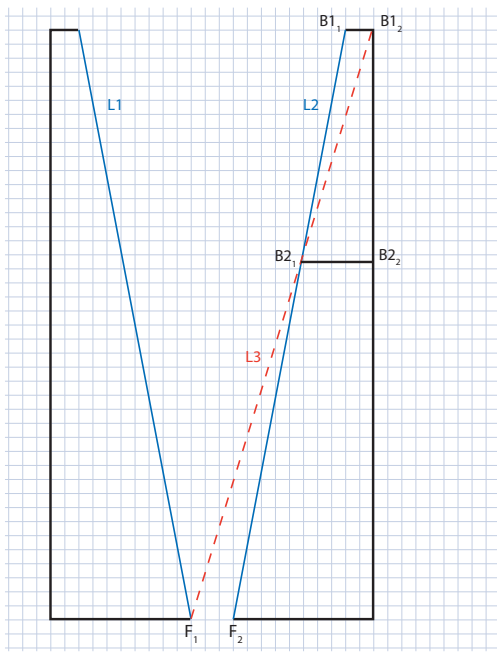


Figure 4: First internal baffle position and size determination.

Draw a line $L3$ from $F1$ to $B1_2$. This represents the most acutely-angled light ray that can strike the inside upper right corner of the snoot box. Note how this line intersects with line $L2$ at point $B2_1$.

It is at this intersection that we'll place the first internal baffle $B2$ represented by the horizontal line between points $B2_1$ and $B2_2$ (where it intersects with the right wall).

We now know everything we need to know about internal baffle $B2$. Measuring off our scale drawing, this baffle is located 25.5 units from the bottom (entrance) baffle of the snoot. Since our snoot drawing shows the snoot width to be 23 units wide and the width of the $B2$ line segment is about 5 units, we know that baffle $B2$'s aperture opening is $23 - 5 - 5 = 13$ units wide.

We've achieved part of our objective by blocking all source light from having any chance to illuminate any part of the side wall between $B1_2$ and $B2_2$. But the side wall below $B2_2$ is visible from the outside (partially) and can be illuminated by the source light so we need to add another baffle.

Note: We're only going to draw on one side of the diagram. It is implicit that a vertically-mirrored image of the same operations is at work on the other side to maintain symmetry. This is not necessary to draw both sides but, if it helps keep things clear, it is perfectly fine to do so.

2.5 More Internal Baffles

Our first internal baffle addressed part of the reflection problem but now we must continue to add necessary baffling to continue to block visibly illuminated snout wall portions farther toward the bottom.

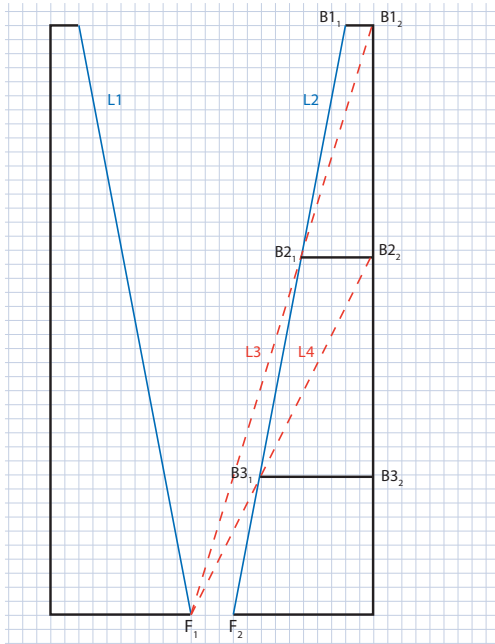


Figure 5: Second internal baffle position and size determination.

Draw a line $L4$ from $F1$ to the corner at $B2_2$. This represents the most extreme angle that light would be able to reach the wall in that corner. Note how this line intersects with the line $L2$ at point $B3_1$.

At this intersection, we'll place our next internal baffle $B3$ represented by the line segment between points $B3_1$ and $B3_2$.

Once again, we read off our scale drawing the dimensions of this baffle. It is located about 10 units from the bottom entrance baffle. The $B3$ line segment is about 8 units wide so the baffle aperture is $23 - 8 - 8 = 7$ units wide.

2.6 Continuing On

We can continue to add internal baffles following the same pattern described in section 2.5 on page 6 but how do we know when we can stop? Recall our objective was to block any illuminated snoot wall from being visible from the outside. In Figure 5 we can see that baffle $B3$ blocks visibility of the bottom portion of the inside wall from the outside. Thus even though that wall can receive illumination from the source, it won't be visible from the outside. So, in our example case, we're done—no more baffles are necessary.

At this point, one could declare the design to be done and the measurements to be close enough for construction to begin. For those who would like a bit more rigor, read the next section for application of mathematics to the design process.

3 The Math

Although not required, applying a bit of simple math can introduce more precision into the snoot design. A careful scale drawing as constructed in section 2 makes it easy to visualize the basic trigonometry, algebra, and geometry that can be used to hone the design's accuracy.

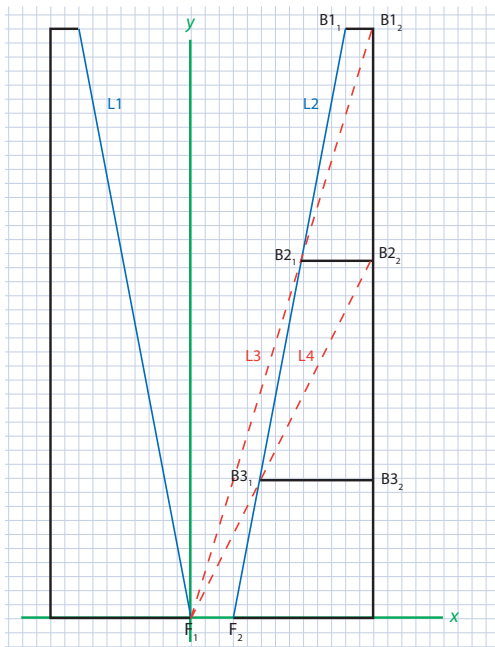


Figure 6: X and Y axis added to the scale drawing.

First, we'll introduce a Cartesian coordinate system into our diagram with the origin arbitrarily chosen to be at the point $F1$. Any origin can be selected but this one makes some of the calculations a bit easier.

We'll be using this coordinate system to come up with formulas for each key line and then solve pairs simultaneously to determine their intersection points.

3.1 Angular Diameter

The angular diameter of the light our snoot will be putting out is the angle between lines $L1$ and $L2$. Looking specifically at $L2$, we see its slope (and therefore tangent) is

$$\frac{\Delta y}{\Delta x} = \frac{42}{8} = 5.25 \quad (1)$$

and therefore its angle is $\arctan(5.25) = 79.2^\circ$. Therefore its angle from the vertical is $90 - 79.2 = 10.8^\circ$ so the angular diameter between $L1$ and $L2$ is twice that or 21.6° .

3.2 Line Equations

In our example, we are particularly interested in the equations for $L2$, $L3$, and $L4$ because they may be used to determine the precise locations of key baffle points. Recalling that the equation for a line is $y = mx + b$ where m is the slope of the line and b is the y intercept, we noted in section 3.1 that the slope for $L2$ is 5.25. Noting that point $F2$ is on line $L2$, and its coordinates are $(3, 0)$, we can calculate the y-intercept:

$$b = y - mx = 0 - 5.25 * 3 = -15.75 \quad (2)$$

Our equation for $L2$ is therefore

$$y = 5.25x - 15.75 \quad (3)$$

Equations for $L3$ and $L4$ are simpler because they both pass through the origin and therefore have 0 as their y-intercept. We only need observe their slopes. So for $L3$ our line equation is

$$y = \frac{\Delta y}{\Delta x}x = \frac{42}{13}x = 3.23x \quad (4)$$

We'll defer on the equation for $L4$ because its precise location depends on solving for the intersection of $L2$ and $L3$ which we'll do next.

3.3 Baffle Calculations

Once we have the equations for the lines in our diagram, it is a simple matter to solve simultaneously for the specific intersection points representing the baffle aperture locations.

Starting with baffle $B2$, we solve equations 3 and 4 to find the intersection point, $B2_1$:

$$5.25x - 15.75 = 3.23x \quad (5)$$

or

$$2.02x = 15.75 \quad (6)$$

and so

$$x = \frac{15.75}{2.02} = 7.80 \quad (7)$$

Plugging back into either line's equation tells us $y = 25.19$. So, estimating from the diagram, we thought that $B2_1$ was located at $(8, 25.5)$ but our calculations show it to actually be at $(7.80, 25.19)$.

This calculation and a glance at the diagram shows the calculation-based location for $B2_2$ will be $(13.00, 25.19)$. Our calculated baffle location is therefore 25.19 units from the bottom entrance baffle and its aperture is $23 - 2 * (13.00 - 7.80) = 12.6$ units in diameter. (Compare with our drawing-based estimate of 13 units.)

For the next baffle, $B3$, we have to solve for the intersection of $L2$ and $L4$ but $L4$'s location depends on the calculation we just did. $L4$ passes through the origin and point $B2_2$ and we now know from our calculations that $B2_2$ is located at $(13.00, 25.19)$ so our equation becomes

$$y = \frac{\Delta y}{\Delta x} x = \frac{25.19}{13.00} x = 1.94x \quad (8)$$

We solve equations 3 and 8:

$$5.25x - 15.75 = 1.94x \quad (9)$$

or

$$3.31x = 15.75 \quad (10)$$

and so

$$x = \frac{15.75}{3.31} = 4.76 \quad (11)$$

Plugging back into either line's equation tells us $y = 9.23$. In summary, point $B3_1$ is at $(4.76, 9.23)$ compared to our original drawing-based estimate of $(5, 10)$.

Going back to our diagram, we see with the benefit of this calculation that $B3_2$ is located at $(13.00, 9.23)$. Baffle $B3$'s location is therefore 9.23 units from the bottom entrance baffle and its aperture is $23 - 2 * (13.00 - 4.76) = 6.52$ units in diameter. (Compare with our drawing-based estimate of 7 units in diameter.)

If there were more baffles required for our design, we would proceed in a similar manner with each set of calculations dependent on the prior baffle's solution. Once completed, jot down all the dimensions on the drawing and it's ready to be used to guide the construction process.

4 Construction

It's up to you to select the materials you want to use to build the baffled snoot you design. Here are a few notes on how I went about it.

4.1 Materials

The walls of the snoot need to be fairly rigid to hold everything in alignment. I used black coroplast which worked fine but black mat board or black-painted corrugated board should work equally well.

The baffles need to be thin and opaque. The thinness will help minimize reflection off the edge of the aperture that could degrade the light. In my case, I used black construction paper with the aperture circle cut out of the center. This paper was then glued to a coroplast backer with a larger hole cut out. This gave the baffle rigidity for construction and still allowed for the thin aperture hole in the middle.

A circle cutter, although not necessary, makes cutting the baffle holes far easier and neater than if you cut by hand. I used a Fiskars brand circle cutter that had the range to handle the smallest to largest holes needed for the snoot.

I used a hot glue gun to tack baffles into place. Once stabilized, I glued all edges. The snoot wall corners were reinforced with black gaffer's tape for stability and light-tightness.

4.2 Mounting

When I initially designed my snoot, I mounted the flash unit I was going to use onto a Strobiframe flash shoe and measured the height, h , from the bottom of the shoe to the center of the flash head. I chose to make my snoot design width $2 * (h - t)$, where t is the thickness of the snoot wall material. This made it trivial to mount the flash and snoot together on a small board glued to the bottom of the snoot, guaranteeing that the flash head lined up perfectly with the center of the entrance-end aperture of the snoot.



Figure 7: Side view of a baffled snoot with flash unit mounted and ready to use.

5 In Use

A well-defined spotlight-like effect is the obvious use of a baffled snoot like this. However, a little imagination will trigger all kinds of ideas for uses where you need a controlled beam of light. You will have a lot of flexibility by adding modifiers to the front of the snoot to restrict the light or create patterns in interesting ways.



Figure 8: Baffled snoot used to create a spotlight effect, showing the more distinct edges achieved compared to a traditional snoot.