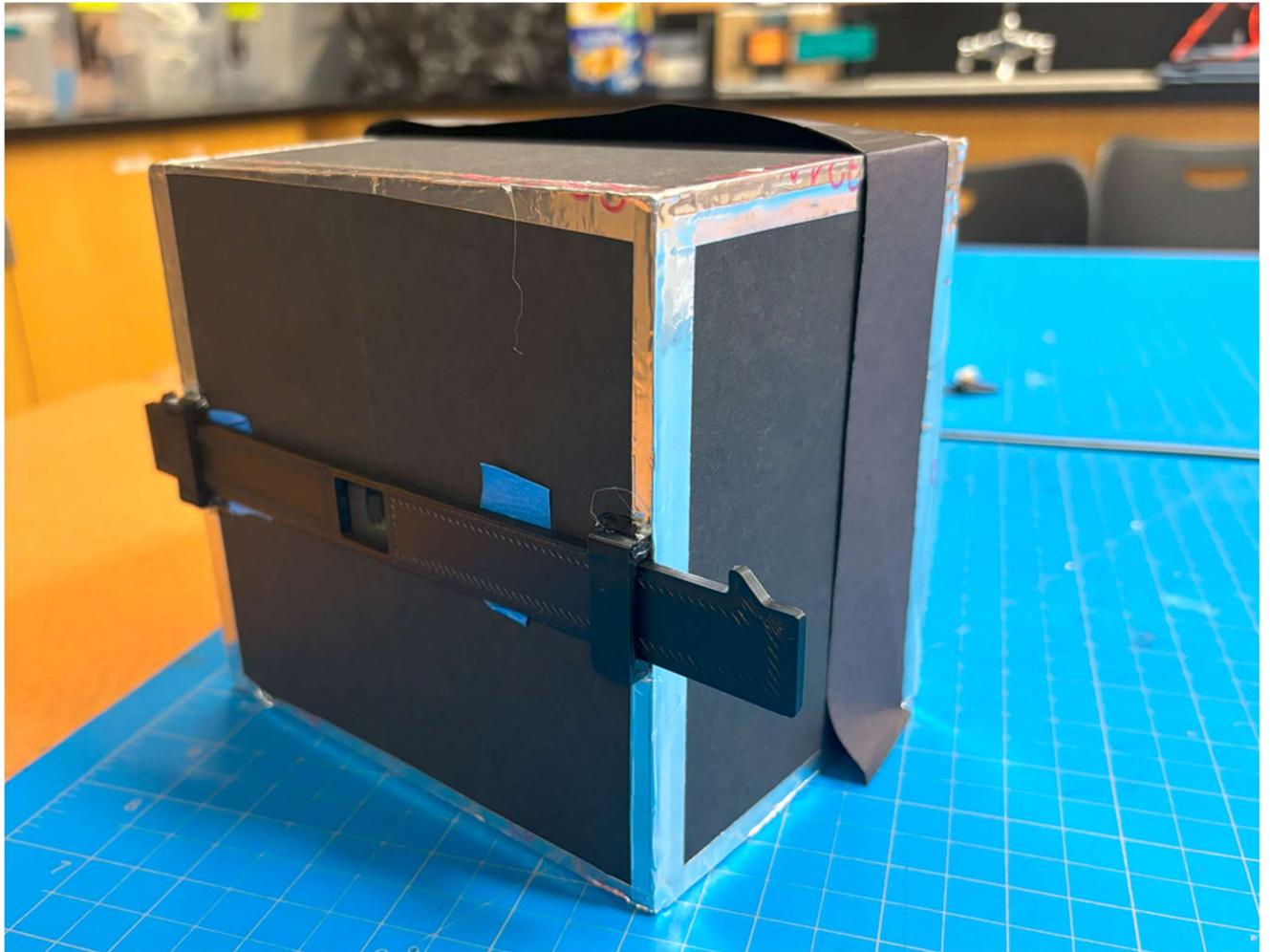


# Final Report: The Pinhole Camera

Period 5

11/3/2023



## Product Description

The product is a pinhole camera that utilizes an extremely small hole, known as a pinhole, to allow light to shine through precisely mapping one external point to one internal point on the film paper. The camera is built to take pictures using the piece of film paper that is to be placed inside the camera and treated with chemicals proceeding removal. Our camera stemmed from our initial challenge, which was to work in pairs to design and build a portable pinhole camera to be used by participants in an arts program for people with disabilities. Our camera is easy to use as it is simple and straightforward to operate and easy to handle for people with limited dexterity. I have carefully designed it to fit all of the requirements of our user with our host of unique features:

- ✓ Portable and easy to hold: The camera is small enough to easily be held with one hand and efficient with storage, being compact and modular, to enable ease of stacking and bulk storage.
- ✓ Durable: Our camera is built to withstand the harsh realities of daily life, accident. Our box is able to protect the film paper contained in the box in order to preserve the precious memory held inside it.
- ✓ Easy to use: The simplicity of our camera is its hallmark. From the straightforward operation to its manageable profile, our camera has been carefully thought out to fit the user the best.

Countless hours of meticulous brainstorming has gone into the planning of the main components, extending past the simple functionality of our camera to the smooth and enjoyable experience for the user of it. Everything from the overall dimensions of the outer box to the shutter and film holder design and even the focal length from the film holder to the aperture has been thought out with you in mind, tested and ensured for optimal performance and user satisfaction. Various alternatives were considered for all of the key components of the camera, including but not limited to:

- Different sizes of aperture diameter, ranging from 0.4 millimeters to 0.6 millimeters to ensure a sharp picture while not sacrificing the size of the photo.
- Various film holders designs, such as clips, guides, frames and a multitude of others to not only reduce the “dead zone” of the picture that was taken, but also secure the film paper well enough to account for the shaking and movement that is inevitable during the transport of the camera
- Dimensions of the box to allow for adequate space for internal components while not sacrificing the protection and structure it provides for those components. We were also inclined to keep the box on the smaller side to ensure that it was easy to manage.
- Aperture covers, which was a tough choice to figure out which would be the most effective in not only blocking out all of the light when closed, but also being very easy to operate. We ultimately ended up with a slider over other popular designs like levers and wheels due to the ease of use and practicality.

We considered and tested various of these options before selecting these components that not only meet the technical requirements, but also exceed expectations of user friendliness and usability. We strongly believe that our design, designed carefully from the pinhole size to the film handling strikes the perfect balance between quality and usability in terms of constraints, derived from our commitment to ensuring easy usage and great experience for all users. We have successfully transformed our challenge into an opportunity. Providing individuals with the opportunity to express themselves through the art of pinhole photography.

### **Product Specifications:**

My design was built from the design specifications that were given to us by the user, mainly the size of the film paper that was to be use by the camera which was a 4 inch by 5 inch piece of film paper to take a picture of a 10 foot by 10 foot wall mural that is in a 20x20 courtyard, with a 5 foot pond in front of. This meant that the camera should be able to take the picture from farther than that 5 feet, which lead us to try to figure out the ideal dimensions of not only the camera, but also the focal length or the length from the pinhole to the film. One of the main things that was conveyed to us was that as much of the film paper should be used for the picture, which made us base all of our calculations off the mapping of the 4 inch side to the 10 foot side. Upon calculations (the process is explained below) we found that the minimum that the focal length could be is 2 inches and the maximum for the focal length was 8 inches. The camera would have to be greater than 4 x 5 inches to allow for the film paper to comfortably fit inside it, and with some realistic constraints, the camera has to be small enough to be easy to be carried around by one person.

Overall Dimensions to note:

Film paper size: 4in x 5in (101.6mm x 127mm)

Camera box dimensions: 160mm x 150mm x 120mm

Slider Width: 210mm

Aperture / Pinhole Diameter: 0.4mm

Focal Length: 112

Camera F-number: 280

Camera Exposure time: 50 seconds

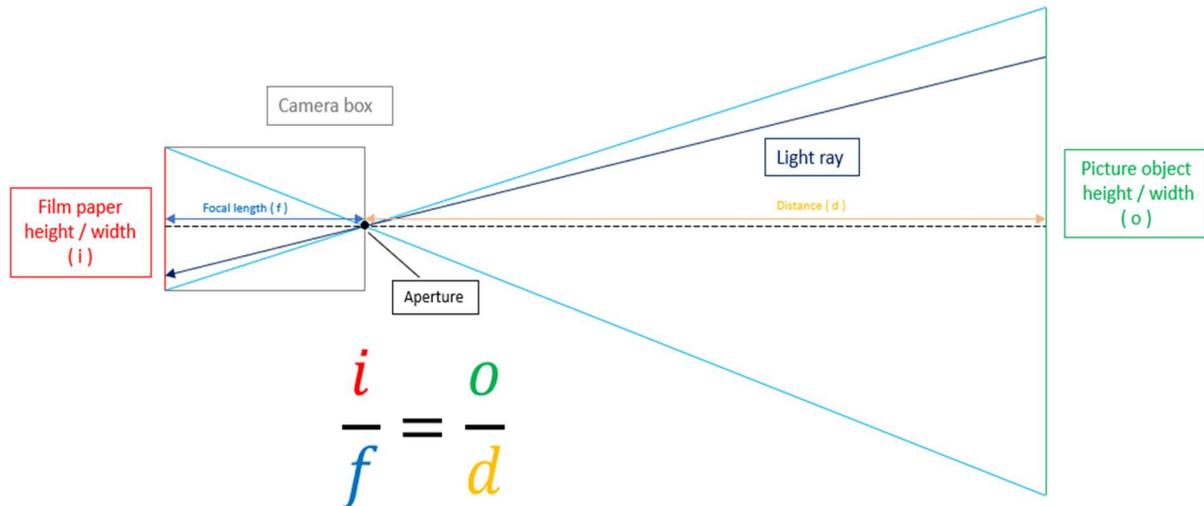
Film holder dimensions: 128mm x 104mm

Object size: 10 ft x 10 ft

Distance for ideal capture: 11 feet

Box elevation distance: 4.5 feet

The focal length was calculated by the use of the similar triangle congruence as shown in the diagram below.



*i* -> Represents the Heights or width of the film paper that is to be mapped to the height or width of the object that the photo is being taken of

*f* -> Represents the focal length, or the distance from the Aperture to the edge of the box where the film paper is fixed

*o* -> Represents the Height or width of the object that is being pictured, and is proportional to the size of the film paper

*d* -> Represents the distance from the box to the object being pictured. This distance will be proportional to the focal length of the camera.

Converting the size of the mural from 10 by 10 feet to 120 by 120 inches, we began calculations of the min and max focal length. Upon plugging in the various values into the equations, we got that at:

Min:

$$i = 4, o = 120, d = 60$$

The equation can be rearranged through cross multiplication so that  $f = d * i / o$ , which yields 240 / 120, or 2.

Max:

$$i = 4, o = 120, d = 240$$

Once again rearranging the equation, we get  $960 / 120$ , which gives us 8.

The distance to place the camera away from the object can be calculated the same way, knowing that:

$$i = 4, o = 120, f = 4.4$$

Rearranging the equation in terms of  $d$  we get  $d = o * f / I$ , or 132 inches, which is 11 feet.

Another major value that needs to be calculated is the camera's F number, which is used for the calculation of the exposure time or how long to leave the aperture open. This cannot be derived through simple calculations, but rather through testing. The F number of the camera is calculated as the focal length over the pinhole diameter, which for our camera is  $112/0.4$ , which is 280. We then plug in this number to the following table:

F	16	22	32	44	64	88	128	176	256	352	512	704	...
Sec	0.1	0.2	0.4	0.8	1.6	3.2	6.4	12.8	25.6	51.2	102.4	204.8	...

**As our number is closest to 256 in the table, our initial exposure time on a sunny ideal condition day is 25.6 seconds. Upon further testing, we figured out that the time that we wanted to leave the aperture open was actually closer to 50 seconds, and over 150 seconds on a cloudy day.**

## Camera Construction and Testing

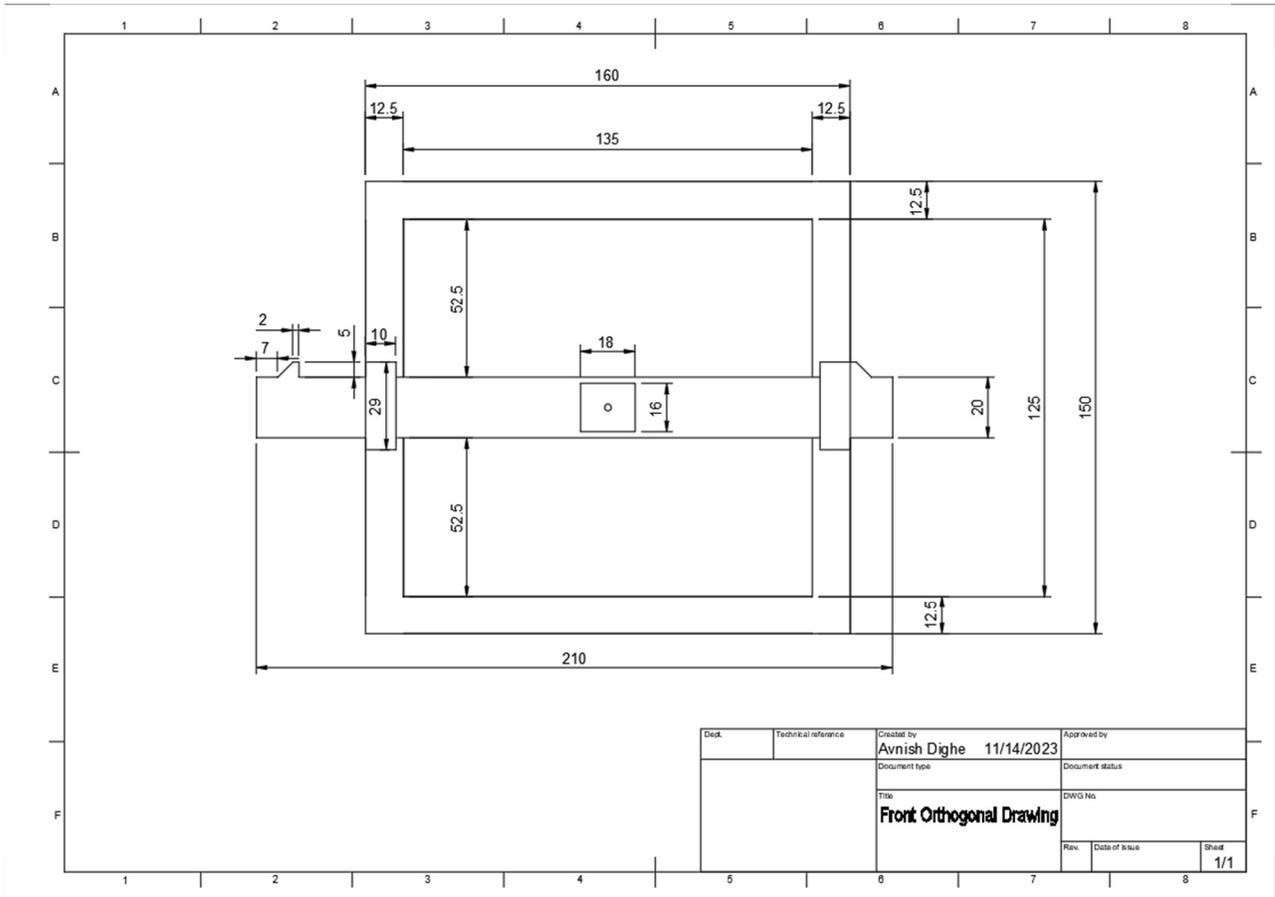
3A.

3B.

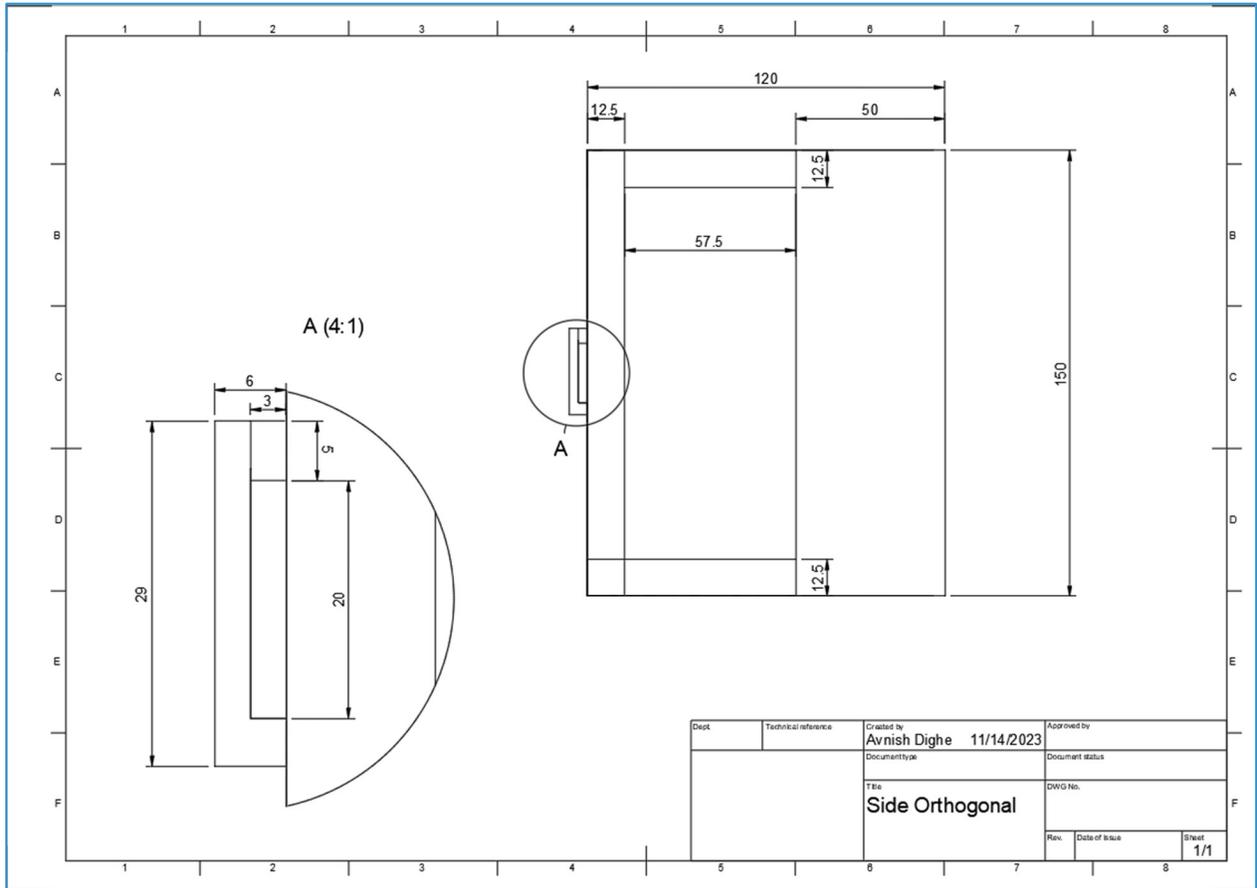
Tools	Materials
OPTIONAL: Access to a 3D printer (3D printing services are cheap)	Black foam core 2(160 x 150mm) 2(160 x 112 mm) 2(112 x 142mm) (25 x 110) 2(30 x 10 mm) 4(3 x 10 mm) (10 x 10 mm)
Boxcutter	Aluminum tape (16 x 740 mm)
Scissors	Electrical tape (552 x 15 mm)
Pin needle	Paper 2(50 x 115mm) (50 x 165mm)
Hot glue gun + hot glue	Aluminum (20 x 20 mm)
Marker	1 Popsicle stick
	Masking tape (50 x 25 mm) (34 x 16 mm)
	1 Sticky note

3C. Diagrams of the Exterior and Interior of the Camera

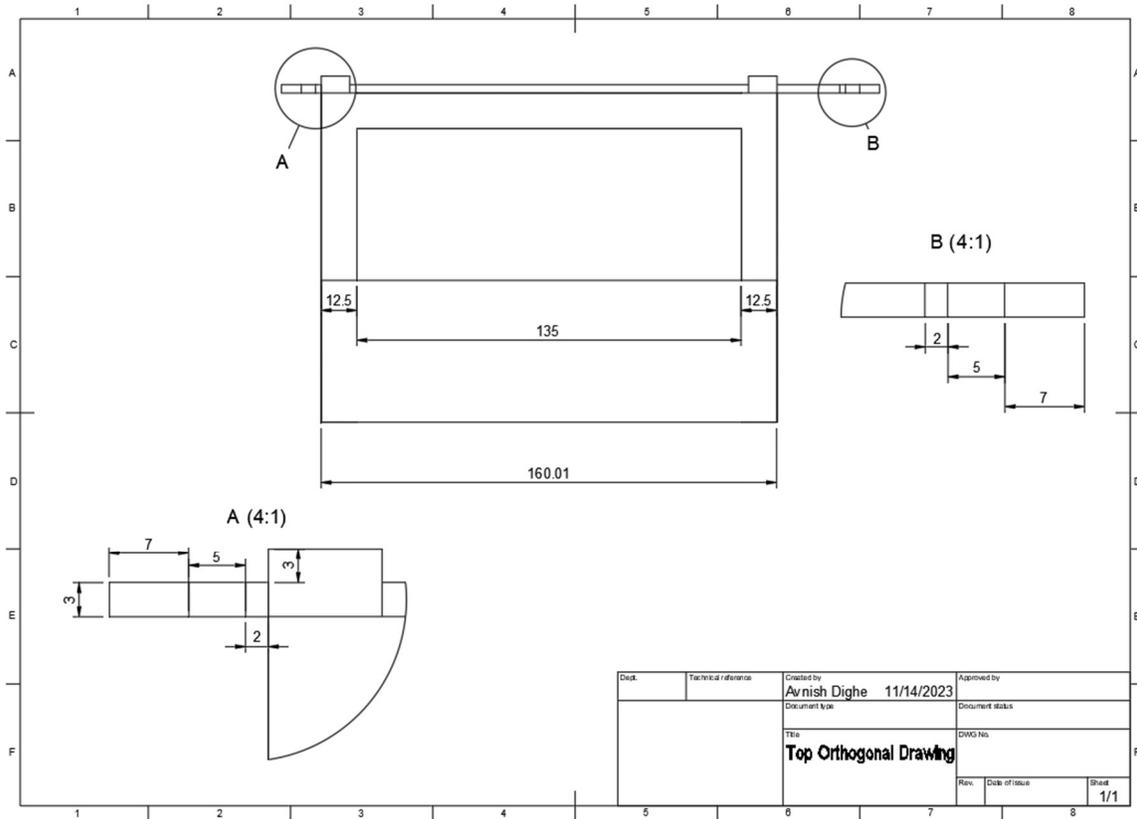
### Pinhole Camera Front Orthogonal Drawing (In mm)



### Pinhole Camera Side Orthogonal Drawing (In mm)

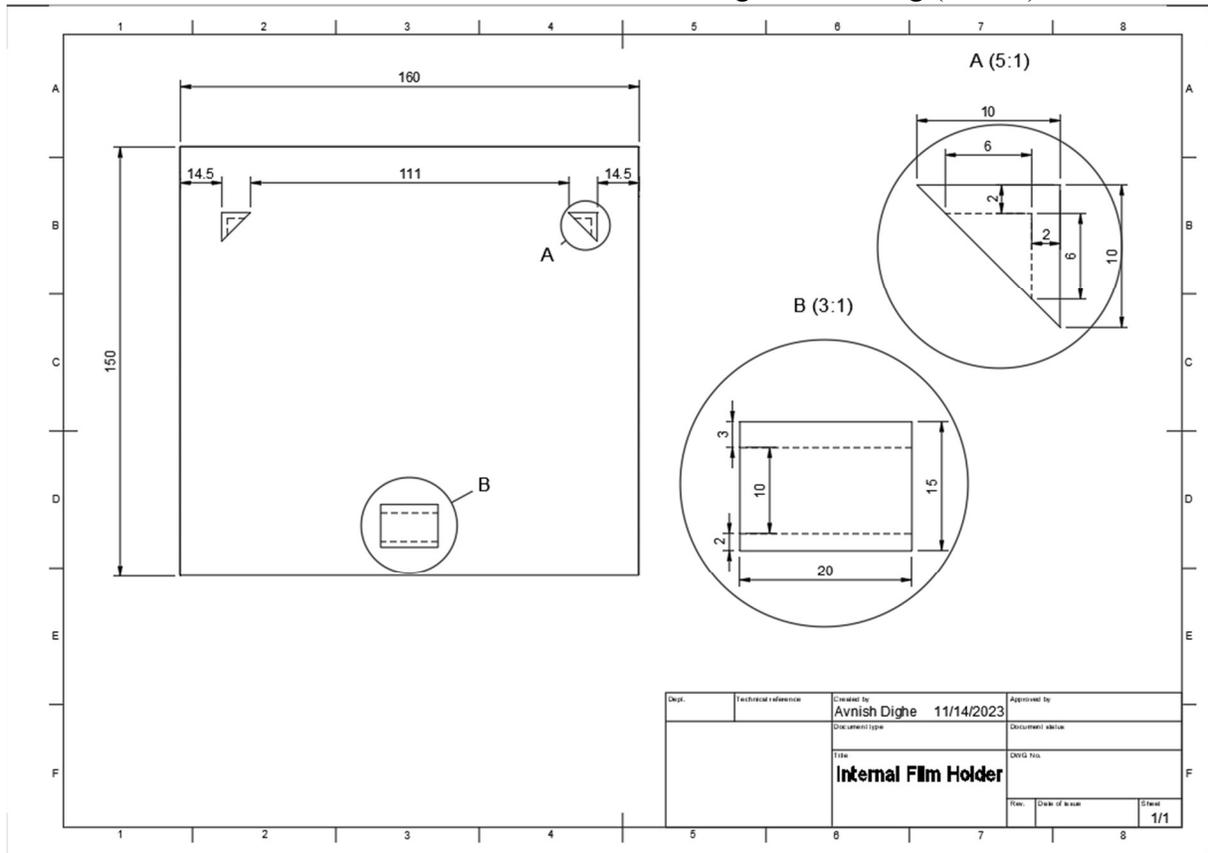


### Pinhole Camera Top Orthogonal Drawing (In mm)



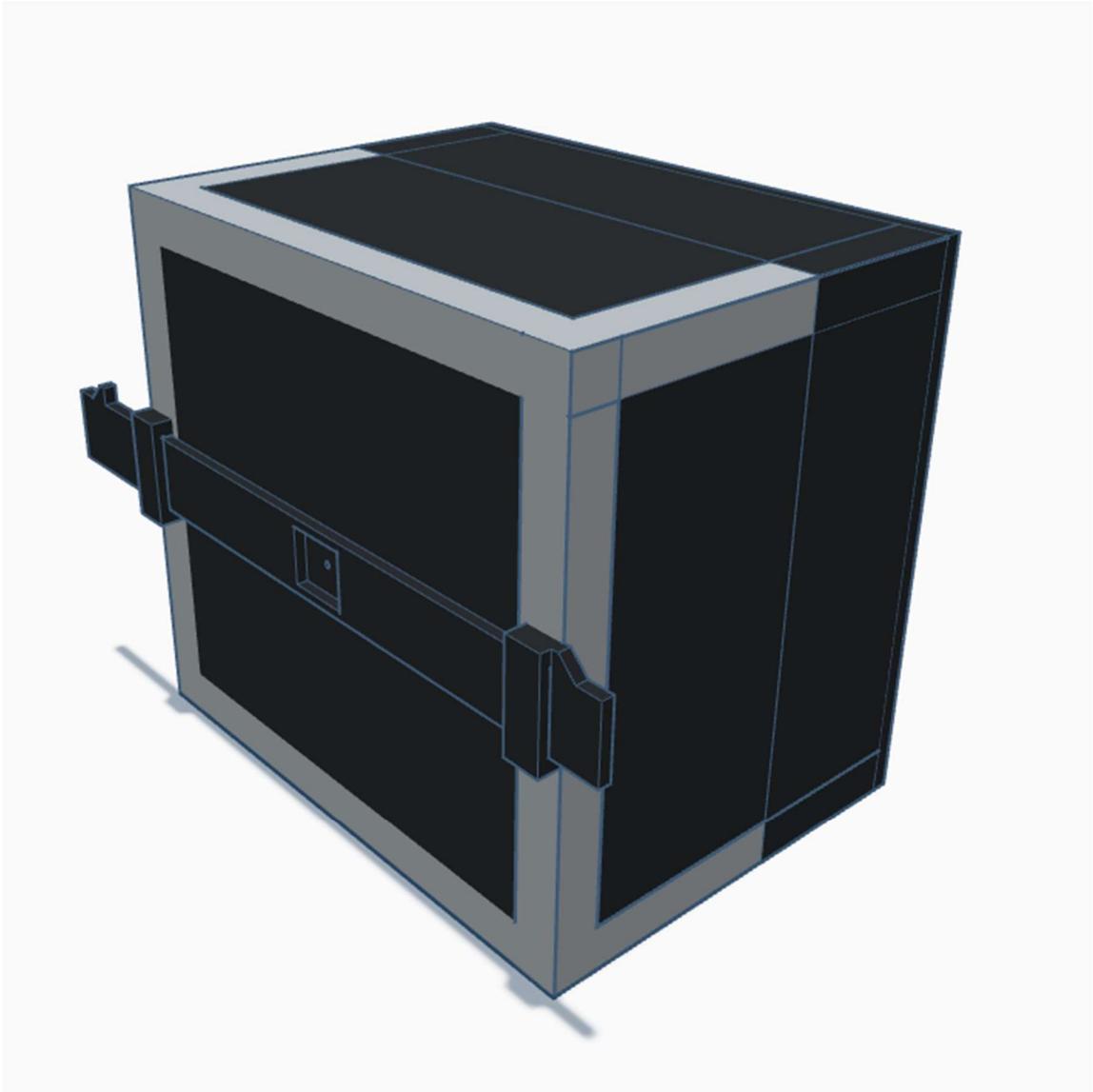
Dist.	Technical reference	Created by <b>Avnish Dighe</b>	11/14/2023	Approved by
		Document type		Document status
		Title <b>Top Orthogonal Drawing</b>		DWG No.
		Rev.	Date of issue	Sheet <b>1/1</b>

# Pinhole Camera Internal Film Holder Orthogonal Drawing (In mm)



Dept.	Technical reference	Created by <b>Avnish Dighe</b> 11/14/2023	Approved by
		Document type	Document status
		Title <b>Internal Film Holder</b>	DWG No.
		Rev.	Date of issue
			Sheet 1/1

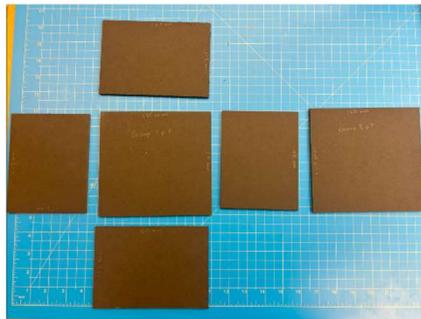
## Final Camera Isometric Drawing



### 3D. Instructions for Building the Camera

Constructing the box:

1. Cut out foam core boards of the following sizes:
  - a. 2 boards 160mm x 150mm
  - b. 2 boards 160mm x 112mm
  - c. 2 boards 142mm x 112mm



2. Glue boards together leaving a 160 x 150 board aside and cut a 16mm x 16mm hole into the 160 x 150 board that you still have. Make sure to glue in the corners for optimal stability. Ensure that the base is the 160 x 150 board, and the overlap is by the 160 x 112 boards as shown below.



3. Cut out aluminum tape into fourths along the long side so that the width of each strand is  $\frac{1}{4}$  of the width of the tape. Cut out 4 of such strands of length 150, 3 strands of length 160, and 4 strands of length 126 (all in mm). Apply these to corners of box to cover the gap between adjacent pieces of foam core board as shown below.



4. Cut out construction paper sheets into sizes of 165mm x 50mm and 2 sheets of 155 x 50mm. Adhere these to the sides of the spare 160mm x 150mm board. Seal with electrical tape in the same way as the foam core boards.



5. Connect the new assembly via the 160mm side without construction paper to the box you have currently using electrical tape on both sides of the joint.



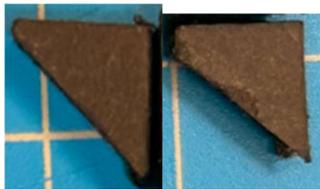
- Attach pinhole piece of can to the inside of the box at the 16mm x 16mm hole and surround with electrical tape as shown to prevent light leakage. Ensure that the aperture that is cut out into the aluminum is centered in the middle of the box.



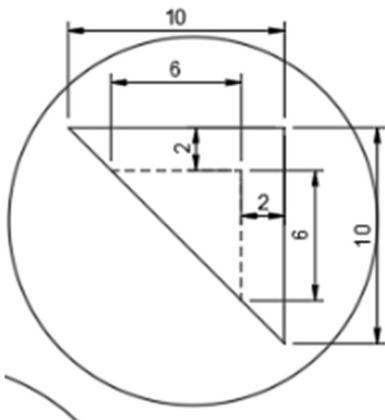
- Follow Light Tight Check steps to test camera

Installing the Film holder:

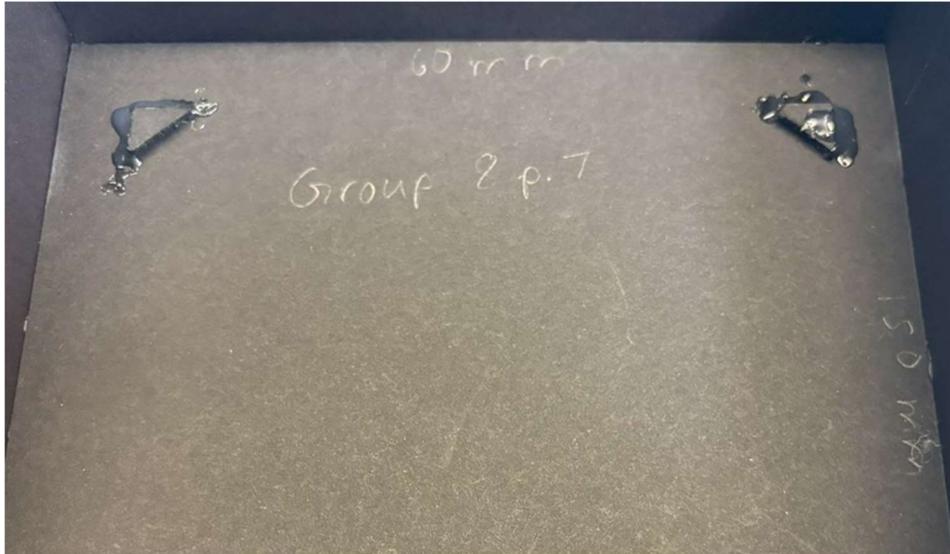
- Cut out a 10mm x 10mm square of foam core board and cut it diagonally from corner to corner to form two triangles.



- Carve out a small triangle leaving 2 mm from the edges with a height of 2 out of the 4mm in the thickness of the foam core board.



- Follow diagram in 3C, Pinhole Camera Internal Film Holder Orthogonal Drawing to measure out and glue down the triangles, ensure that the air pocket is unobstructed by glue and only the 2mm edges have glue under them.



4. Get a Large and mini popsicle stick and cut them both to a length of 20 mm in length, and glue them together leaving 2mm on one side and 3mm on the other side. Once again follow the Diagram 3C, Pinhole Camera Internal Film Holder Orthogonal Drawing to install the popsicle stick assembly. Ensure the overhang of the jumbo popsicle stick is unobstructed and only glue on the underside of the mini popsicle stick.



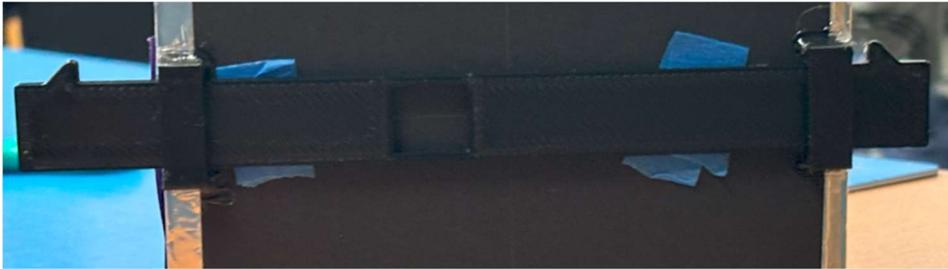
5. Move on to installing the aperture cover.

#### Aperture Cover Installation:

1. If you have the 3D printed assembly, skip to step 4
2. Cut out a piece of foam core board that is 30mm x 210mm, and carve out the shape based on diagram 3C, Pinhole Camera Side Orthogonal Drawing. Additionally, cut two pieces that are 29mm x 10mm, and four more that are 10mm x 5mm. Glue together one of the 29 x 10 pieces to 2 of the 10 x 5 pieces to form an arch similar to the one below.



3. Take the initial 30x210 piece and cut a 18mm x 16mm hole in it with 18mm being the width along the long side of the strip. There should be 85mm to the right of the 18mm hole and 107mm to the left.



(open)



(Closed)

4. Align the slider with the aperture ensuring the 16mm x 18mm hole contains the aperture perfectly in the center and install the “bridge” assemblies as shown above. Hot glue them only below the 5 x 10 pieces to prevent locking the bar in place.
5. Ensure that slider covers the aperture on one side and completely exposes it on the other.

#### Pinhole punching:

1. Obtain a 40mm x 40mm sheet of aluminum from a can
2. Take your needle and firmly press it in the center of the metal, so that a dimple starts to form on the other side. Do not push needle all the way through
3. Use a metal file to file the side of the dimple that is protruding out until you see a hole appear all the way through the aluminum.
4. Measure the diameter of the aperture using the magnifying glass with the ruler built into it.
5. If you require multiple attempts to get it, ensure the old hole attempts have been completely covered before using it as your aperture.

#### Light leak test:

1. Bring camera into dark room with aperture closed
2. Turn on phone flashlight and try to shine through various angles of the box for any obvious light leaks. If there are none, continue, else add aluminum tape to those exposed areas.
3. Open box and using a piece of tape stick the test strip on the side opposite from the aperture, glossy side facing the aperture
4. Close box and ensure aperture cover is still closed
5. Exit the dark room and hold box up to light sources from different angles without opening the box.
6. Re-enter the dark room and when completely dark remove the test strip from the box and follow development process listed: developer (90 s), water (30 s), and fixer (60 s), followed by water (120 s).
7. If test strip comes back white, camera is finished, else, go back to flashlight test and begin analyzing where the light leak comes from.

### Instructions for use:

1. Take camera into the dark room, open the box to reveal the film holder
2. Push the film paper into the two corner triangles of the film holder



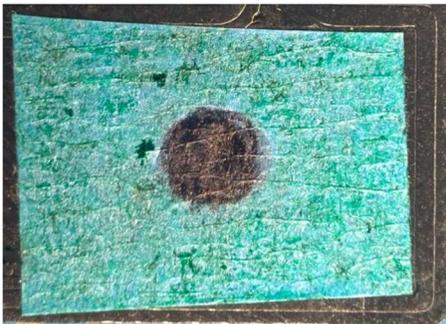
3. Push on the bottom of the film paper so that it bends upward and tuck it into the popsicle stick holder
4. Release the paper to lock it in place, ensure that it is secure and cannot move
5. Close the box and ensure the aperture cover is closed so that light cannot leak in yet. The green slider should be showing to indicate that the aperture is closed.



6. Leave the dark room and walk down to the location that you would like to take your picture
7. Use the formula listed above to calculate the distance to place the camera away from the object
8. Place the camera on a level surface that distance away and get a phone ready to time
9. Begin the stopwatch and shift the slider to open the aperture, keeping an eye on the clock. Slider should show red to signify that the aperture is currently open and to proceed with caution



10. When the clock reaches the exposure time that you have found for your box and your location, shift the slider back into place to close off the aperture. Ensure that the slider has once again returned to green to signify that the aperture is once again closed off from any light being able to enter



11. Pick up your box and carefully transport it back into your dark room, ensuring that the box does not open nor does the aperture cover open.
12. Once back in the dark room, after ensuring no light sources are present, open the box to reveal the film holder
13. Similar to placing in the film paper, gently push on the bottom of the film paper so that it creates a slight bend and comes free of the popsicle stick clip.
14. Lift the film paper away from the holder and bring it to the table that you have set up for the treatment of the film.
15. Follow this order to treat the film: developer (90 s), water (30 s), and fixer (60 s), followed by water (120 s).
16. Proceeding the treatment, place the film paper on to a paper towel to dry off the film paper, as it will be wet from the water treatment.
17. After the film paper is dry, carefully remove it from the paper towels and bring it back into the classroom or wherever you mean to view the picture

18. On your phone, invert the colors of your phone (you may have to look up how to do this for your specific phone, as it differs from phone to phone).
19. Take a picture of the film paper, which should invert the colors and your picture should be clearly visible.
20. If the picture is too light or too dark, revisit previous steps to increase or decrease the exposure time depending on the saturation of the picture. The process may need to be repeated a few times for optimal results.
21. Store the picture in a secure and safe location so that it stays dry and crisp.