

# Enhancements and Faculty Tools for Course 2: *Laser Systems and Applications*

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## **Enhancements and Faculty Tools for OP-TEC Course 2** *Laser Systems and Applications*

### **Background:**

OP-TEC Course 2, *Laser Systems and Applications*, was completed in 2014. College faculty teaching photonics technicians used this text in 2014-2016 and provided suggestions for revisions. Course 2 has been updated and the second edition is now available. In addition to printed books, the revised version is available as an eTextbook.

### **Enhancements:**

To support the use of *Laser Systems and Applications* OP-TEC staff have prepared the following enhancements for students and faculty:

- Complete indexes, located at the end of each module.
- An “Acronym Glossary”, located in the back of the text.
- Lab videos, showing setup, operation, safety precautions and some measurements.
- Copies of all the figures used in the modules. A PDF version and a Power Point version are available.
- Student Assignment Videos: A listing of videos that will further explain the content or demonstrate an application for each of the first nine modules.
- Student Assignment Questions for use with each video.

Lab Videos can be accessed at <http://optecvideo.opteccrm.org/laser-systems-and-applications/lab-videos/>

Figures and images used in the modules can be downloaded without cost by placing an order on the OP-TEC store website at:

<https://www.optecstore.org/products/figures-images-for-instructors-course-2-laser-systems-and-applications/>

Indexes and the Acronym Glossary are provided in Course 2 *Laser Systems and Applications*.

### **Student Assignment Videos:**

The following videos and articles can be accessed from the Internet. Some reinforce the material presented modules 2-1(temporal laser modes) and 2-2 (laser output characteristics). Some may be selected for use in module 2-3 *Laser Types and Applications*. Others explain important features that describe specific lasers and their applications in modules 2-4 through 2-8.

It recommended that these videos be used as student out-of-class assignments. Questions are provided for faculty to pose, or assign with the videos.

### **Module 2-1 Laser Q-Switching, Mode Locking and Frequency Doubling**

- Video Name: How LASERs work!
  - URL Address: <https://www.youtube.com/watch?v=1LmcUaWuYao>
  - Assignment Questions
    1. What does it mean for an electron to be “excited”?
    2. What is the difference between stimulated emission and spontaneous emission?
    3. What component is responsible for optical pumping?
    4. What does optical pumping do?
    5. What is population inversion?
- Video Name: Diode Pumped Solid State Laser
  - URL Address: <https://www.youtube.com/watch?v=0k-4fCdpv94>
  - Assignment Questions
    1. Is the laser wavelength visible? How are invisible laser beams viewed?
    2. What are the safety precautions when you build such a laser?
    3. Which laser is used to align each component of the diode pumped solid state laser?
    4. How is a laser used to align each component?
- Article Name: Q-Switching
  - URL address: [https://www.rp-photonics.com/q\\_switching.html](https://www.rp-photonics.com/q_switching.html)
  - Assignment Questions
    1. What is a Q Switch?
    2. What is the difference between active and passive Q-switching?
    3. What are some of the technical issues involved in Q-switching?
    4. Where in the laser cavity do you find a Q-switch?

### **Module 2-2 Laser Output Characteristics**

- Video Name: Characteristic Properties of Laser – Coherence - Physics
  - URL address: <https://www.youtube.com/watch?v=bWTxf5dSUBE>
  - Assignment Questions
    1. What does it mean for the light waves to have a phase relation? What is it called?
    2. Why is temporal coherence important to a laser?
- Video Name: Characteristic Properties of Laser – Monochromaticity - Physics
  - URL address: <https://www.youtube.com/watch?v=y-JCF3K9ntc>
  - Assignment Questions
    1. What is a common example of a monochromatic light source?
    2. What does it mean for light to be monochromatic?
    3. What is the bandwidth of a laser, in nanometers?
    4. What benefit does a small bandwidth provide for lasers?

- Video Name: Fundamentals of Laser Measurement & Beam Profiling
  - URL address: <https://www.youtube.com/watch?v=VeTccw0Cyao>
  - Assignment Questions
    1. A power or energy sensor can measure average or instantaneous power output in \_\_\_\_\_.
    2. A beam profiler measures and displays the spatial distribution of the power intensity \_\_\_\_\_.
    3. Historical methods of measuring a laser beams include \_\_\_\_\_.
    4. Electro-mechanical methods to profile your beam include \_\_\_\_\_.
    5. Scanning slit technology works well for both \_\_\_\_\_ lasers.
    6. A scanning slit beam profiler will access a laser beam profile up to \_\_\_\_\_ times/second.
    7. Why is a sample of the beam “split off” from the original beam to be measured?
    8. In two of the industry scenarios, how was the beam restored to Gaussian?
    9. What was used to change the thin file joining laser’s beam profile to be used efficiently?

### **Module 2-3 Laser Types and Their Applications**

- Video Name: Construction and Working of Helium - Neon Laser
  - URL address: <https://www.youtube.com/watch?v=RyY4PEpV2RQ>
  - Assignment Questions
    1. What is the function of the perfectly reflecting mirror in a Helium-Neon Laser?
    2. What is the function of the discharge tube in a Helium-Neon Laser?
    3. What is the function of the power supply in a Helium-Neon Laser?
    4. What is the function of the partially reflecting mirror in a Helium-Neon Laser?
- Video Name: Explanation of Working of Helium Neon Laser
  - URL address: <https://www.youtube.com/watch?v=VexLofD89K0>
  - Assignment Questions
    1. Describe how He atoms are pumped in a Helium-Neon Laser.
    2. What is meant by population inversion and why is it important?
    3. What are the three transitions that must occur for lasing?
    4. The video shows an output wavelength of 6328 Angstroms. Convert 6328 Angstroms to nm. Be sure to show your work.
- Video Name: Laser Applications
  - URL address: <https://www.youtube.com/watch?v=BA5W7CXbDno>
  - Assignment Questions
    1. When was the laser developed?
    2. What is a MASER?
    3. What are shock experiments and how are lasers used in them?
    4. Why are lasers effective in weapons testing?
    5. How are lasers being used to make jet engines more effective?
- Video Name: Laser Tattoo Removal
  - URL address: <https://www.youtube.com/watch?v=7BgEzOTCV0k>
  - Assignment Questions
    1. Why are there six different laser frequencies used in tattoo removal?

2. Why are multiple laser procedures required for tattoo removal?
3. Explain what happens to tattoo ink when a laser is used for removal.
4. How does tattoo ink depth effect laser tattoo removal?

#### **Module 2-4 Carbon Dioxide Lasers and Their Applications**

- Video Name: Carbon Dioxide Lasers Information
  - URL address: [http://www.globalspec.com/learnmore/optical\\_components\\_optics/lasers/carbon\\_dioxide\\_lasers](http://www.globalspec.com/learnmore/optical_components_optics/lasers/carbon_dioxide_lasers)
  - Assignment Questions
    1. List and define the three components found in all lasers.
    2. Describe what happens when electrical current is introduced to the carbon dioxide laser gain medium.
    3. How are carbon dioxide lasers commonly used?
    4. How is the output wavelength of a carbon dioxide laser adjusted?
- Video Name: Construction of carbon dioxide (CO<sub>2</sub>) laser
  - URL address: [https://www.youtube.com/watch?v=ioE1X\\_Wiyjc](https://www.youtube.com/watch?v=ioE1X_Wiyjc)
  - Assignment Questions
    1. Describe the carbon dioxide laser symmetric stretching vibration mode.
    2. Describe the carbon dioxide laser asymmetric stretching vibration mode.
    3. Describe the carbon dioxide laser bending mode.
    4. As a result of vibrational modes, how is the carbon dioxide molecule characterized?
    5. What is a carbon dioxide discharge tube filled with?
    6. How is a carbon dioxide laser different from a HeNe laser?

#### **Module 2-5 Fiber Lasers and Their Applications**

- Video Name: 500W Fiber Laser
  - URL address: <https://www.youtube.com/watch?v=ac3LYj3T14I>
  - Assignment Questions
    1. Why would an automatic search edge function be important for an industrial cutting laser?
    2. Research fiber lasers and list three beneficial characteristics when compared to other laser types.
- Video Name: Coupling a LASER into a single mode fiber
  - URL address: <https://www.youtube.com/watch?v=kQvhbJbDG0M>
  - Assignment Questions
    1. Describe a coupler and how is it used when coupling a laser into a single mode fiber.
    2. Why are two adjustable mirrors used to couple a single mode fiber?
    3. What is a back propagating laser and how it is used for single mode fiber laser coupling?
    4. Describe “walking the beam” with reference to single mode fiber laser coupling.
- Video Name: How a Fiber Laser Works
  - URL address: <https://www.youtube.com/watch?v=ofEqFlqkiS0>
  - Assignment Questions
    1. What is meant by the numerical aperture of a fiber?
    2. What is the difference between a single mode fiber and a multimode fiber?

3. Which element is the most common element used for the fiber laser? Its pump wavelength and lasing wavelength?
4. How a fiber Bragg grating is used to build a monolithic fiber laser?
5. Why a double clad fiber geometry can provide a higher output power but maintain the same laser beam quality?

### **Module 2-6 Diode Lasers and Their Applications**

- Video Name: Laser Diodes - How it Works
  - URL address: [https://www.youtube.com/watch?v=Dk\\_CbGJI41U](https://www.youtube.com/watch?v=Dk_CbGJI41U)
  - Assignment Questions
    1. Compare a Semiconductor Laser with a conventional laser.
    2. List the common semiconductor materials used in diode lasers.
    3. What is electrical pumping?
    4. What is a Bragg Reflector?

### **Module 2-7 Argon-Ion Lasers and Their Applications**

- Video Name: High Power Argon Laser
  - URL address: <https://ocw.mit.edu/resources/res-6-006-video-demonstrations-in-lasers-and-optics-spring-2008/demonstrations-in-laser-fundamentals/high-power-argon-laser/>
  - Assignment Questions
    1. Why is one side of the tube is terminated with a Brewster angle?
    2. How are different laser wavelengths separated in an Ar ion laser?
    3. What is the output laser power from the Ar ion laser?
    4. What are the possible wavelengths of the Ar-ion laser?
    5. What is the color of the laser light from the Ar ion laser before it is separated into different colors?

### **Module 2-8 Nd:YAG Lasers and Their Applications**

- Video Name: Laser Hair Removal with NdYAG 1064nm Laser, Skin Type IV VI
  - URL address: <https://www.youtube.com/watch?v=DSNcBVjdGu0>
  - Assignment Questions
    1. What is the best wavelength and pulse length combination to use for hair removal on people with dark skin and/or fair skin people with coarse dark hair? Why?
    2. What pulse duration is best for people with thicker hair and why?
    3. Why are cooling attachments used on hair removal lasers?
- Video Name: Nd YAG-Laser Animation
  - URL address: <https://www.youtube.com/watch?v=aRLPlmMWbUw>
  - Assignment Questions
    1. Where is the laser light generated in a Nd:YAG laser?
    2. What is the lamp function in a Nd:YAG laser?
    3. What is the reflector function in a Nd:YAG laser?
    4. Describe why one Nd:YAG laser mirror is semi-permeable and the other is not.