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Custom built laser instrumentation laboratories for physics and chemistry courses

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Undergraduate students are typically introduced to advanced optical instrumentation during their senior physics and chemistry courses. Experiments available from educational companies typically use low end optics in customized formats, beneficial for younger students eager to explore the physical and chemical phenomena under study. However, these setups prevent senior students from learning more advanced optical techniques increasingly desired by employers, such as experience with laser beam alignment, laser beam quality and divergence, the function of real (imperfect) optics, and limitations of photodetectors. Therefore, senior students would benefit from experience with the same professional equipment used in advanced research and development laboratories.

Consequently, we have developed three laboratory modules that provide students with the opportunity to build their own advanced instrumentation, allowing them to learn laser-based instrumental procedures while simultaneously determining the function of advanced optical components. In one experiment, students build a laser interferometer with which they study the temperature dependency of the refractive index of solutions. In a second module, students develop their own laser-beam profiler. In a third experiment, students develop their own laser-based polarimeter to measure polarization scattering and optical rotation by incorporating Stokes-based measurements.

The experiments consist of standard laboratory optics and optomechanics, more expensive than the low-cost versions of these instruments, but less expensive than the instruments sold by educational companies. Further, these parts are of high quality, and by choosing standard optics, compatibility issues are nonexistent. Optical components can be easily re-combined to produce alternative arrangements, allowing senior students to perform novel proof of principle optical techniques in literature. As a result, students gain understanding, confidence, and excitement for science, as well as practical experience by assembling, operating, and troubleshooting their devices. Furthermore, because students use the same equipment found in professional optics labs, they are more prepared for the workplaces of tomorrow.

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