General remarks

A. Words that are underlined refer to objects that may be new to you.

   The majority of optical components in your kits are sold by either Thorlabs (`https://www.thorlabs.com/`) or Edmund Optics (`https://www.edmundoptics.com/`). Using the part number listed on a component or its box, you can find its description and specifications on the manufacturer's website. Anytime that you are not sure what something is, use this process to learn what the component is called, and more importantly, what it does.

   If you are still not sure how to use something even after looking at the manufacturer websites, ask a teaching assistant for help.

B. Most optics components are made of glass and should be handled with care. Wear gloves, and grip them on the periphery (not on the face). Do not drop them.

C. Words that are in *italics* are optics concepts that may be new to you. Learn about them from the textbook or other online resources, and ask questions during lectures or office hours if you want to learn more.

Description

In this lab you will learn how to use some basic components from your optics kits. You will use all of these components in the graded labs (Labs 1-4). So if you become comfortable with them now, you can work quickly and efficiently during the future labs.

These components will be assembled on a platform called an optical breadboard. The breadboard has an array of threaded holes, spaced on a 1" x 1" grid.

1: Camera

A camera consists of an array of pixels, each of which measures the total amount of optical energy deposited on it during the exposure time. You can therefore use a camera to measure the overall "brightness" of a light source, or you can use it to record the spatial pattern of brightness (i.e., an image).

Task 1.1 Familiarize yourself with the camera: connect it to the computer, and fix it to the optical breadboard stably. To mount it on the breadboard, you will need to use posts, post holders and clamps.

Task 1.2 Practice acquiring images from the camera on the computer using Python. You can use the program `acquire_image.py` program that is provided on Quercus, and you are welcome to modify it as appropriate to make it more useful for your measurements. The acquired images can be easily converted into Python arrays, so that you can process them further using Python.

Task 1.3 Learn how to attach lenses and/or neutral density filters directly to the front of the camera using a lens tube, so that you can take sharp images that are not over-exposed or saturated.

2: Laser

A laser is a light source that has a property called *coherence* (you will learn more about it in the lectures). For the purposes of the lab, notice that the light from the laser also happens to be *collimated*, which means that the beam propagates for a long distance without significantly spreading apart.

Task 2.1 Without turning it on, mount the laser to the optical breadboard using posts, post holders and clamps. Make sure the laser does not wobble or move.

Task 2.2 Hold a small square of paper or card in front of the laser, turn it on, and observe the beam emerging from the laser on the card.[1]

Task 2.3 Move the card and observe how well the laser stays collimated over a long distance.

When you are done with the laser for the moment, or if you need to work on something else, make sure that the output beam from the laser is blocked with a card so that the beam does not shoot across the lab in an uncontrolled manner.

3: Mirrors

Your optics kits have a selection of mirrors and mirror mounts. You will learn to set these up so you can control the laser beam path over the breadboard.

Task 3.1 Carefully – holding it with a gloved hand and gripping only the edge – remove a mirror from its box and mount it in a mirror mount. Attach the mirror mount to a post and post holder, and then clamp it onto the breadboard.

Task 3.2 Set up two mirrors to channel the light from the laser into the camera: the beam from the laser should bounce off the first mirror, then the second, before entering the camera. You will find this easier if you arrange for the reflections from the mirrors to be approximately 90 degrees for each of them.

You can rotate the knobs on the mirrors to change the angles of reflection of the laser, and adjust where it goes.

You can use the lines of holes as a visual guide to keep laser beams propagating rectilinearly.

[1] NEVER PUT YOUR EYES IN THE PATH OF THE LASER BEAM.
Any failure to control the path of your laser beam which results in it getting close to your eyes, or someone else's eyes, will immediately and automatically earn you an 'F' grade in this course.

Task 3.3 When the laser beam appears on the camera, use the Python program to record an image of the laser. Observe the shape of the laser beam. You may need to use a combination of neutral density filters to reduce the amount of light reaching the camera, to record an image that is not over-exposed.

4: Photodiode

A photodiode is a pn-junction diode that absorbs energy from incident light to produce electrical current. You can use a photodiode to measure light intensity. Unlike a camera, a photodiode is only one sensor, so you cannot gain information about the spatial distribution of the light intensity. However, photodiodes usually have a larger bandwidth, so can respond faster than a camera.

Task 4.1 Familiarize yourself with the photodiode: unscrew the metal cap and insert the battery in the correct orientation, connect the photodiode to a voltage measuring device using a BNC cable, and fix the photodiode to the optical breadboard stably. To mount it on the breadboard, you will need to use posts, post holders and clamps.

Task 4.2 Check the specifications for the photodiode on the Thorlabs website. Photodiodes have a range of wavelengths of incident light they can detect, depending on the material in the semiconductor sensor. They also have a saturation intensity – the output voltage cannot go above a certain limit. Take note of the saturation voltage.

Task 4.3 Measure light using the photodiode. Turn the photodiode on. See if light from your phone can be measured using the photodiode, and try measuring the intensity of the laser with the photodiode. Is the photodiode output saturating? Use a combination of ND filters to reduce the incident light so that the photodiode is not saturating.

Lab Reports

In future labs, you will be required to submit an **individual lab report** for each lab. As you go through this practice Lab 0, develop plans for

a) how you will record your measurements

b) how you will sketch or record optical beam paths (eg, using diagrams, or photos with your phone, etc.)

c) how you will transfer images from the camera to your own devices for further processing or inclusion in the reports (eg, email, or USB sticks, etc.)

Figure out these steps now, so that you can work quickly and efficiently in future labs.