**Conclusion**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Exp. |  |  |  |  |  |
| A | 12 | 12 | 4% | 0% | YES |
| B | -15 | -15 | 33% | 0% | YES |
| - | - | - | - | - | - |
| - |  |  | - | - | - |
| C | 2 | 1.95 | 2% | 3% | NO |

**Experiment A:**

The equivalent focal length of two combined lenses, one with focal length 20cm and the other with focal length 30cm, was found to be 12cm with a 4% uncertainty. The percent difference from the theoretical value of 12cm is 0%, which is within the margin of error. The experiment required great precision to be taken, ensuring that the two laser beams were parallel with each other and with the principal axis of the lenses. Because of the small diameter of the lenses, it was difficult to position the lasers close enough together without having interference from the surrounding apparatus. The experiment could be improved by using a beam splitter with a single laser.

**Experiment B:**

The focal length of the diverging lens was found to be -15cm with a 33% uncertainty. The uncertainty was obtained by error propagation and is surprisingly high at first glance. With closer observation, however, the high value makes sense when comparing the ratio of absolute error (0.5cm) to the distance between the virtual object and final image (2.5cm). The percent difference from the theoretical value of -15cm is 0%, which is within the margin of error. The experiment could be improved by using different lenses and/or repositioning the apparatus such that the distance between the virtual object and final image is increased. This could be achieved by simply moving the diverging lens closer to the converging lens, making -10cm instead of -5cm.

**Experiment C:**

The magnification of the beam expander was experimentally found to be 1.95 with a 2% uncertainty. The percent difference from the theoretical value of 2 is 3%, which is not within the margin of error. While diameters and were measured with a very accurate tool, it was difficult to properly measure the final expanded beam. Also, with the small magnitude of magnification, the ratio of absolute error to measured value is high. The experiment could be improved by using an iris with a larger diameter, or by using different lenses and/or repositioning the apparatus to produce a larger final beam, thus reducing the error to measured value ratio.