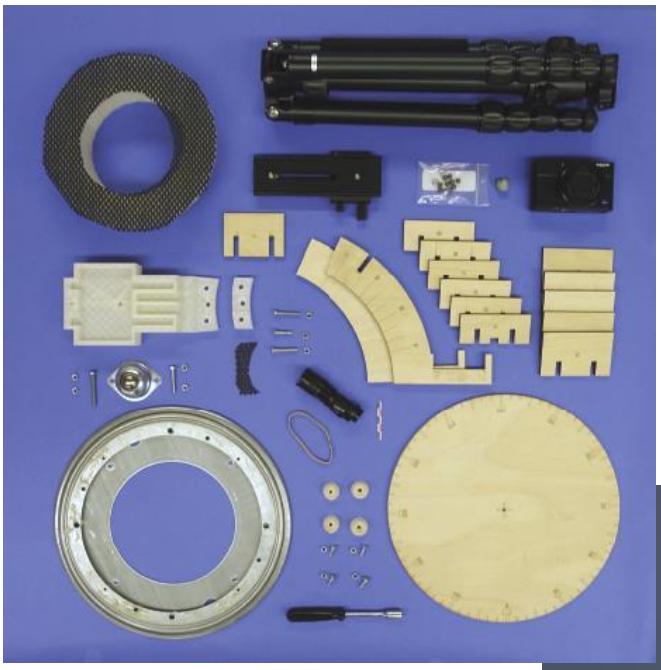
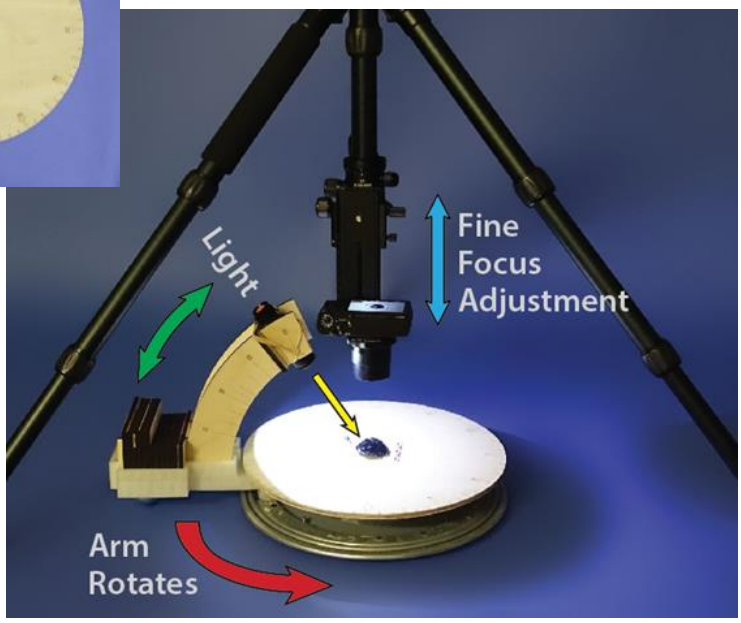
A Portable, Low-Cost, Open-Design Rig for Reflectance Transformation Imaging

Parts List, Rig Assembly, and Image Acquisition Instructions

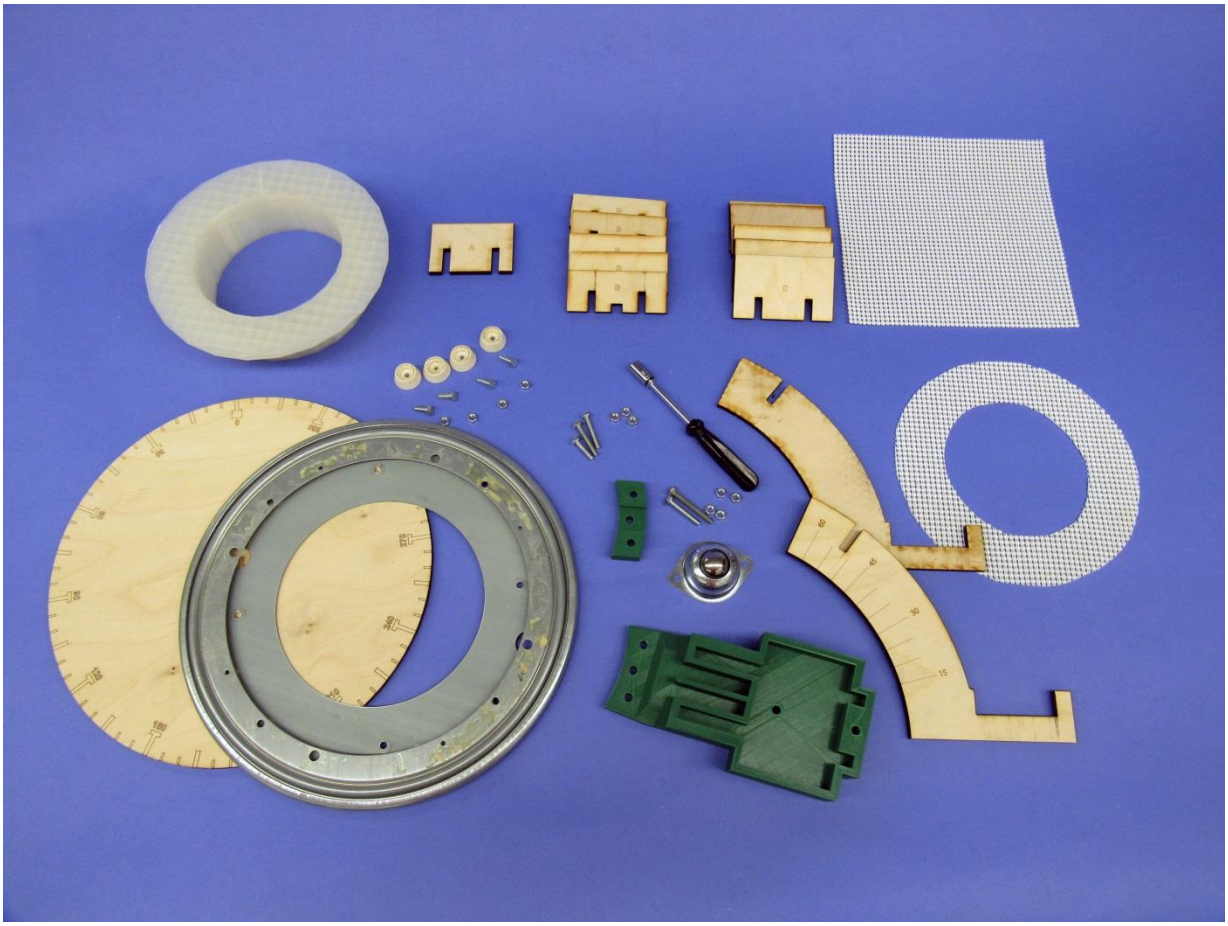




Samantha Thi Porter – port0228@umn.edu
University of Minnesota, Twin Cities

Supplemental Material for a Poster Presented at the 2016 Meeting of the European Society for the Study of Human Evolution (ESHE)

Table of Contents

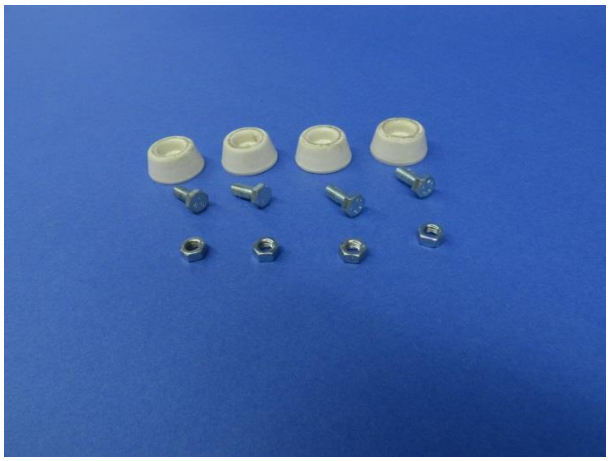


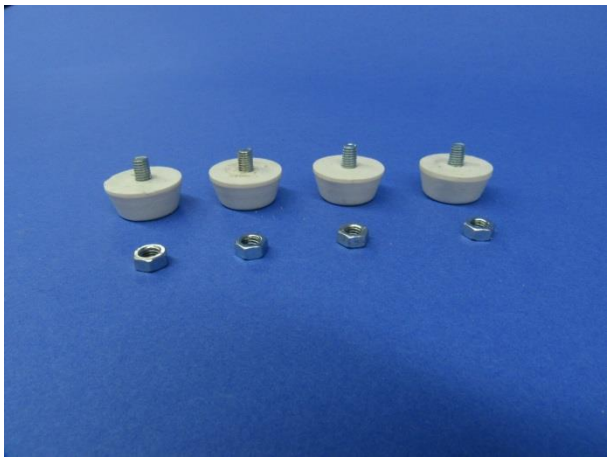
Rig Parts List

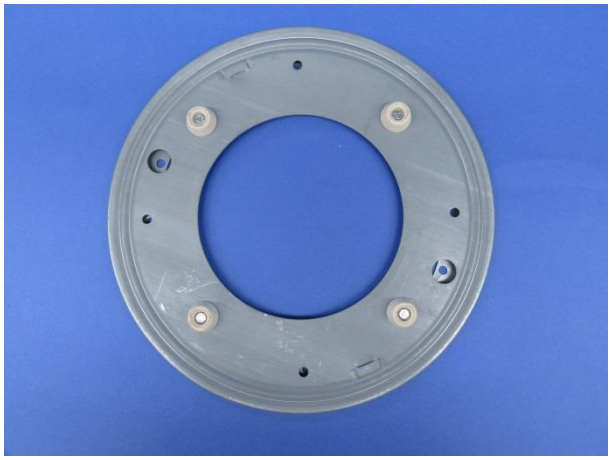
Part	Specifications	Count	Comments	Make I Used
digital camera or USB microscope				
macro adapter lens			optional, but can be used with high optical zoom cameras instead of a usb microscope	Raynox DCR-250
tripod or copy stand	camera must be able to face straight down			
macro focus rail			technically optional, but makes fine focusing much easier	Neewer 10cm
non-slip shelf or rug liner		1 roll		
scale bar(s)				
reflective spheres	size will depend on size of objects being imaged		I recommend using silicon nitride ceramic ball bearings	E-accexpert 1/4"
kneaded rubber eraser			used to hold up objects and reflective spheres	
3D printed platform base		1	may be downloaded from the Digital Repository for the University of Minnesota	
laser cut platform and arm mount		1	may be downloaded from the Digital Repository for the University of Minnesota	
small LED flashlight		1	can use additional flashlights if you don't want to adjust the angle of the light as often	Smart&Cool mini 7W
rubber bands			used to attached flashlight(s) to arm	
lazy susan bearing	12 inch (diameter)			
rubber feet	10 mm (height)	4		
bolts (aka hex cap screws) for attaching feet	12mm (length) pick diameter based on the size of the holes in your feet	4		
nuts for attaching feet	see above	4		
roller ball transfer bearing	1 inch (bearing diameter)	1	arm mount is designed for bearing with approx. 55 mm between the center of mounting holes	Shepard Hardware 9549
bolts (aka hex cap screws) for arm mount	20 mm (length) by 5 mm (diameter)	1		
bolts (aka hex cap screws) for arm mount	25 mm (length) by 5 mm (diameter)	2		
bolts (aka hex cap screws) for arm mount	30 mm (length) by 5 mm (diameter)	2		
bolts (aka hex cap screws) for arm mount	40 mm (length) by 5 mm (diameter)	1		
nuts for arm mount	5 mm (internal diameter)	10	it's a good idea to purchase a few extra in case of loss or to act as spacers	
washers	5 mm (internal diameter)	10	optional, but helps reduce strain on 3D printed parts and can act as spacers; it's a good idea to purchase a few extra	

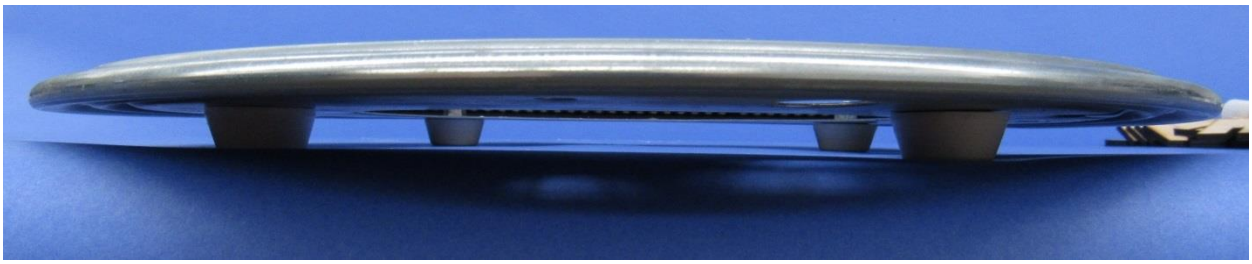
Rig Assembly

1. First, attach the rubber feet to the lazy susan bearing. Push 20mm long hex cap screws through your feet, then secure them to the bearing using nuts.



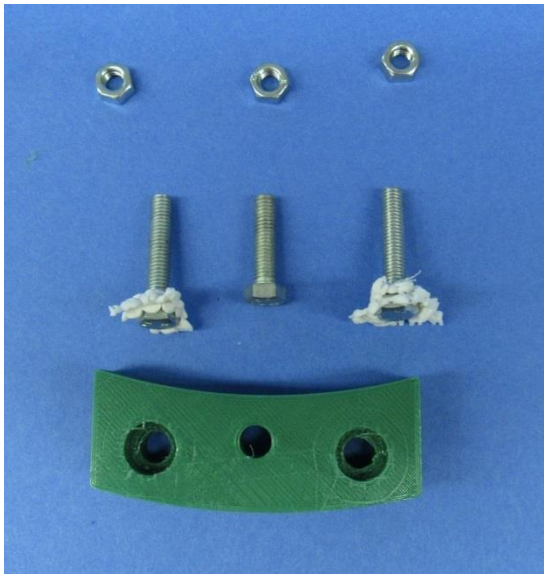




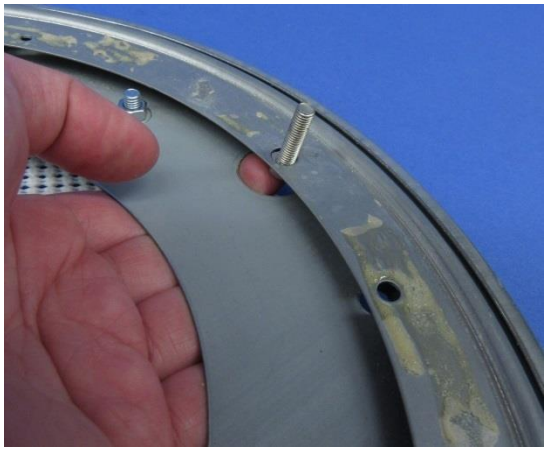
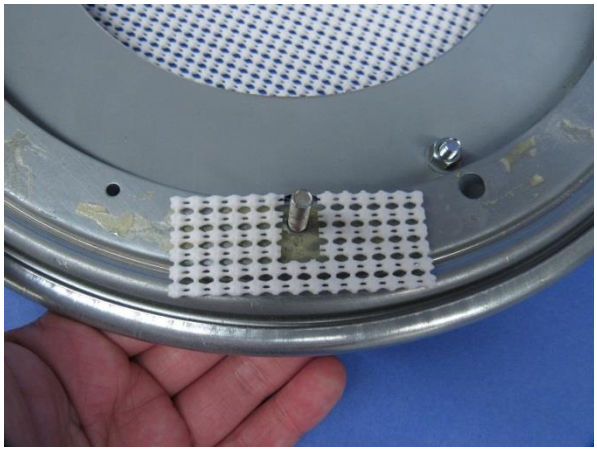


2. Next, attach the arm mount connector to the lazy susan bearing. You will need two 25 mm hex cap screws for each side of the connector, and one 20 mm hex cap screw for the center.

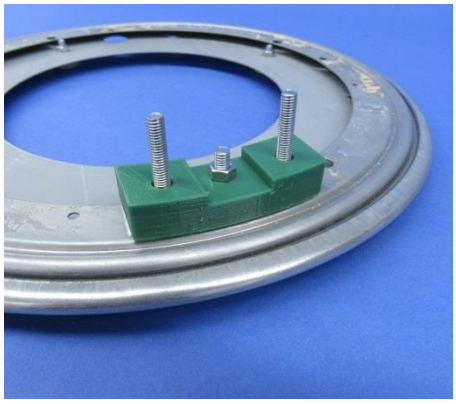
   Because of the way the connector piece prints, you may need to tighten the fit between the screw heads and the recesses in the connector. You can do this by adding pieces of shelf liner around the screws. Push the screws into the two holes on either side of the connector.



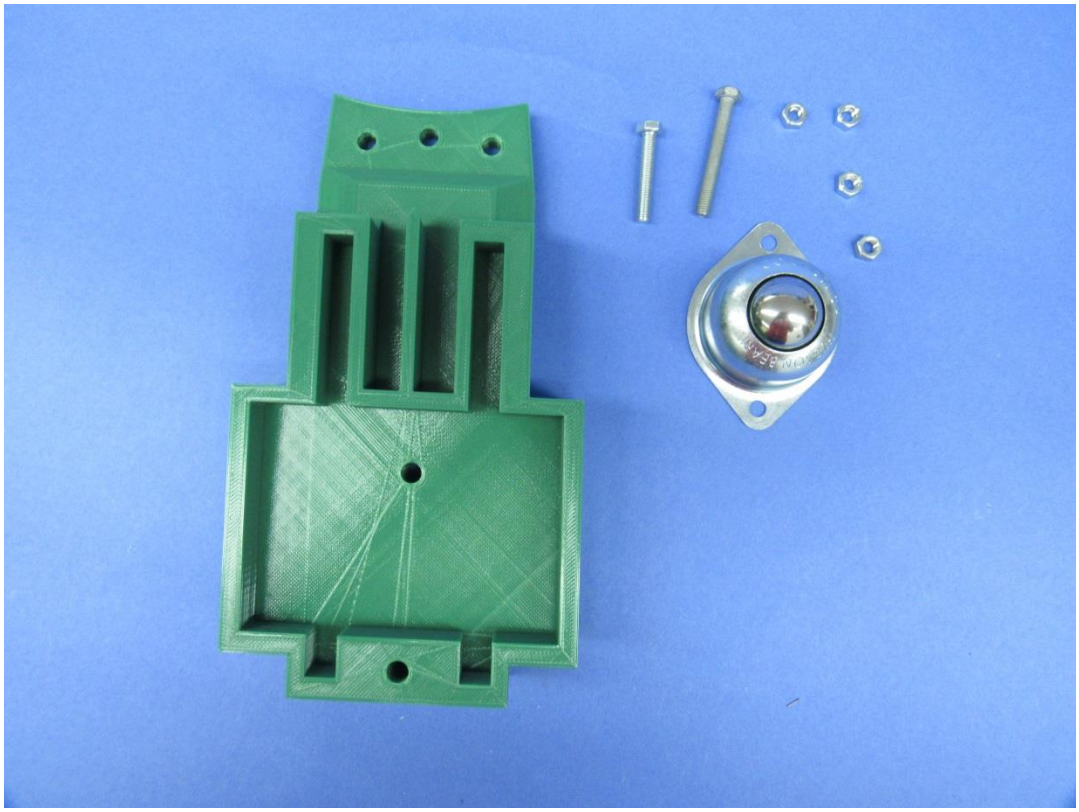

There should be a hole in the bottom of the bearing that allows you to stick a screw through the top. Push a 20 mm screw through this hole. In order to prevent the connector from shifting once the rig is assembled, lay a piece of shelf liner across the top of the bearing.

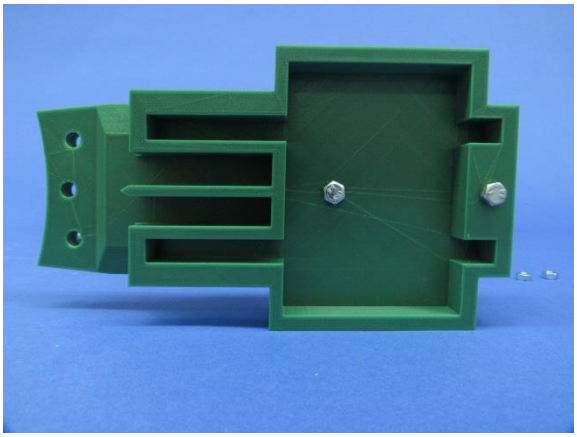
Attach the connector to the lazy susan bearing using the center screw and a nut.

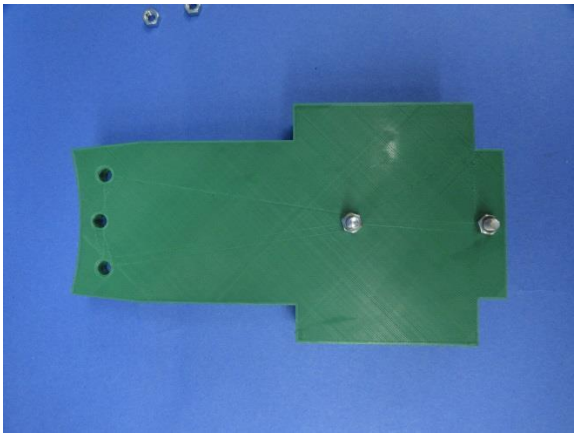




3. Attach the 1” roller ball transfer bearing to the bottom of the 3D printed arm mount. You will need the arm mount, bearing, one 30 mm long screw, one 40 mm long screw, and nuts / washers / spacers (optional).

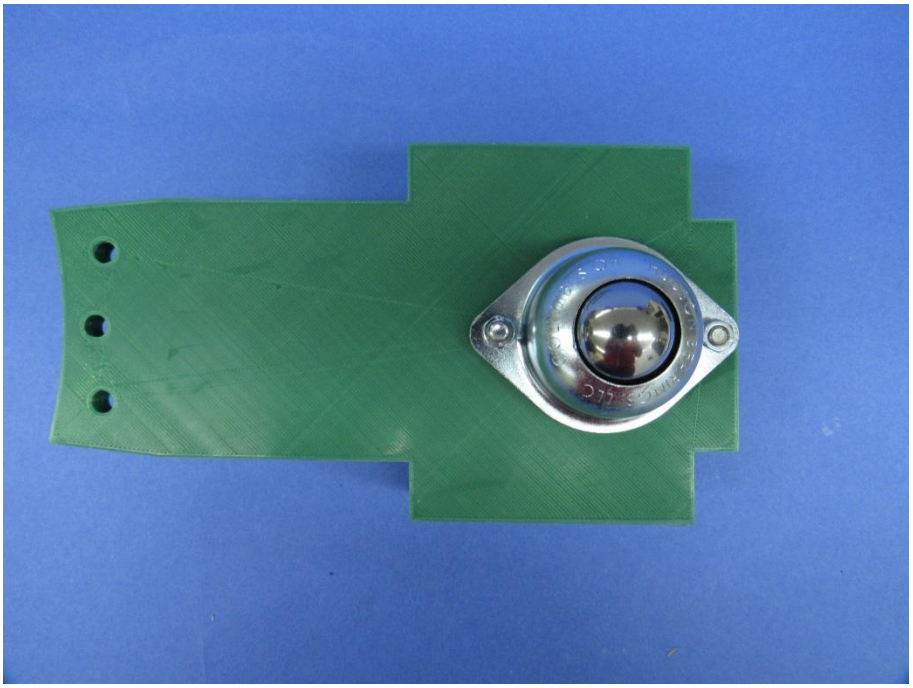


Insert the 30 mm screw through the hole in the center of the arm mount and the 40 mm screw through the hole in the end of the arm mount. Depending on the exact height of your feet, you may need to add nuts or washers on the back of the arm mount to act as spacers so the mount sits level on the lazy susan bearing. Here, I've used two nuts attached to the screws on the bottom of the arm mount as spacers.

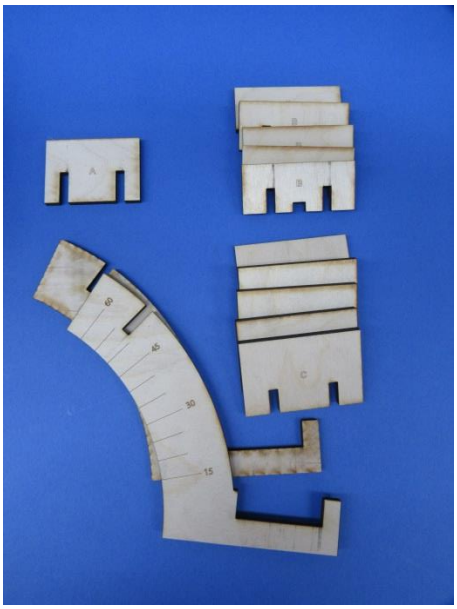


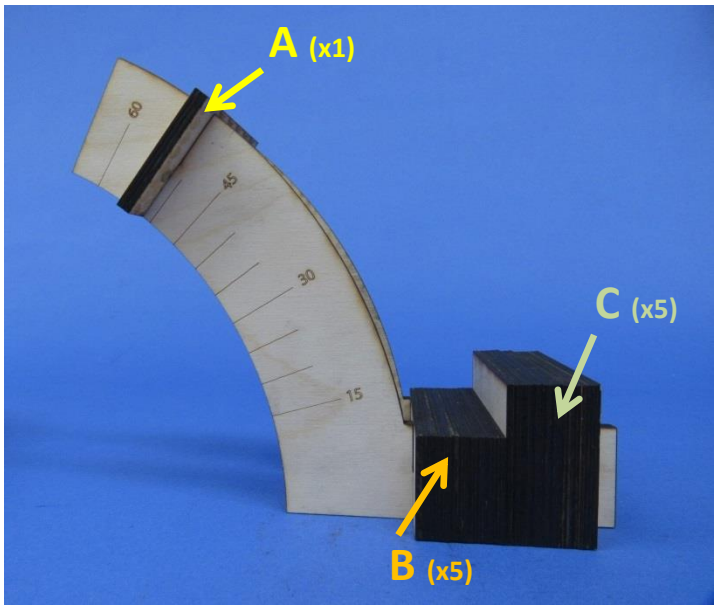


Position the 1" roller ball transfer bearing over your screws, and secure with nuts.

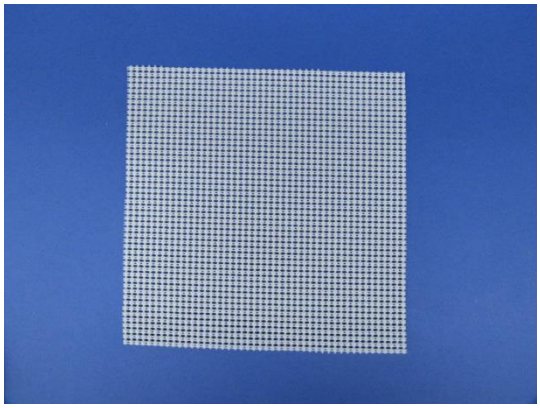


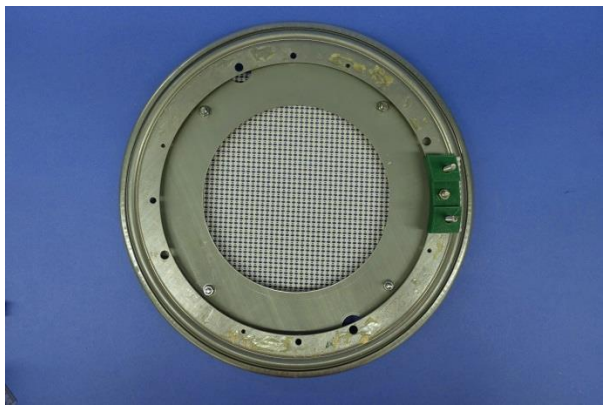
4. Assemble the laser cut pieces of the rig arm.



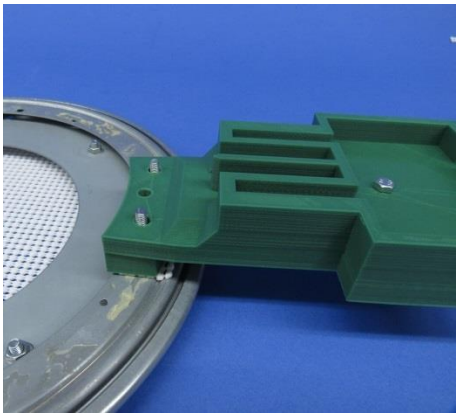
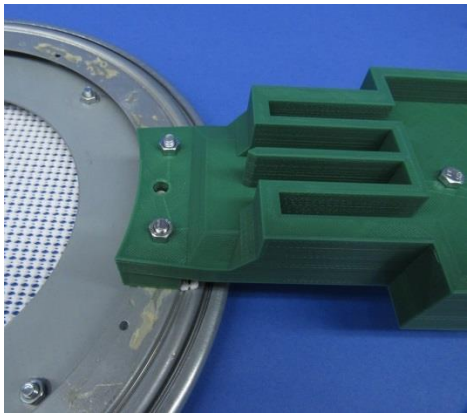


5. Now you're ready to set up your rig for photography. First, put down a square piece of shelf liner. This is meant to stabilize the rig. You will want the piece of shelf liner to be slightly larger than the extent of the feet attached to the lazy susan bearing. Place the lazy susan bearing on top of the shelf liner.

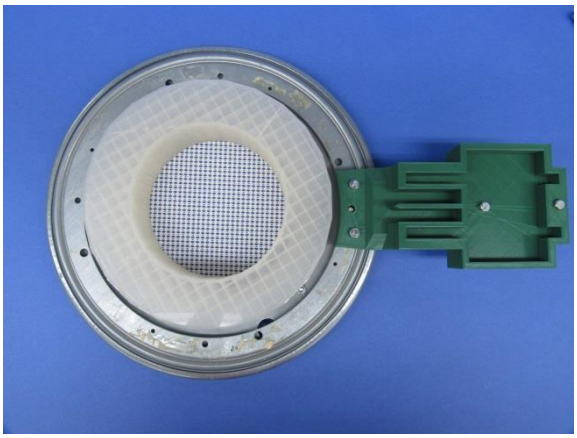
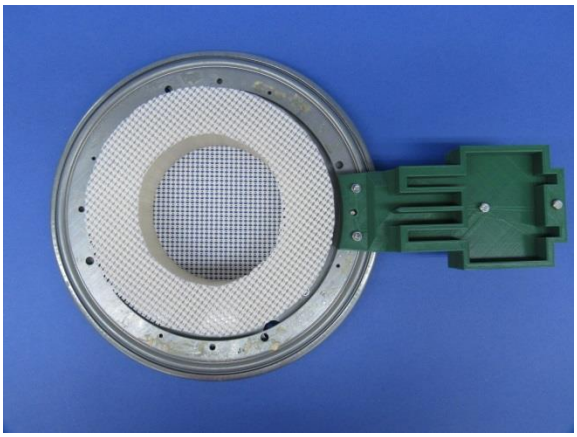




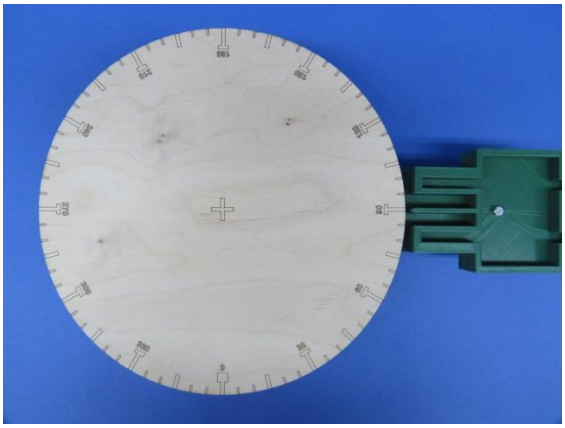
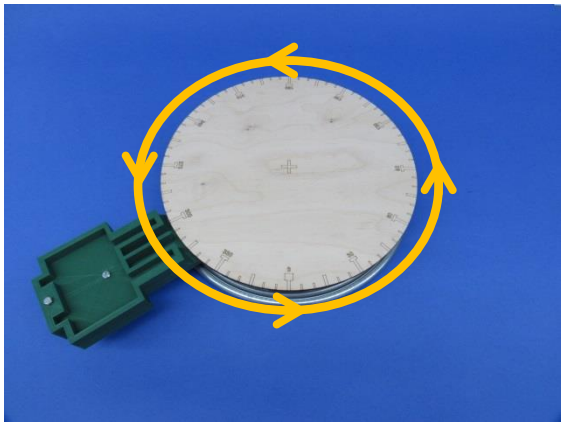
Set the arm mount on top of the arm connector, and secure with two nuts.

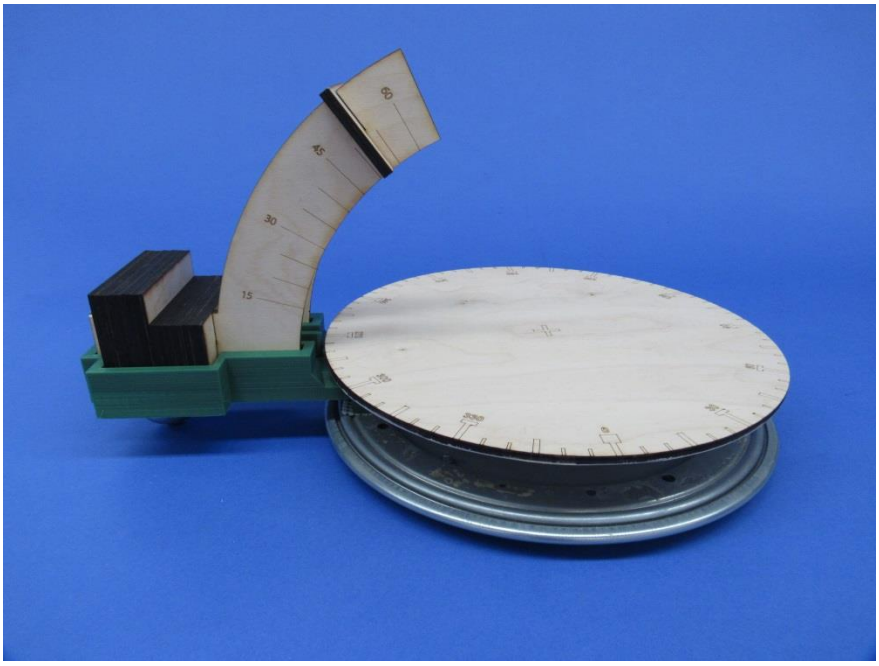
Set the 3D printed platform base in the center of the lazy susan bearing on top of the shelf liner. Put another piece of shelf liner cut to fit the top of the platform base on top of that.

Place the laser cut platform on top of the platform base. Make sure it is centered, and that the arm mount can rotate freely around the entire perimeter of the platform.

Place the arm in the arm mount.



Use a tripod or copy stand to position your camera above the center of the platform, making sure the camera is level. In this case, we've attached the camera to a macro focus rail. This makes fine focus adjustments much easier. If you're using a setup similar to the one pictured, make sure that the legs of the tripod do not get in the way of the rotation of the arm around the platform.

6. If possible, remove the lens from the flashlight you are using by unscrewing the top ring. This will give you a more diffuse light source, which is better for RTI.

7. Attach the flashlight to the arm using a rubber band. As you take photos, you can move the flashlight up and down by removing the rubber band, or simply sliding the flashlight along the arm.

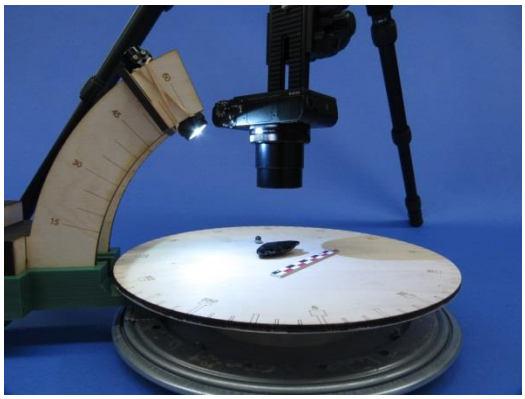
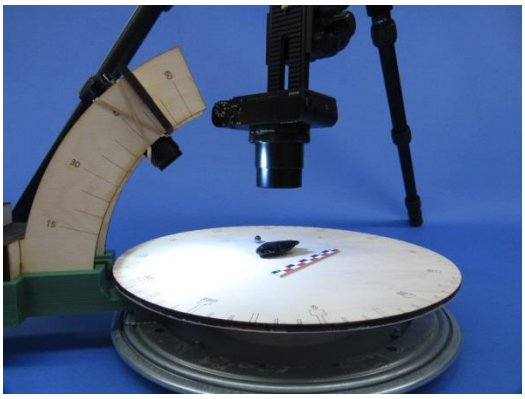
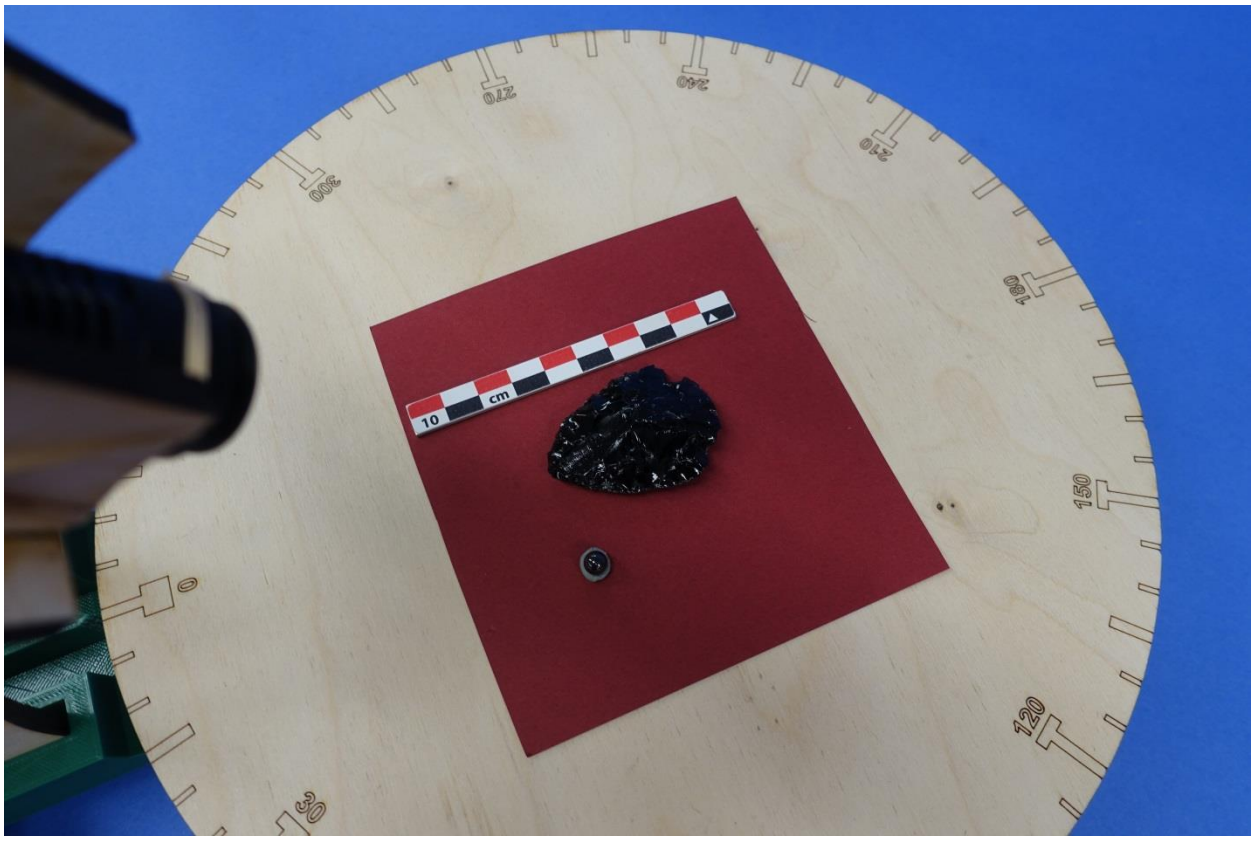



Image Acquisition

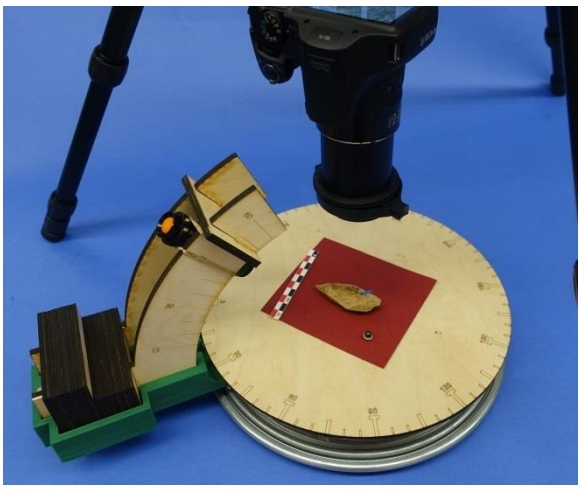
1. Place your target object, scale, and at least one reflective sphere on the platform. To avoid too much light reflecting off the surface of the platform, you may want to place these objects on top of a less reflective material, such as a dark piece of construction paper.



2. Set up your camera. It is best to take photos in manual mode. Use a low ISO to minimize image noise. Set your F-stop to maximize depth of field while minimizing distortion (i.e. between about 5.6 and 11). Finally, set your exposure so that images are not too bright when the flashlight is at its highest position (e.g. 60 degrees) and not too dim at its lowest position (e.g. 20 degrees). Ideally, you should turn off or shade other sources of light in the room that may be reflected in your sphere. Manual focus is also recommended.

   Highlight based RTI can work at different level of magnification as long as you can fit an appropriately sized reflective sphere into the scene. Options for high magnification include USB microscopes (e.g. a DinoLite) or cameras with high optical zoom capabilities combined with an additional macro lens. Pictured below is a Canon sx530 HS camera with a 67 mm filter adapter and a Raynox DCR-250 snap on lens. The reflective ball in the photograph below is 1/16 of an inch, or approximately 1.6 mm in diameter.

   If you are using high magnification, be sure to remember to take at least one image with a scale for later reference.

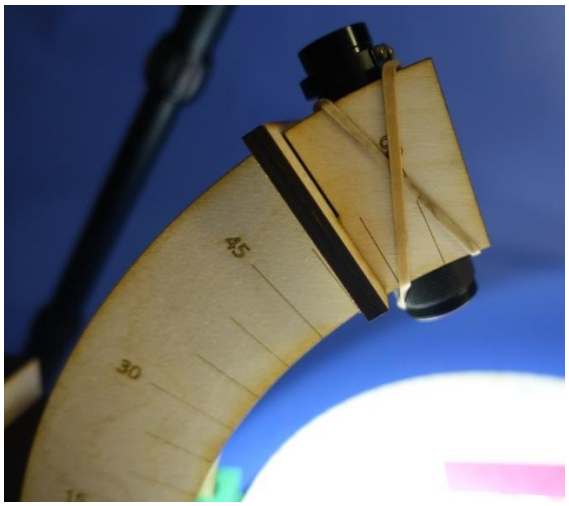


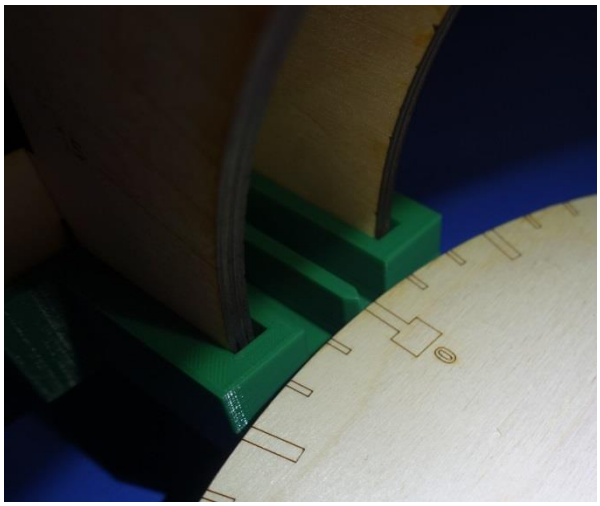
3. Set up a remote trigger system. You want to avoid any actions that will change the position of the camera relative to the object(s) you are photographing. Options include using a hand held trigger, connecting your camera to a computer, using a smart phone app, or using a motion detection script.

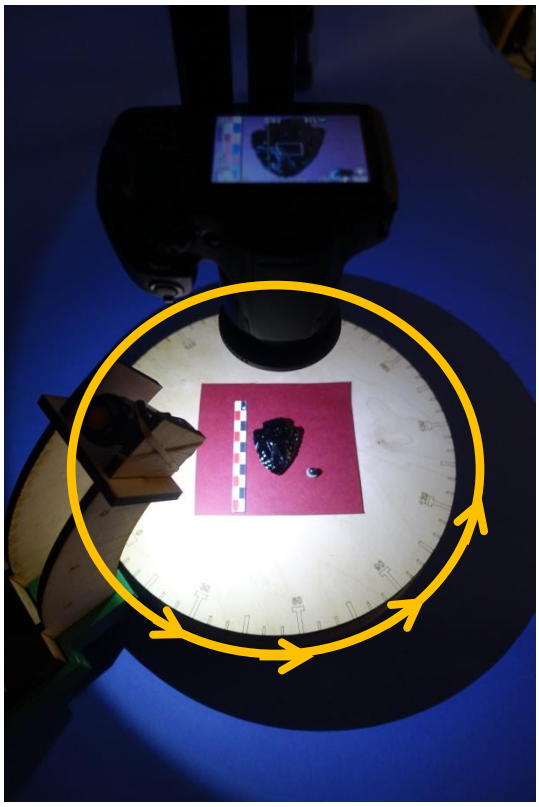
   My current setup uses a motion detection script installed on a Canon sx530 HS camera, which I installed using the Canon Hack Development Kit also known as CHDK (see chdk.WIKIA.com and specifically chdk.wikia.com/wiki/Motion_Detection). Waving a hand in front of the camera triggers the camera to shoot. I also manually set a two second shutter delay, and set a 2000 millisecond delay after each photograph before the script stars look for motion. You can do this by editing the script code (see previous link).

4. Now you're ready to take your photos. There is no one set of established lighting positions needed for RTI, but I use the following progression:

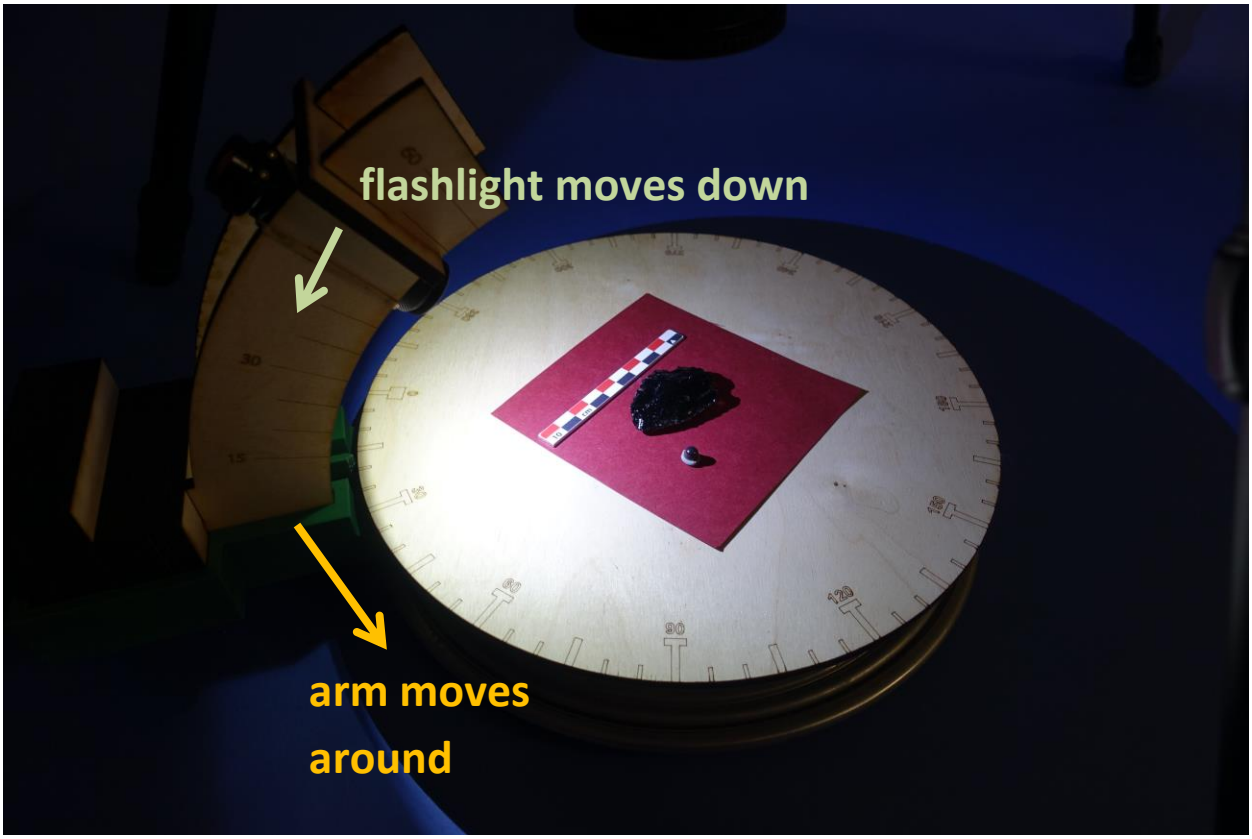
   Set the center of the 3D printed RTI arm mount to 0 degrees and your flashlight in the highest lighting position you want to use. I generally start at 60 degrees. Take a photo, then move the rig arm so that it is centered at the 30 degree mark. Take another photo and continue moving in 30 degree increments until you've taken a photo at the 330 degree mark.



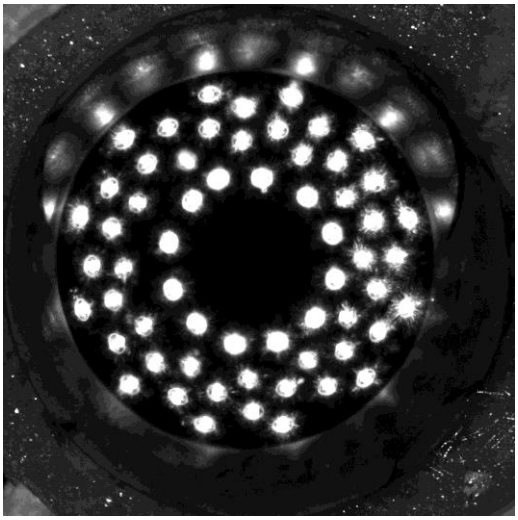




Move the flashlight down to the 50 degree mark on the rig arm. Move the rig arm so that it is centered around the 15 degree mark on the rig platform. Take a photo, move the arm 30 degrees to the 45 degree mark on the platform, and take another photo. Continue this pattern moving around the platform and moving the flashlight down in 10 degree increments down the rig arm after each rotation. A table of the lighting positions I usually use are listed on the following page.



Round	Flashlight Position	Position around Platform	Round	Flashlight Position	Position around Platform	Round	Flashlight Position	Position around Platform
1	60°	0°	3	40°	0°	5	20°	0°
1	60°	30°	3	40°	30°	5	20°	30°
1	60°	60°	3	40°	60°	5	20°	60°
1	60°	90°	3	40°	90°	5	20°	90°
1	60°	120°	3	40°	120°	5	20°	120°
1	60°	150°	3	40°	150°	5	20°	150°
1	60°	180°	3	40°	180°	5	20°	180°
1	60°	210°	3	40°	210°	5	20°	210°
1	60°	240°	3	40°	240°	5	20°	240°
1	60°	270°	3	40°	270°	5	20°	270°
1	60°	300°	3	40°	300°	5	20°	300°
1	60°	330°	3	40°	330°	5	20°	330°
2	50°	15°	4	30°	15°			
2	50°	45°	4	30°	45°			
2	50°	75°	4	30°	75°			
2	50°	105°	4	30°	105°			
2	50°	135°	4	30°	135°			
2	50°	165°	4	30°	165°			
2	50°	195°	4	30°	195°			
2	50°	225°	4	30°	225°			
2	50°	255°	4	30°	255°			
2	50°	285°	4	30°	285°			
2	50°	315°	4	30°	315°			
2	50°	345°	4	30°	345°			



If you use the above list of camera positions, you should end up with a lighting distribution similar to what you can see in the image to the left.

For a more comprehensive guide to photography for RTI, I suggest visiting the follow page from Cultural Heritage Imaging: culturalheritageimaging.org/What_We_Offer/Downloads/Capture/index.html.

5. Process your images using RTIbuilder. You can find the program, along with a guide on processing RTI projects at: culturalheritageimaging.org/What_We_Offer/Downloads/View/index.html