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Instrumentation laboratories are a key component of science and engineering education. These experiences provide familiarity with research tools and strengthen the link between theory and application. Optical trapping technology can be used at both the undergraduate and graduate level to reinforce classroom instruction and provide hands on experience with advanced biophysical methods. We have designed and produced five optical traps for biological engineering teaching laboratories. Our home built, open optical, inverted design provides significant flexibility for modification and experimental variety, while maintaining refined functionality at low cost using primarily commercially available parts.

The economical instrument costs less than $12,000 to construct, yet is not limited in functionality. Major advantages of this design are a quadrant photo diode for position detection and automated stage movement, allowing for calibration using all three primary methods, roll-off frequency, variance, and drag force. This design demonstrates nearly 6nm position resolution, and can produce a trap with a stiffness of 0.07 pN/nm. An integrated 532nm diode laser extends applications to a multitude of fluorescence based experiments.

Core laboratory modules have been organized and implemented in a student laboratory to address understanding basic operation of the optical tweezers, calibration of the position detection system, and characterization of the trap stiffness using all available methods. Additional experimental modules are being developed including measurements of E.coli flagellar rotation, DNA tether stretching, and kinesin and myosin motility.

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