CubEd
Classroom Manual

 1

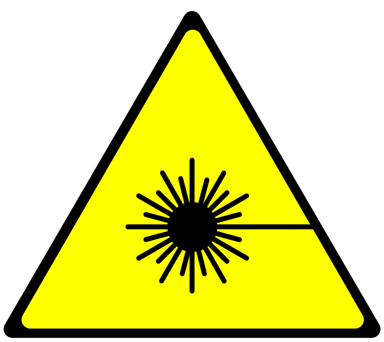
Safe Use Guidance — General

WARNING

CHOKING HAZARD - Small parts not for children under 3 years or any individuals who have a tendency to place inedible objects in their mouths.

Choking Hazard!

This product uses small neodymium magnets! Not for use with children under 3!!!



CAUTION

CLASS 3R LASER PRODUCT

A Class 3R laser is low powered, which normally does not harm eyes during momentary exposure. This duration is within the aversion response, when a person turns away and/or blinks to avoid bright light.

Do not deliberately look or stare into the laser beam. Laser protective eyewear is normally unnecessary. A Class 3R laser is neither a skin nor materials burn hazard.

However, a Class 3R laser can be a distraction, glare or flash blindness hazard for pilots and drivers. **NEVER aim any laser towards an aircraft or a vehicle in motion.** This is unsafe and is illegal – you could be arrested and jailed.

ONLY ALLOW USE BY RESPONSIBLE PERSONS!!!

This is NOT a toy. Continuous adult supervision is required for children to safely use Class 3R lasers.

Lasers

Based on lasers listed for use in associated publication(s).

Laser Source	Power (With ND Filter)	Power (Without ND Filter)
Red (640 nm)	13.9 mW	109.2 mW
Blue (405 nm)	7.9 mW	49.7 mW
Green (532 nm)	4.3 mW	29.5 mW

Please refer to the documentation provided by the manufacturer for additional warnings and preventive, protective equipment (PPE) requirements (e.g. laser safety goggles).

Always consult your local Laser Safety Officer or Radiation Safety Officer and refer to your laboratory safety documentation for more information.

You can also consult your Laser Safety Standards ANSI Z136 in North America, SUVA 66049.D in Europe, and BS EN 60825-1 in the UK. Additionally, laser safety standards and regulations are covered by IEC norm 60825-1, and LED eye safety standards and regulations are covered by IEC norm 62471 in Europe.

Safety guideline: Hazardous, visible, or invisible radiation from lasers, lamps, and other light sources used for microscopy can cause permanent damage to the retina, skin burns, and fire. Always follow proper laser safety protocols for your equipment and situation.

Reminders!

- Never touch any lenses or mirrors directly with your hands or fingers!
- Never put any part of your body in the beam path, it is dangerous!

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Cubes

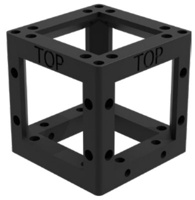
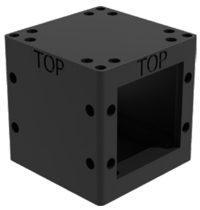
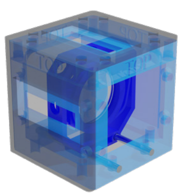
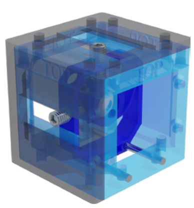
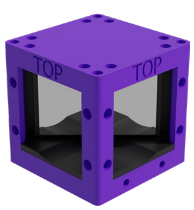
Image	Name	Description
	Support	**Black** cube used for support to place other cubes in the correct position in space.
	Shielded	**Black** horizontal or vertical tunnel that prevents unnecessary noise and signal interruption and provides an easy solution to a safely enclosed light path. Also used to space cubes at the correct distance relative to each other.
	1” Lens	**Light Blue** cube designed to hold a standard 1” optical lens. The lens is fixed in place by an M4 set screw; a press fit cap is included for extra security. The lens is positionally aligned with 2× M6 set screws and a manual rail adjustment.
	0.5” Lens	**Light Blue** cube designed to hold a standard 1/2” optical lens. The lens is fixed in place by an M4 set screw; a press fit cap for extra security. The lens is positionally aligned with 2× M6 set screws and a manual rail adjustment.
	Horizontal Mirror	**Purple** cube designed to fit a rectangular mirror. The mirror’s distance and alignment are determined by 3× heat pressed brass thread inserts, along with an M3 screw contacting magnets on the mirror plate.
	Vertical Mirror	**Purple** cube designed to fit a rectangular mirror. The mirror’s distance and alignment are determined by 3× heat pressed brass thread inserts, along with an M3 screw contacting magnets on the mirror plate.

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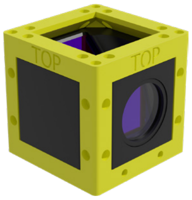
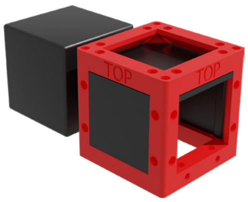
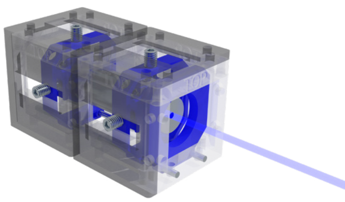
Image	Name	Description
	Dichroic	**Yellow** cube that holds a standard 1” dichroic mirror. It is sized for SM1 to hold standard 1” filters via press fit.
	Camera	**Red** cube that fits a standard size SM1 via a press fit and encloses the light path.
	Objective	**Pink** cube that holds a standard microscope objective. It is positioned along the z-axis of the xyz-stage.
	Light Source	White* cube pair that hold the light source and are adjustable similarly to the lenses; the system of 2× mounts facilitates positional alignment as well as tilt. Covers are included to enclose the light once aligned. ***Tip:** These cubes can be printed in the color corresponding with the laser they will hold.

Additional Elements

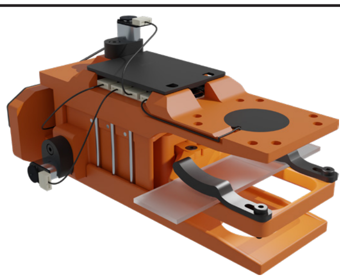
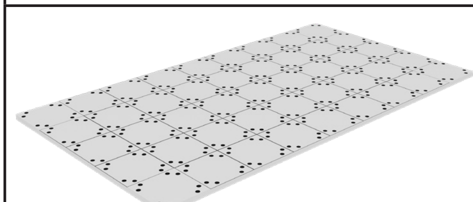
Image	Name	Description
	xyz-Stage	**Orange** housing contains consumer electronics from Pimoroni to create a functional, position control stage. Currently the encoders are unused, and other attachments for the stage are available.
	Gamepad	**Orange** gamepad controls the various functions of the xyz-Stage
	Baseplate	Lasercut acrylic plate holds magnets arranged along a grid to assist in cube alignment and to give some stability to their position.

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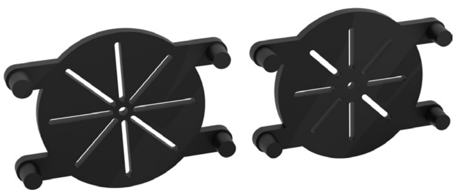
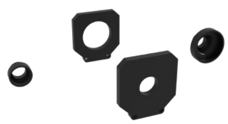
Image		Name	Description
		Accessories	Provide mounting points inside the cubes that are adjustable within plane.
		Targets	Attach to structural cubes and are used during alignment of the beam path.
		Filters	Adapters that hold either an SM1 or SM05 filter from Thorlabs.

Minimum Requirements

23× Shielded cubes
2× Support cubes
2× Horizontal mirror cube
1× Vertical mirror cube
1× Light source assembly
1× Dichroic cube
1× 0.5” cube containing an f30 lens
3× 1” cube containing an f200+ lens
2× Targets (at least one per type)
1× Objective cube
1× Camera cube
1× xyz-Stage

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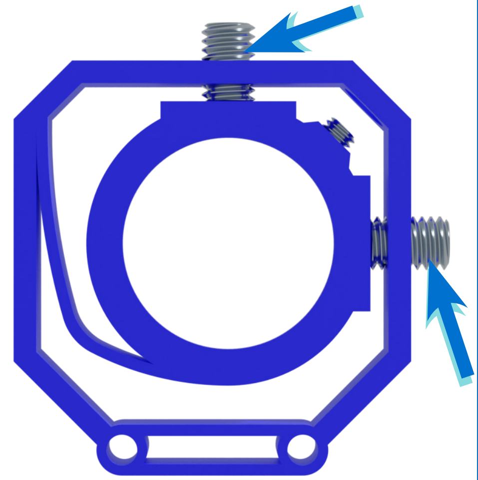
Excitation Beam Path

Laser Alignment

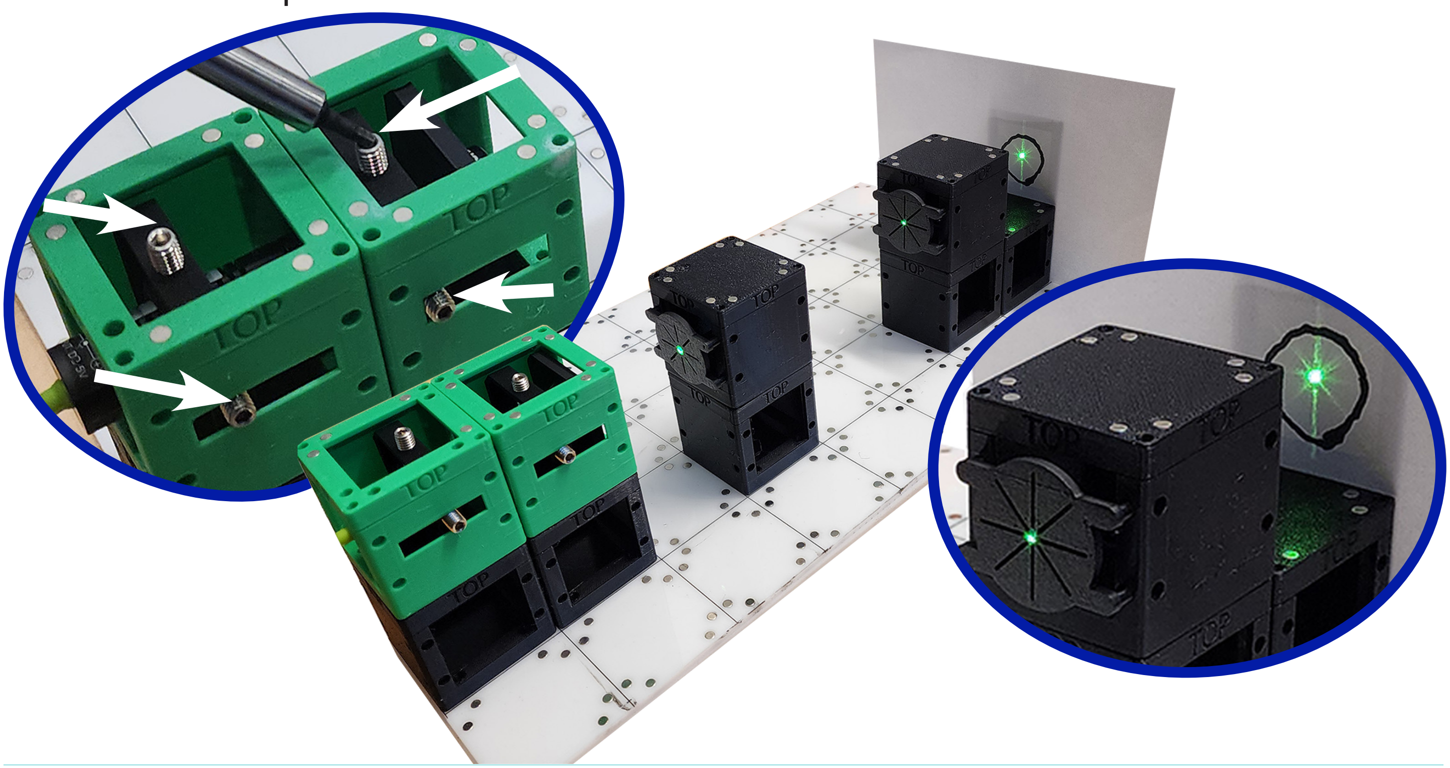


The set screws push the inner mount horizontally and vertically, allowing precise control of mount's movement. As a result, you can make small adjustments to center and tilt the laser so that the beam path passes through the center of both targets.

1. Place a laser source (green[1]) on top of two base cubes (black), and position it on the magnetic base plate. Remove the covers from the laser source and unscrew the four set screws enough to loosen them a little bit.
2. Place two targets in front of the laser (see image below), at least three cube lengths away from each other and one cube length away from the laser.
3. Set up a flat target such as paper on the other end of the targets, to see how the laser needs to be adjusted.

Recommendations

- Tap top of the laser source with your screwdriver after every adjustment to make sure the internal mount is seated correctly.
- The target positions can be swapped to confirm that the laser is aligned correctly.
- Slightly tilt the cubes to adjust their position, as the magnets don't set exactly into the same spot.



1 The light source cubes may be another color. Printing them in the color of the laser they contain is recommended when possible. However, in the case of changing the color of the laser within the cubes, it may be beneficial to use white cubes and indicate the laser color another way (e,g. the laser color with electrical tape on the cord).

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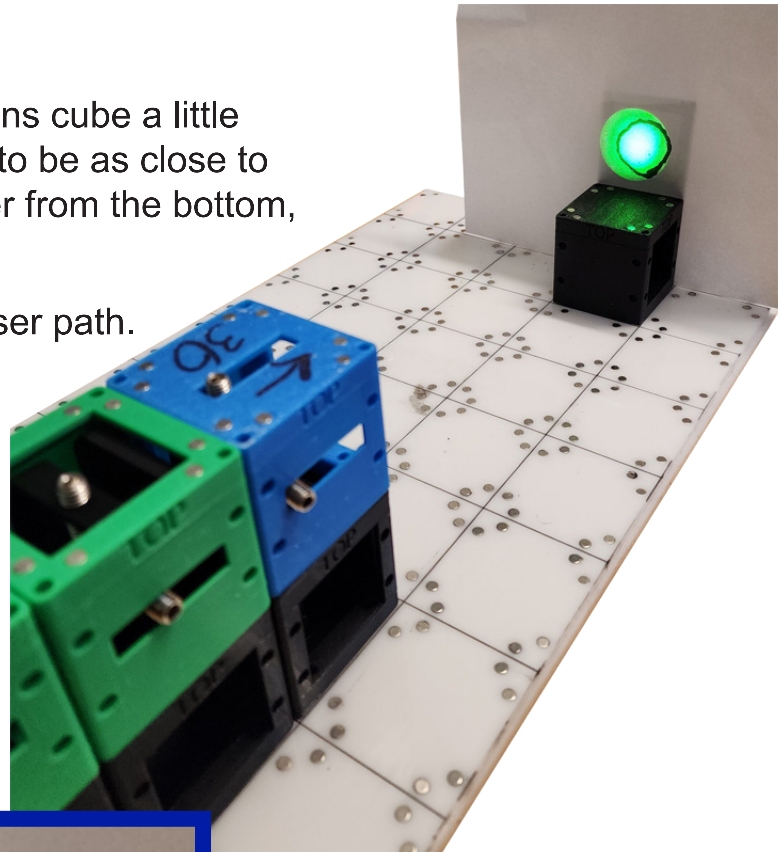
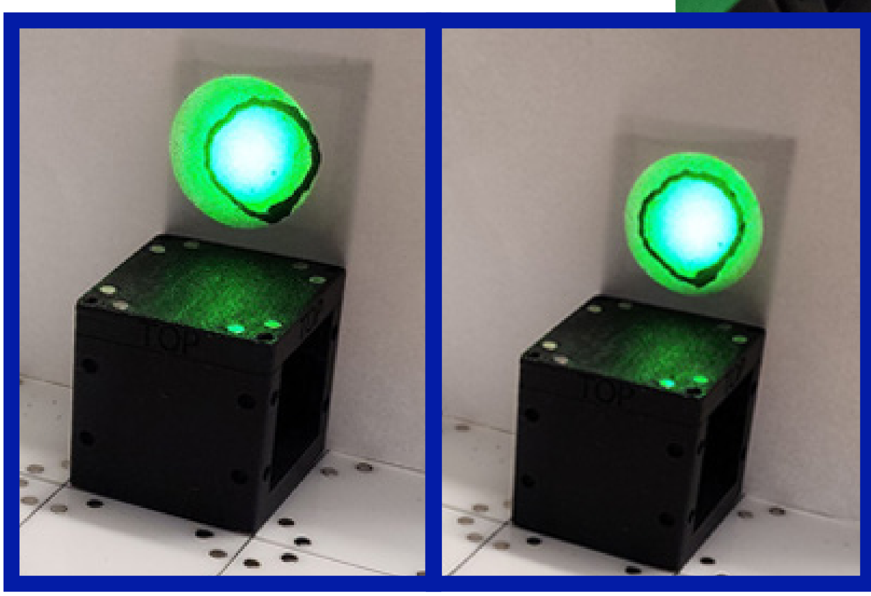
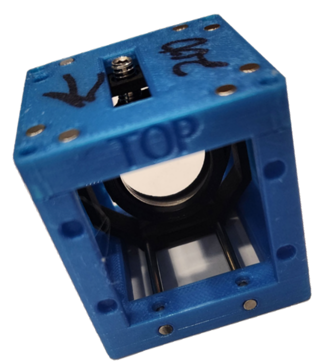
Beam Collimation

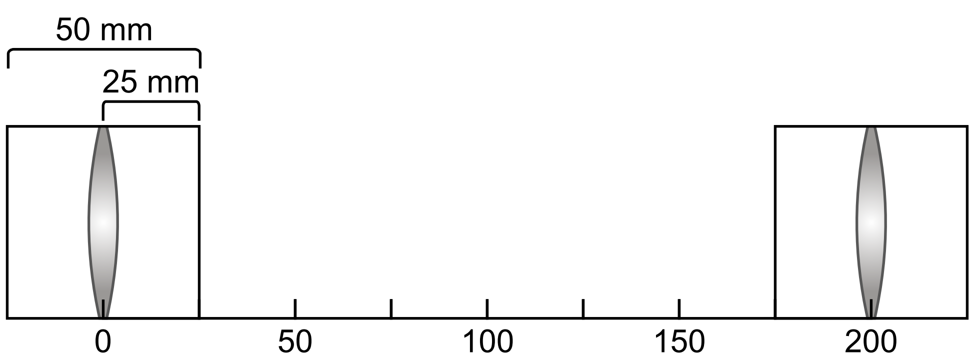


1. Loosen the set screws of an f30 lens cube a little bit. Slide the lens back on its rails to be as close to the laser as possible. This is easier from the bottom, while holding the cube.
2. Place an f30 lens directly in the laser path.
3. Use the set screws to center the lens as close as possible to the beam path. To determine whether the beam is centered, place a cube on the other side of the paper with light behind it to act as a target for centering the beam path.

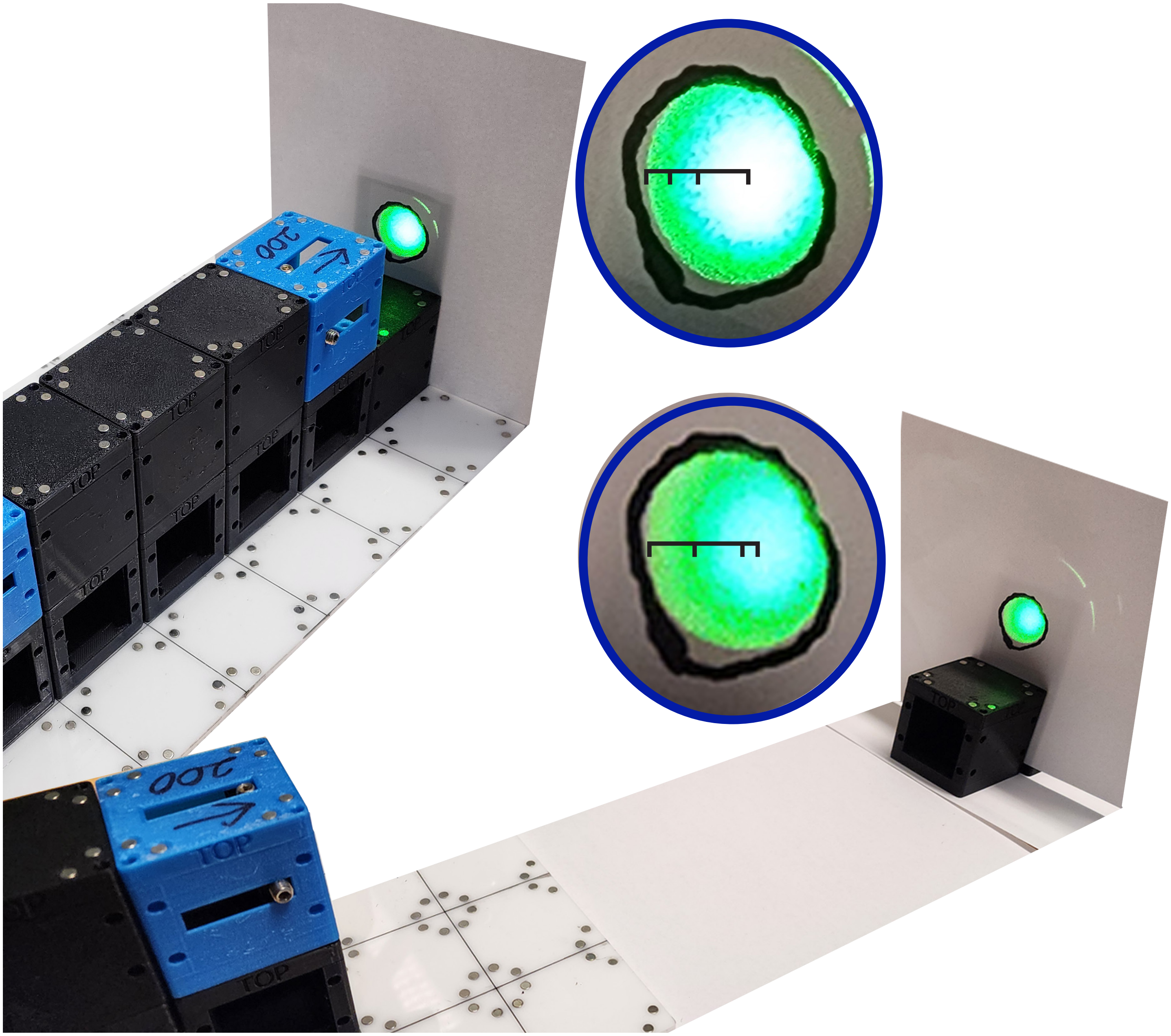


4. Place an f200 lens 200 mm away[1] from the f30 lens.





1 The sides of each cube measures 50 mm. Therefore the distance between the center of 2 adjacent cubes is 50 mm. To place a lens 200 mm away, one considers the 50 mm contributed by the 2 lens cubes and adds 150 mm or 3 cube lengths of distance.



5. Center the f200 lens using the same method used to center the f30 lens in (1–3).
6. Slide the f200 lens back and forth along the cube rails until it focuses the beam path on the target. The goal is for the emitted light waves to be aligned and parallel—*collimated*.

Note: You may have to adjust the f30 lens on its rails as well to get the best alignment.

7. Collimation of the beam path can be confirmed by moving a piece of paper closer to and further away from the beam path. The circle of collimated light striking the paper will not appear to shrink or grow as the target moves closer or further away from the lens.

Note: The alignment methods employed in this section are used frequently throughout the protocols in this manual.

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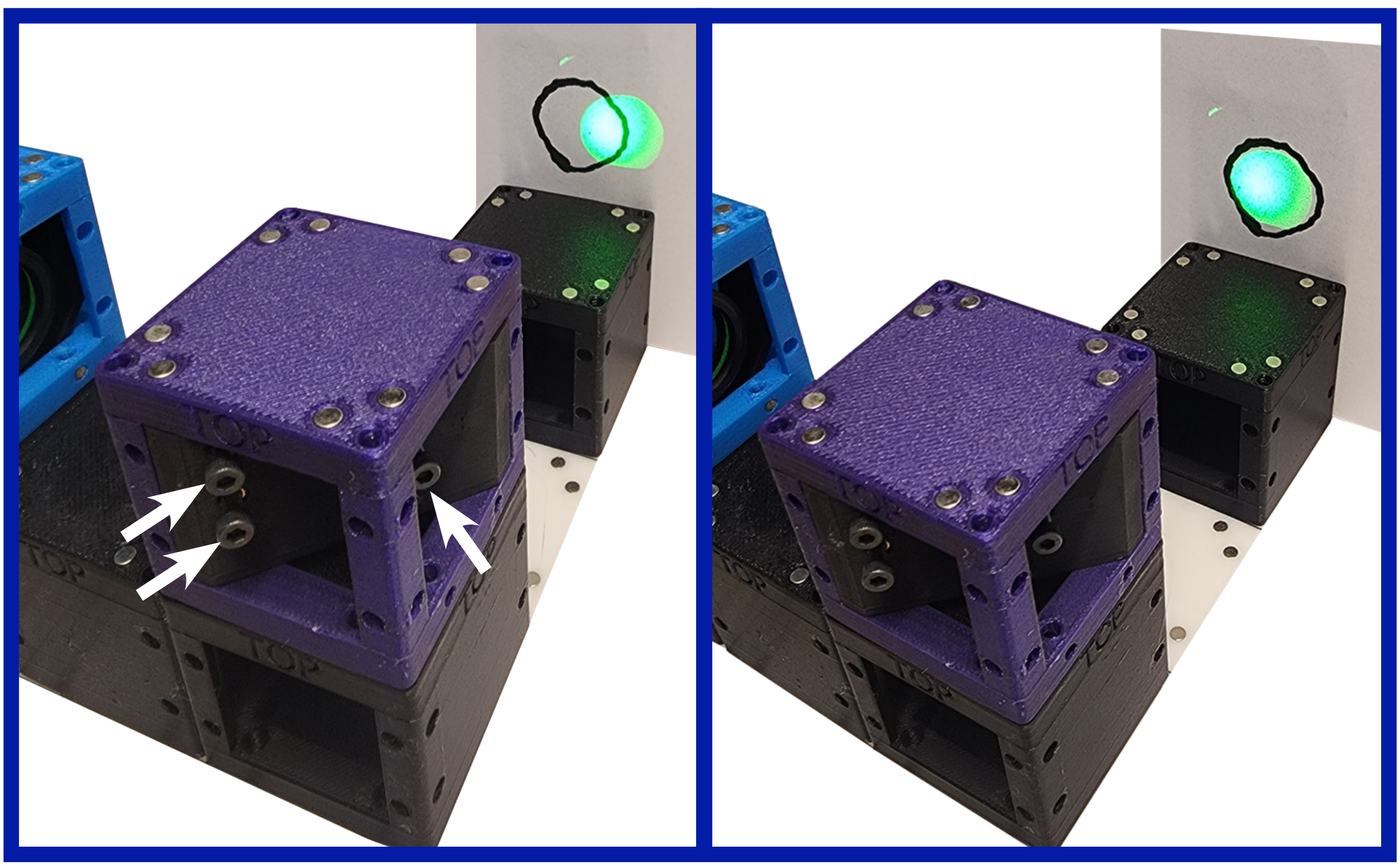
Mirror Alignment

Mirrors can be used to direct the beam. The CubeEd mirrors are orientated within the cube allow a 90° redirection, give or take with adjustments; i.e. the mirrror cubes enable the beam to travel around corners.
Horizontal mirrors can be used to direct the beam path 90° left or right. Vertical mirrors can be used to direct the beam path 90° up or down.

1. Adjust the mirror angle with the set screws to keep the beam path on the same plane.

Tip: Use the same paper method as that used in the *beam collimation* step 3 to ensure that the beam path stays straight.



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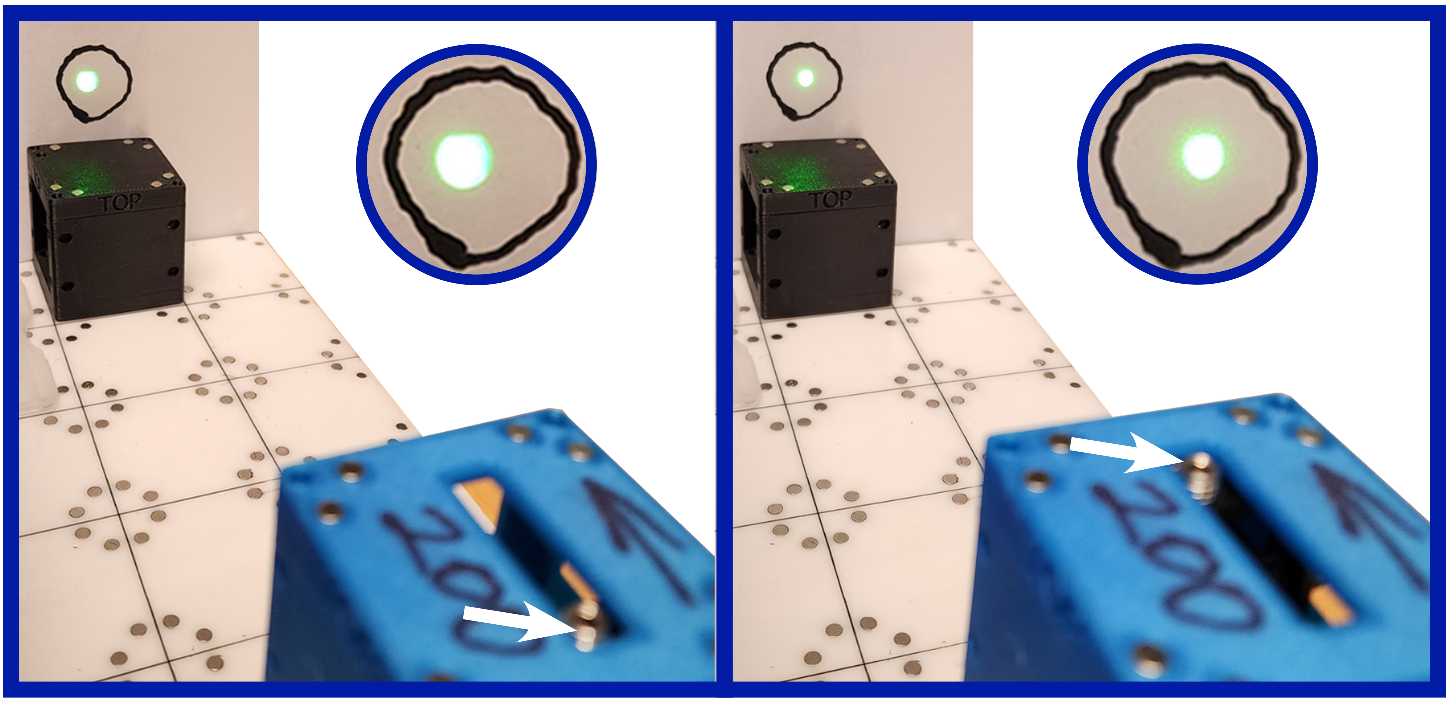
Excitation Tube Lens Use

1. Direct the beam path through an f200 lens; if necessary, center the lens by adjusting the set screws.
2. The alignment procedure is the same as the collimation.

Tip: Use the same alignment procedure as that used in the *beam collimation*.



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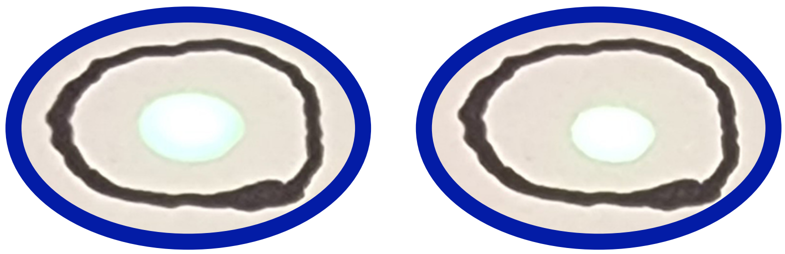
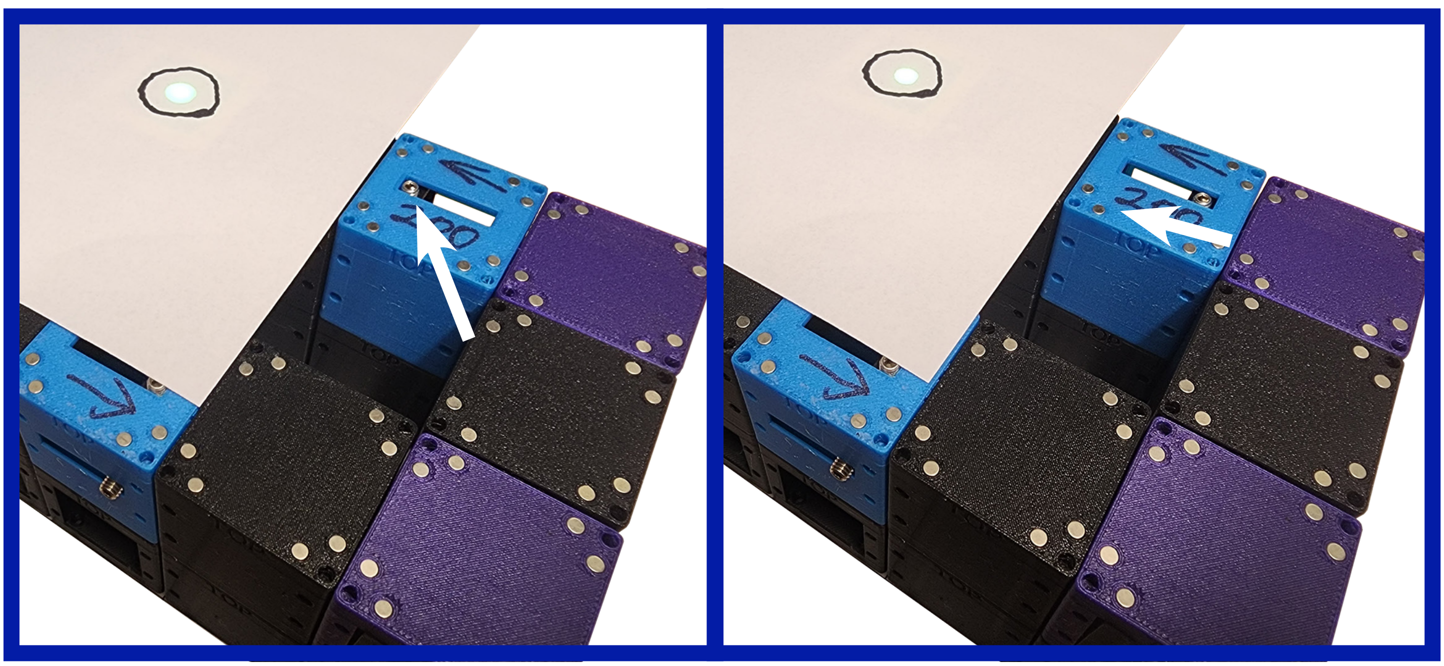
Dichroic Cube

1. Direct the beam path toward the dichroic cube; if necessary, adjust the mirror by adjusting the set screws.

> **Tip:** Use the same paper method as that used in the *beam collimation* step 3 to ensure that the beam path stays straight.

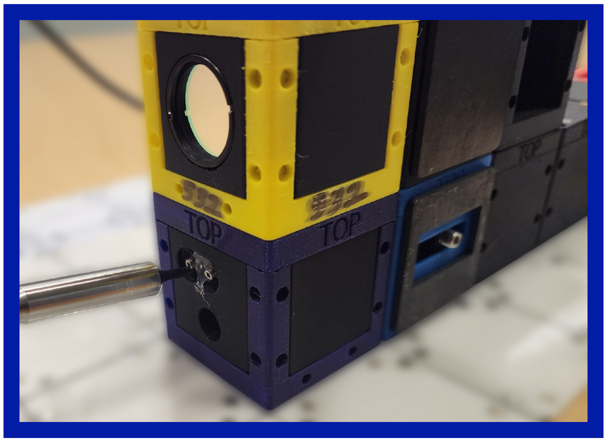




Think about it:
Why does adjusting the excitation cube lens changes the diameter of the beam path?

Emission Beam Path

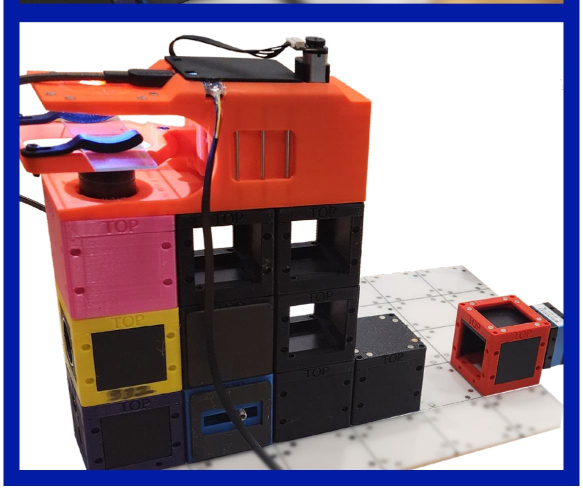
Note: The photos in this section were taken of a fully constructed CubEd. Add each optical component sequentially, checking the beam path as each element is added.



1. Let the beam pass through the filter cube and onto a vertical mirror. Adjust the mirror angle via its set screws to maintain a parallel beam path, directing the path forward.

2. Place a f200 lens in front of the beam. Center the lens using the set screws.
3. Confirm the alignment of the beam path as before.

Tip: Use the same alignment procedure as that used in the *beam collimation*.



4. Place the camera so the camera sensor is about 200 mm from the f200 lens.

Tip: Use the same paper method as that used in the *beam collimation* step 3 to ensure that the beam path stays straight.

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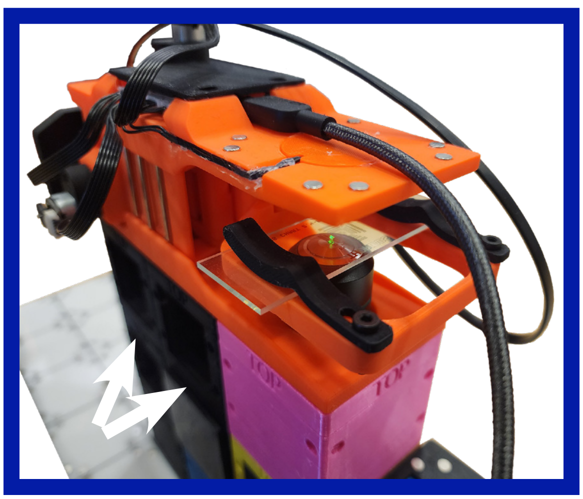
Objective Focusing

1. Focus the beam through the objective (pink) using the f200 lens: slide the lens along the rails to adjust the distance between the lens and objective until the beam path passes through the infinity corrected objective



2. Place the *xyz*-stage (orange) on top of the objective. If necessary, use support cubes to reinforce the structure.

3. Direct the beam through the appropriate set of filters and dichroic mirror, mounted in the filter cube (yellow), and up through the objective.

Controlling the Stage

Joystick – Controls the movement of the stage. Does not contribute to speed control. Push the joystick all the way in one direction at a time to move the stage. Movement of the x- and y-axes are controled in one mode, the z-axis is controlled in a second mode.

Start – Switches between the two joystick modes: x/y and z (z-mode only uses the vertical axis of the joystick). Hold for one second.

Select – Resets the stage to the “home” position: hold for one second.

Y	Motor Speed 27.5%
X	Motor Speed 62.5%
A	Motor Speed 100%
B	Toggle LED On/Off

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