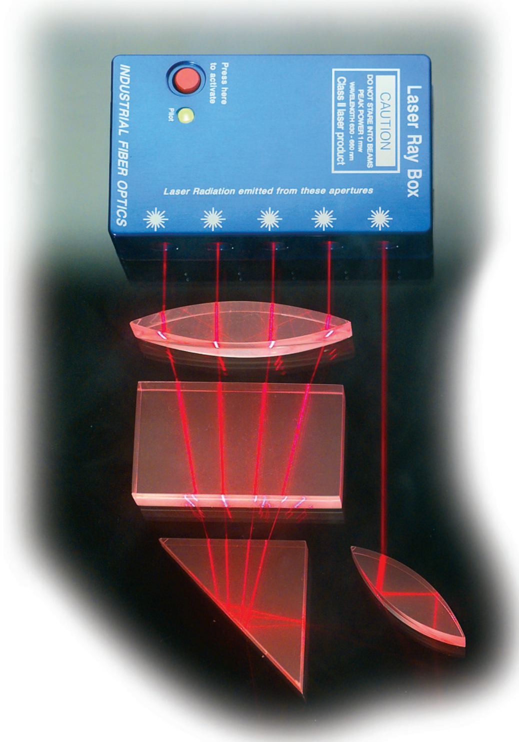
Laser Ray Box

Operator's Manual



Model Number:

IF-550

INDUSTRIAL FIBER OPTICS

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Printed in the United States of America

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INTRODUCTION

*This manual provides information about Industrial Fiber Optics' Laser Ray Box Model **IF-550**. It contains all the information needed to set up and operate this device safely and knowledgeably, even if you are a novice to laser technology. Please read the manual carefully before operating the laser.*

As soon as you receive the Laser Ray Box, inspect it and the shipping container for damage. If any damage is found, refer to the section of this manual titled Shipment Damage Claims.

*The next **very important step** is to charge the internal battery. Refer to page 10 for instructions. Do not attempt to operate the Laser Ray Box until the internal battery has been charged for at least 12 hours.*

*Industrial Fiber Optics makes every effort to incorporate state-of-the-art technology, highest quality, and dependability in its products. We constantly explore new ideas and products to best serve the rapidly expanding needs of industry and education. We encourage comments that you may have about our products, and we welcome the opportunity to discuss new ideas that may better serve your needs. For more information about our company and products refer to **www.i-fiberoptics.com** on the Worldwide Web.*

Thank you for selecting this Industrial Fiber Optics product. We hope it meets your expectations and provides many hours of productive activity.

Sincerely,

The Industrial Fiber Optics Team

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LASER CLASSIFICATIONS

All manufacturers of lasers used in the United States must conform to regulations administered by the Center for Devices and Radiological Health (CDRH), a branch of the U.S. Department of Health and Human Services. CDRH categorizes lasers as follows:

Class	Description
I	A laser or laser system that does not present a hazard to skin or eyes for any wavelength or exposure time. Exposure varies with wavelength. For ultraviolet, .2 to .4 μm exposure must be less than from .8 nW to .8 μW. Acceptable visible light exposure varies from .4 μW to 200 μW, and for near IR, the acceptable exposure is < 200 μW. Consult CDRH regulations for specific information.
II	Any visible laser with an output less than 1 mW of power. Warning label requirements — yellow caution label stating maximum output of 1 mW. Generally used as classroom lab lasers, supermarket scanners and laser pointers.
IIIa	Any visible laser with an output over 1 mW of power with a maximum output of 5 mW. Warning label requirements — red danger label stating maximum output of 5 mW. Also used as classroom lab lasers, in holography, laser pointers, leveling instruments, measuring devices and alignment equipment.
IIIb	Any laser with an output over 5 mW of power with a maximum output of 500 mW, and all invisible lasers with an output up to 400 mW. Warning label requirements — red danger label stating maximum output. These lasers also require a key switch for operation and a 3.5-second delay when the laser is turned on. Used in many of the same applications as the Class IIIa when more power is required.
IV	Any laser with an output over 500 mW of power. Warning label requirements — red danger label stating maximum output. These lasers are primarily used in industrial applications such as tooling, machining, cutting and welding. Most medical laser applications also require these high-powered lasers.

GENERAL

Discoveries in laser and photonics technology have created a booming industry worldwide, and in the United States in particular. In the last few years they have brought the world many technological advances and a standard of living inconceivable a hundred years ago. Lasers have affected our lives in many daily activities. Examples of this include the distinctive red bar code scanners that speed checkout at supermarkets; lasers in computer printers that provide quick, high-quality printouts; three-dimensional color holograms on credit cards that improve security. Many laser applications affect us indirectly but are just as important because they improve the quality of products we use or services we receive. Some examples include automobile manufacturing sheet metal cutters that reduce waste and increase production speed; laser based data communication carried over fiber optics that lowers the cost of long-distance telephone calls; surgical procedures that use lasers as a precision scalpel to reduce blood loss and trauma and promote quicker recovery.

From a historical perspective the creative ideas behind modern-day lasers could be said to have started with scientist Gordon Gould's handwritten notes in 1957. Theodore Maiman performed actual demonstration of the first working laser — a pulsed ruby laser — on May 16, 1960. Soon other scientists also demonstrated the ruby laser, and then began research on lasers that used different materials (such as gases) as their active lasing element. The most prominent gas laser that emerged was the helium neon, or "HeNe" laser, which many of you have used.

Much earlier, in 1907, researcher H. J. Round found that the semiconductor material silicon carbide produced light when subjected to an electrical field. Building on that discovery, by the 1950s many of the world's leading scientists were performing research involving semiconductor materials and the creation of the transistor. It is not surprising, with some of the brightest people in the world working in the laser and semiconductor fields, that somebody would create a laser from semiconductor materials. In the fall of 1962 several different companies succeeded in producing working semiconductor lasers. Although these devices had to be cooled to 77 degrees Kelvin and used very short high-current pulses to produce short bursts of light, they were indeed working lasers.

The success of early semiconductor lasers soon led to creation of the modern marvel known as the semiconductor laser diode. Diode lasers are smaller, more efficient, and superior in nearly every aspect to any other device when it comes to communications or data technology applications. These microchip systems are the smallest and most widely used lasers in the world. Industrial Fiber Optics utilizes aspects of that cutting edge laser technology along with miniature electronics in creating the Laser Ray Box. Without semiconductor diode technology the miniaturization of this versatile, high tech device could not have been achieved. Read on to learn more about the Laser Ray Box and how it combines two scientific disciplines to demonstrate the phenomenon known as *ray tracing through lenses*.

The Laser Ray Box is used in conjunction with the study of geometric optics. This is an important field of physics and the beginning of all basic optical studies. Geometric optics is the study and understanding of how light rays behave as they travel between different types of transparent media, or are reflected from mirrored surfaces.

The tools and understanding that scientists developed in the study of geometric optics have enabled the design of devices such as microscopes, magnifying glasses or telescopes that enlarge images or make objects appear closer.

The Laser Ray Box is a useful tool in the study of geometric optics. Using it and appropriate optical materials you can easily see how light rays bend due to curved optical surfaces. (See the section titled "Using the Laser Ray Box").

The unique characteristics and performance of lenses, prisms and other optical components can be determined using Geometric Optical methods. Parallel beams of visible light can be passed through the component being tested to observe what effect the component has on the direction of the beams.

Table 1. Common abbreviations used in this manual.

Abbr.	Long version	Numerical representation
mW	milliwatts	1×10^{-3} watts
µW	microwatts	1×10^{-6} watts
nW	nanowatts	1×10^{-9} watts
cm	centimeters	1×10^{-2} meters
mm	millimeters	1×10^{-3} meters
µm	micrometers	1×10^{-6} meters
nm	nanometers	1×10^{-9} meters

OPERATIONAL INFORMATION

Electrical and Optic Controls

The optical on/off controls for the Laser Ray Box are located on the top of the chassis as shown in **Figure 1**. The electrical jack for charging the internal battery and the LED charging indicator are on the side of the ray box chassis as shown in **Figure 2**.

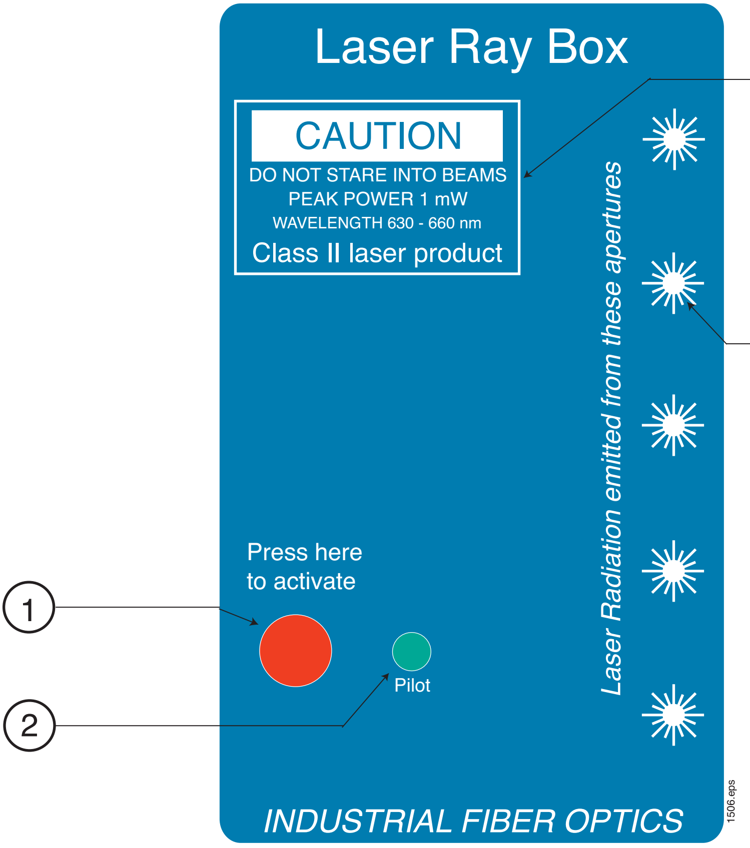

Figure 1. Top view of the Laser Ray Box.

1. Momentary ON/OFF Switch

The Momentary Switch is located on the top face of the Laser Ray Box enclosure. (Momentary means the switch button must be held down to maintain the electrical connection). The switch controls electrical power from the internal battery to the electrical circuitry that powers or activates the lasing elements. Pressing the switch button closes the electrical circuit and powers the lasing elements. The button is recessed from the surface of the enclosure to prevent it from being turned on unintentionally.

2. Pilot Light

Immediately to the right of the momentary switch is the pilot light that indicates the status of the internal laser elements. The pilot light is required by CDRH regulations, and illuminates whenever the Laser Ray Box is in the lasing mode. That occurs whenever electrical power is applied from the internal battery to the laser circuitry. The indicator light is a semiconductor light-emitting diode (LED) producing a green light when power is applied.

3. Warning Logo

This identification is a warning logo as required by the CDRH. See Laser Classifications within the section entitled "Laser Regulations" for more detail.

4. Aperture Indicators

All lasers are required to identify the location or aperture from which laser radiation is emitted. The 5 laser insignia engraved on the top side of the Laser Ray box indicate the apertures from which laser beams will emerge.

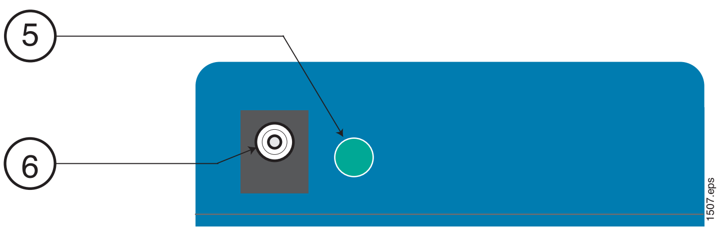

Figure 2. Side view of the Laser Ray Box.

5. Charging Indicator Light

The Laser Ray Box has a Charging Indicator located immediately to the right of the power jack. The indicator is a green LED similar to the laser Pilot Light. The LED illuminates when electrical power is applied to the Laser Ray Box to charge the battery.

6. Power Jack (PWR)

A standard 2.1 mm DC power input jack is used as an input connection to provide electrical power to charge the internal NiCd battery pack. This jack is the same as used on other Industrial Fiber Optic laser products.

Power input must be applied from a low-voltage DC power source in the range of 12 to 18 volts, as supplied with the Laser Ray Box. See Item 8 in this section for more information about the VAC-to-DC power adapter.

7. NiCd Battery (Internal)

The Laser Ray Box contains 3 Nickel Cadmium (NiCd) rechargeable cells connected in series as an internal battery. The battery provides power for the internal lasing elements, and the Laser Ray Box will not operate unless the battery is charged. When you first receive the Laser Ray Box, charge the NiCd battery for at least 12 hours prior to use.

NiCd batteries will self-discharge over a period of several months. If you have not used the Laser Ray Box for several months you may find that the internal battery is dead. Recharge the internal battery and you are back in business.

NiCd batteries can be recharged many hundreds of times, but do not have an unlimited life. Eventually the NiCd battery in the Laser Ray Box may fail to hold a charge. In this case, no matter how long you charge the battery pack, it will never furnish enough power to operate the internal lasing devices. See the "Service and Maintenance" section of this manual for details about battery replacement.

8. Power Adapter (not shown)

All Industrial Fiber Optics laser products sold in the United States are supplied with a power adapter suitable for 60 Hz 110 VAC-to-VDC conversion. All others are provided with 50 Hz, 220 VAC-to-VDC power adapters. It is strongly recommended that the power adapter furnished with the laser be the only supply used.

If you must use another power supply, it must be one with voltage output between 12 to 18 volts DC and minimum current capability of 50 milliamperes. Do not use a power supply or power adapter that generates voltage spikes exceeding 36 volts, or has an AC output.

9. Magnetic Back (not shown)

On the backside of the Laser Ray Box is a magnet. The magnet holds the Laser Ray Box to vertical magnetic surfaces for classroom demonstrations of optical lenses. Many classroom white boards are metal-backed surfaces that are magnetic, but not all. Generally speaking the more expensive white board surfaces are metal backed, and the inexpensive ones are not.

The Laser Ray Box can be used on flat horizontal surfaces where the magnetic material is not necessary.

Specifications

CAUTION: Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Table 3. Laser Ray Box specifications.

Parameter	Value	Units
OPERATING		
Input voltage	12 to 18	volts
Input current	35	milliamperes
Temperature	0 to 40	°C
OPTICAL		
Polarization	linear	
Wavelength	635	nm
Output Power (per beam)	1.0 maximum	mW
Beam diameter (at aperture)	1	mm
Beam divergence, half angle maximum	110	milliradians
STORAGE		
Dimensions	6.7 x 2.6 x 11.2	cm
Weight, chassis	.27	kg
Weight, power adapter	.26	kg
Temperature	-20 to 50	°C

Models and Laser Classifications

The Laser Ray Box part number IF-550 is classified as a Class II laser product.

Table 4. Laser BeamPowers for Laser Ray Box.

Laser Model	Classification	Min. power	Max. power	Units
IF-550	CLASS II	.6	1.0	mW

SAFETY

While lasers are valuable sources of light for exciting demonstrations, laboratory experiments and industrial use, one must treat lasers and high voltage power supplies with the utmost respect. One should never disassemble a product without proper training.

Optical

The lasing elements used in the Laser Ray Box addressed by this manual emit visible beams of red light. No infrared, ultra-violet, x-ray or other non-visible radiation is emitted. Common sense dictates that one should avoid direct skin and eye exposure to direct laser energy, and that from surface reflections.

This low-power laser cannot be used to burn, cut or drill. Even so, you should use caution, because the beams are concentrated. One of them could become focused to a pinpoint within the human eye. **Never look directly into a laser beam or stare at its bright reflections — just as you should avoid staring at the sun or other very bright light sources.**

Review the ***Rules for Laser Safety*** listed on the back cover of this booklet.

Electrical

Included with this laser is a VAC-to-VDC adapter for use with common VAC electrical power. The standard adapter shipped with all lasers is a UL-approved 110 VAC-VDC power adapter. Power adapters using a 220 VAC input and other electrical certifications are furnished upon request.

The Laser Ray Box is particularly safe because it operates at low wattage and current levels. However, as when using any electrical device, you must take certain safety precautions:

- Always plug the adapter into a grounded circuit.
- Do not touch (or short-circuit) the connection point on the 2.1 mm plug, as this could damage the power supply.
- Do not open the housing under any circumstances, as this will expose you to unshielded electrical connections, violating federal government regulations and voiding the product warranty.

LASER REGULATIONS

The U.S. Department of Health and Human Services regulates and classifies all laser products sold in the United States. Within this department is the Center for Devices and Radiological Health, which monitors and regulates laser products. The Laser Ray Box is registered and fully complies with laser performance standards established by the Center for Devices and Radiological Health (CDRH) under Federal Regulation, Title 21, parts 1040.10 and 1040.11, Code of Federal Regulations.

Specific labeling is required by federal regulations on all laser products. ***For your safety and that of others, do not remove any of the labels.***

Certification/Identification

Laser certification and identification labeling required by federal regulations have been combined in a single label located on the underside of the laser ray box. A graphic representation of that label is shown in **Figure 3**. It certifies that this laser complies with federal regulations, identifies the manufacturer, and lists the model number and date of manufacture.

Manufactured by:
INDUSTRIAL FIBER OPTICS, INC.
1725 West 1st Street
Tempe, AZ 85281-7622

Model Number:

Output Power:

Manufacturing Date:

Serial Number:

This LASER product complies with
C.D.R.H. Regulation 21 CFR 1040.10 and 10410.11

No User Serviceable Parts Inside

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Figure 3. Laser certification and identification label.

Classifications

The Laser Ray Box is classified as a Class II Laser product as defined by CDRH standards. It produces visible light where each beam is no more than 1 milliwatt of power. Each laser is marked or labeled to designate its classification. These laser classification labels are commonly known and specified as the "warning logotype" by CDRH regulations. The typical warning logotype label for a Class II laser is shown in **Figure 4**.

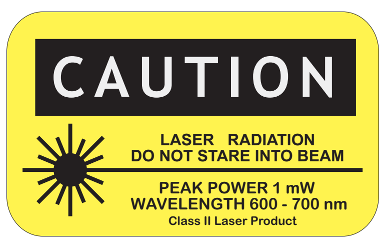

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Figure 4. Warning logotype label for Class II lasers.

Class II lasers may not exceed 1 milliwatt (1 mW) of visible radiation (light), and must contain a pilot light and a beam attenuator. By design, the Laser Ray Box deviates from the standard labeling suggestions by the CDRH. Rather than apply a label designating the laser classification, Industrial Fiber Optics chose to engrave the designation into the aluminum chassis. Compared to conventional labeling, the laser engraving is permanent and can never be removed. The location of the laser engraved laser classification label and an illustrative example is shown as Item 3 of **Figure 1**.

Aperture Symbols

Federal regulations also require that the laser emission apertures/ports be labeled. A typical graphic representation of that symbol is shown in **Figure 5**.

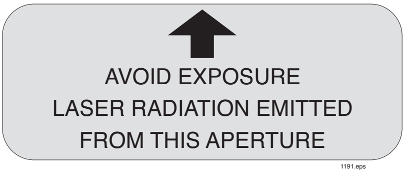

Figure 5. Beam aperture symbol.

The Laser Ray Box has a separate aperture symbol for each of the laser beams as shown in **Figure 1**. The symbols are along the edge of the enclosure face next to where the laser beams are emitted. They are permanently engraved like the classification label.

Beam Attenuator

Federal regulations suggest that a mechanical beam attenuator or blocker be part of all laser products. CDRH has allowed laser pointers to be sold without mechanical beams provided that they have **momentary** electrical switches. Industrial Fiber Optics has taken that same approach on the Laser Ray Box. Safety is further insured since each beam has 1 mW or less power as defined for a Class II laser product.

Additional References

For more information about lasers and laser standards, contact your local U.S. Department of Health and Human Services, or write to the agency's headquarters at 1390 Piccard Dr., Rockville, MD 20850.

For U.S. guidelines on laser classifications and health standards, refer to the American National Standards Institute (ANSI) specifications governing lasers and laser safety. The guidelines are published by the Laser Institute of America, 12424 Research Parkway, Suite 130, Orlando, FL 32826.

OPERATING PROCEDURES

The first thing to do after receiving and inspecting the Laser Ray Box is to charge the internal nickel cadmium (NiCd) battery. It is essential that the battery be charged for 12 to 14 hours at the first charging; otherwise it may never achieve its full energy capacity.

The Laser Ray Box has not been designed to operate with the power adapter. Its purpose is strictly to charge the internal battery. If the battery is not charged, the Laser Ray Box will not operate.

Charging the NiCd Battery

1. Plug the 110 VAC*-to-DC power adapter (provided with the laser) into an AC wall outlet.

2. Plug the cord from the power adapter into the power jack (PWR) located on the side of the Laser Ray Box as indicated in Figure 2. The Charging Indicator Light should illuminate, indicating that the internal battery pack is charging.

3. Allow the battery pack to charge a minimum of 12 hours before using the Laser Ray Box.

Important: If you must use a power adapter other than the one supplied with this laser, check the section entitled *Operational Information* in this manual to ensure the power adapter's voltage and current levels are within recommended specifications.

* 220 VAC for most customers outside of North America

Using the Laser Ray Box

The Laser Ray Box generates five individual light beams that bend or reflect as they interact with various optical materials. The beams can be directed at optical elements to demonstrate these effects. Using this method to observe how optical elements affect light is commonly known as light ray tracing. Demonstrations of light ray tracing can be done with a single lens, or with multiple lens configurations, depending upon what you are trying to illustrate. For beginning educational purposes we suggest that you start with a simple lens, then progress to the more advanced lens setups.

There are several sources for the special lenses that function with the Laser Ray Box. They are made from a variety of materials, but some work better than others. Lenses made of clear acrylic or polystyrene will serve, but those molded from special polymer materials work especially well. The polymer material scatters a portion of the laser light as it passes through the lens. This gives a more effective visual result when ray tracing with the Laser Ray box. Industrial Fiber Optics sells a set of lenses made with the special polymer material, the part number is IF-551.

Following are the steps we suggest for using the laser ray box to begin your studies of light ray tracing.

1. Review the laser safety steps on the back cover of this manual.
2. Position the Laser Ray Box on a horizontal or vertical surface as desired.
3. Check to make sure the laser beams are pointed in a safe direction.
4. Press and hold the momentary switch on the face of the laser ray box.
5. You should now see 5 parallel laser beams being emitted from the apertures on the side of the Laser Ray Box, as shown in the **Figure 6**. If you do not see 5 laser beams please see the section titled "Troubleshooting."

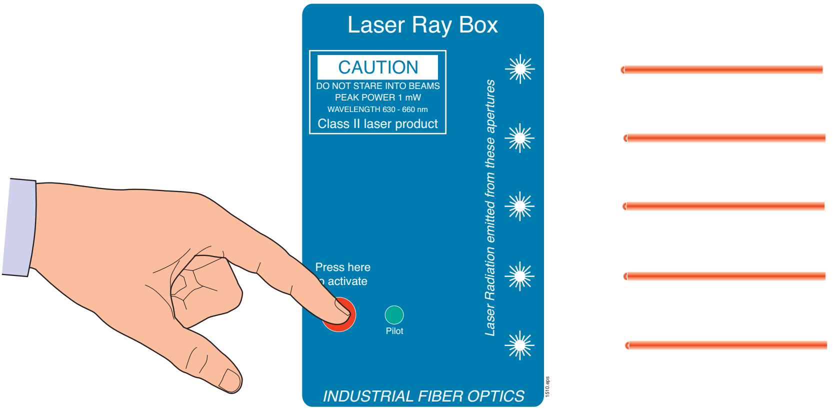

Figure 6. Laser Ray Box emitting 5 parallel light rays

6. The next step is to demonstrate light ray bending as the beams pass through an optical lens. Place a double convex lens within the 5 laser beam paths as shown in **Figure 7**.

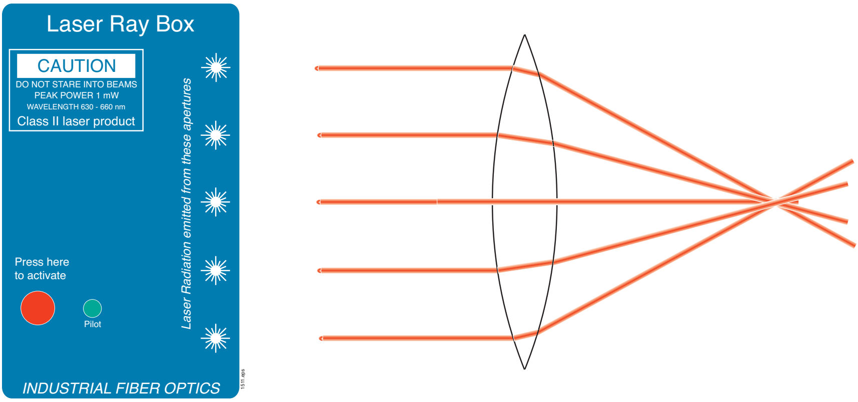

Figure 7. Laser Ray Box and a 100 mm focal length double convex lens, demonstrating the converging or focusing of light rays.

7. Observe the convergence of the 5 laser beams. The distance from the approximate center of the lens to the convergence point is the focal length of the lens. This focal point measurement is accurate only if the light rays entering the lens are exactly parallel to each other, as is the case with a Laser Ray Box.

8. Another important demonstration is the phenomena of *total internal reflection.* Set a right angle prism to intercept two or more light beams as you hold down the momentary switch, as shown in **Figure 8**. You should now see a pattern as depicted. The reflection of the beams from the interior surface of an optical material illustrates a basic but very important principle. Total internal reflection is what allows light to be "transported" inside fiber optic cables used in communication networks.

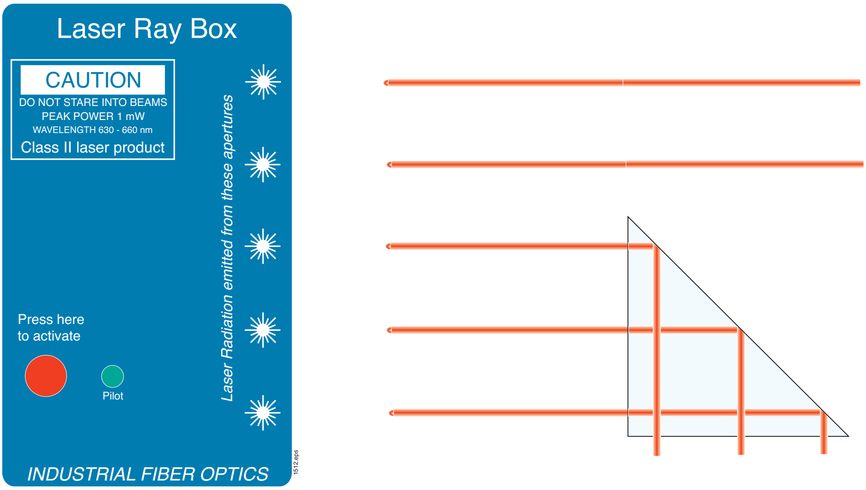

Figure 8. Laser Ray Box with a right angle prism demonstrating the reflection of light rays from the interior prism surface.

The brief activities above are a fraction of what you can perform using the optical elements from the IF-551 Ray Optics Kit. The number of experiments, light ray analysis and fascinating visual effects you can produce is as endless as your imagination.

TROUBLESHOOTING

Dim Laser Beam Output

- Internal battery needs charging.
- Battery needs replacing.
- Laser Ray Box is over 40 degrees C.

No Laser Beam Output

- Make certain the momentary switch on top of the Laser Ray Box chassis is *completely depressed*.
- If the Pilot Light does not illuminate when the momentary switch is pressed, charge the battery pack for a minimum of 12 hours. If the pilot light still does not illuminate, then the internal battery must be replaced.
- If after a complete charge the pilot light is dim and the lasers do not emit light, then the internal battery must be replaced. See the "Service and Maintenance" section of this manual for details.

No Charging Indication

- Check to see if the 110 (or 220) VAC-to-VDC power adapter is plugged into the laser and an appropriate wall outlet or extension cord.
- Is there power to the wall outlet?
- The power adapter is damaged or inadequate.
- Wrong power adapter. If Industrial Fiber Optics did not supply the power adapter check the electrical requirements on page 7.

Laser Beams are not parallel or level

- The Laser Ray Box has been subject to excessive shock or has been dropped. Send the Laser Ray Box to the Industrial Fiber Optics factory for re-alignment.

SERVICE AND MAINTENANCE

After several years of continued use the NiCd battery within the Laser Ray Box may require replacement. The indication that the battery needs to be replaced is that the Laser Ray Box operates only a short time between charges. It is highly recommended that you do not replace the battery yourself, but send the Laser Ray Box back to the factory for service. Cost of replacing the battery is a flat fee of $45.00 (for USA only), including return freight.

For battery replacement or other Laser Ray Box repair, please do the following:

- In writing, describe the problem, person to contact, phone number, and return address.
- Carefully pack the Laser Ray Box, power adapter, manual, and written description of the problem in a stout box with sufficient packing material to prevent damage in shipment.
- Ship the package to:

Industrial Fiber Optics
1725 West 1st Street
Tempe, AZ 85281-7622
USA

WARRANTY

Industrial Fiber Optics' Laser Ray Box is warranted against defects in materials and workmanship for 1 year. The warranty will be voided if the laser components have been damaged or mishandled by the buyer, including entry to the laser housing and/or removal of screws.

Industrial Fiber Optics' warranty liability is limited to repair or replacement of any defective unit at the company's facilities, and does not include attendant or consequential damages. Repair or replacement may be made only after failure analysis at the factory. Authorized warranty repairs are made at no charge, and are guaranteed for the balance of the original warranty.

Industrial Fiber Optics will pay the return freight and insurance charges for warranty repair within the continental United States by United Parcel Service or Parcel Post. The customer must pay for any other delivery means.

The customer must pay the costs of return shipments for lasers no longer under warranty. If an item is not under warranty, repairs will not be undertaken until the customer has approved the cost of such repairs in writing. Typical repair costs range from $50 - $150 and repairs usually take two to three weeks to complete.

When returning items for analysis and possible repair, please do the following:

- In a letter, describe the problem, person to contact, phone number, and return address.
- Pack the Laser Ray Box, power adapter, manual, and letter carefully in a strong box with adequate packing material, to prevent damage in shipment.
- Ship the package to:

INDUSTRIAL FIBER OPTICS
1725 WEST 1ST STREET
TEMPE, AZ 85281-7622
USA

SHIPMENT DAMAGE CLAIMS

If damage to an Industrial Fiber Optics product should occur during shipping, it is imperative that it be reported immediately, both to the carrier and the distributor or salesperson from whom the item was purchased. DO NOT CONTACT INDUSTRIAL FIBER OPTICS.

Time is of the essence because damage claims submitted more than five days after delivery may not be honored. If shipping damage has occurred during shipment, please do the following:

- Make a note of the carrier company; the name of the carrier employee; the date and the time of the delivery.
- Keep all packing material.
- In writing, describe the nature of damage to the product.
- In cases of severe damage, do not attempt to use the product (including attaching it to a power source).
- Notify the carrier immediately of any damaged product.
- Notify the distributor from whom the purchase was made.

Rules for Laser Safety

- Lasers produce a very intense beam of light. Treat them with respect. Most educational lasers have an output of less than 3 milliwatts, and will not harm the skin.
- Never look into the laser aperture while the laser is turned on! **PERMANENT EYE DAMAGE COULD RESULT.**
- Never stare into the oncoming beam. Never use magnifiers (such as binoculars or telescopes) to look at the beam as it travels – or when it strikes a surface.
- Never point a laser at anyone's eyes or face, no matter how far away they are.
- When using a laser in the classroom or laboratory, always use a beam stop, or project the beam to areas, which people won't enter or pass through.
- Never leave a laser unattended while it is turned on – and always unplug it when it's not actually being used.
- Remove all shiny objects from the area in which you will be working. This includes rings, watches, metal bands, tools, and glass. Reflections from the beam can be nearly as intense as the beam itself.
- Never disassemble or try to adjust the laser's internal components. Electric shock could result.