

## Setting up the Cenco Student Spectrometer

These directions, adapted from the manufacturer's instructions, explain the setup and alignment of the *Cenco Student Spectrometer* used in the Phys 152 experiment "Diffraction Gratings and the Hydrogen Spectrum". Numbers refer to the pictures at the end of these directions. The process is time consuming, taking about 20 to 30 minutes per spectrometer (*i.e.*, about three hours to set up 6 spectrometers). The spectrometers must also be checked before each lab section begins. I print these instructions single-sided and unstapled to make it easier to see the figures and instructions at the same time. *Note that Spectrometer A is annotated, corresponding with Figure 1.*

### Initial setup: **THE ROOM LIGHTS CAN BE LEFT ON UNTIL THE LAST SECTION**

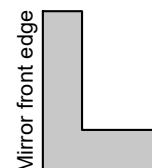
1. Check the following settings and adjust each to its center position relative to its movement: telescope horizontal alignment (13), telescope fine adjustment (15), vernier adjustment (24) and collimator horizontal alignment (27). (See *Figure 2*; other settings are similar)
2. Remove the grating from the stage and loosen the telescope locking screw (17). Move the telescope (8) so that it is in-line with the collimator (3) by looking through the eyepiece and aligning the vertical cross hair with the image of the slit (room light is sufficient). Tighten screw (17). If needed, loosen the vernier clamping screw (25) and rotate the verniers so that they are aligned at 3:00 and 9:00 as shown in *Figure 3*. Tighten (25) and the divided circle clamping screw (30).

### Focusing the eyepiece:

3. The diopter compensation collar (11) is used to make the image of the eyepiece reticle clear. Move the eyepiece all the way back by rotating the collar, then move it forward until the image of the reticle can be seen. Finally, move the eyepiece backward again slowly to achieve focus.

### Focusing the telescope:

4. Insert the blue plastic eyepiece plug into the socket on the rotating mount. Then insert the transformer's blue plastic output plug into the socket on the base (*Figure 4*). Plug the magnifying glass into the transformer, plug the transformer in and turn the switch on. Make sure the bulb in the magnifying glass works properly (replace bulbs as needed; spares are in a small wood box on instructor's bench).
5. Adjust the telescope axis using screws 12 and 13 until it appears to be level and pointing across the center of the stage (these adjustments should be fine so just check it and move on). *Note: Don't use a bubble level to check the stage; the tables are not level, so this doesn't save any time!*
6. Place the alignment mirror (18) on the stage and arrange it so that the mirror surface *on the front edge* is centered on the stage, and parallel to one of the scribed radial lines on the stage. Loosen the clamping screw (23) and adjust the angular position of the stage so that the mirror's reflecting surface faces the telescope objective and is perpendicular to the telescope's axis. Tighten (23).
7. Adjust the stage leveling screws (6) to make the telescope and its reflected image line up when viewed from just *above* the eyepiece (again, this should be fine so just check it and move on.)
8. Look through the eyepiece. A bright green patch will be visible at the bottom of the field of view. A small bright green cross should be visible in the field of view (if not, then tilt the mirror to find it, and adjust the stage level to bring it into the field of view). If needed, release the eyepiece clamping screw (9) and move the eyepiece unit back to focus the telescope on the green cross. Align the image of the green cross with the vertical crosshair in the middle of the reticle by rotating the stage (loosen/tighten (23)), and fine-adjust the focus until no parallax is seen between the reticle crosshairs and the sharply focused cross. Clamp the eyepiece unit in place.



**Making the telescope axis perpendicular to the axle:**

9. Adjust the telescope leveling screw (12) to make the reflected cross accurately coincide with the upper horizontal crosshair.
10. Loosen the vernier clamping screw (25) then rotate the vernier and the mirror on the stage together by  $180^\circ$  until the bright green cross is again centered in the reticle. The image of the cross will now be a little above or below the upper crosshair – or maybe not. Regardless, continue with the next step; the green cross will appear in the next step.
11. Adjust the stages' three leveling screws (6) to reduce the displacement of the cross with respect to the upper horizontal cross hair by one half.
12. Eliminate the remaining vertical displacement by using the telescope's leveling screw (12).
13. Repeat steps 10 through 12 until the displacement is eliminated completely in both orientations of the stage. Return the stage & mirror to their starting position and tighten the vernier clamping screw (25).

**Making the crosshairs vertical and horizontal:**

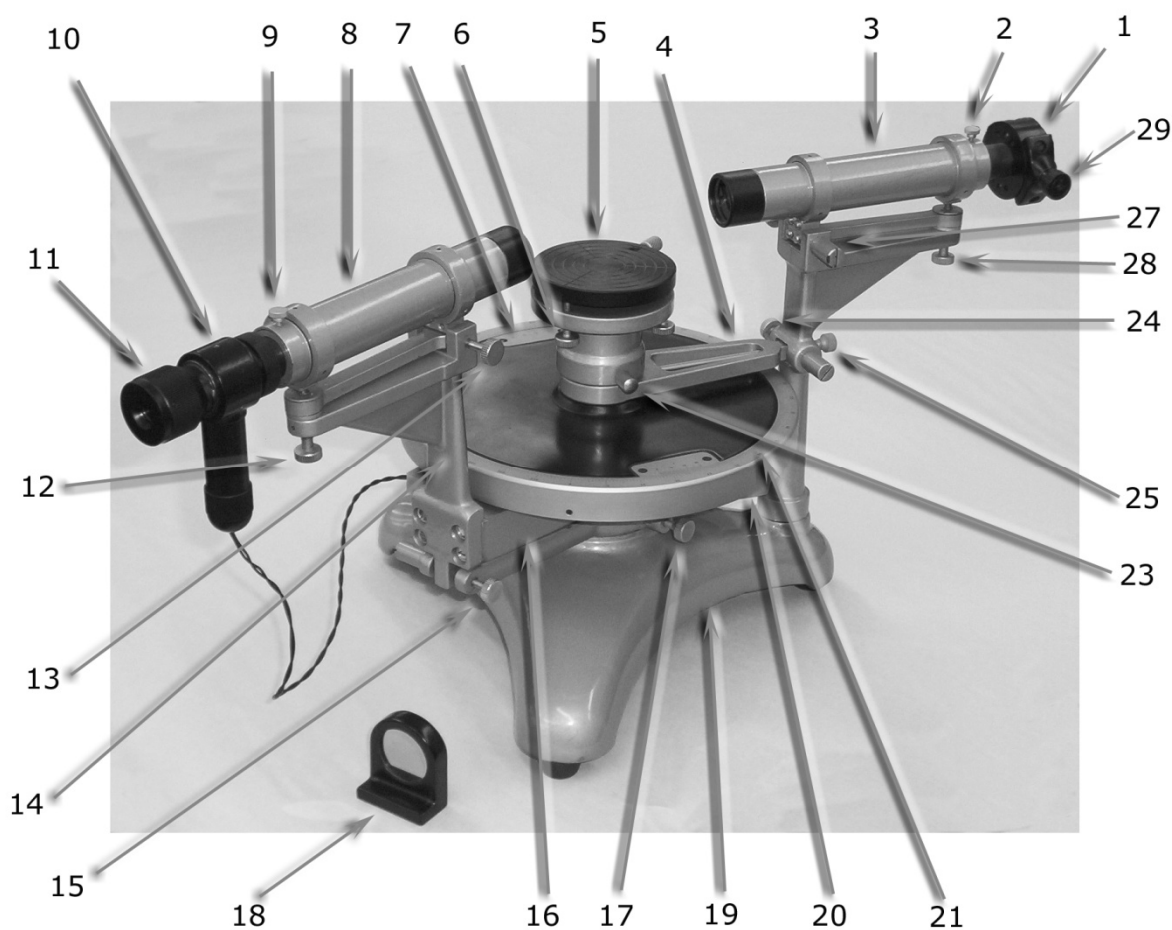
14. Loosen the stage clamping screw (23) and rotate the stage and mirror together by a small amount with respect to the telescope. Observe whether the motion of the bright cross is horizontal or not.
15. If the movement of the bright cross is not parallel to the horizontal crosshair of the reticle, loosen screw (9) and rotate the eyepiece in its tube to correct it, taking care not to disturb the focus. Re-clamp the eyepiece with screw (9) and the stage with (23).

**Focusing the collimator:**

16. *Leave the alignment mirror in place!* Turn on the Hydrogen lamp and place it in front of the collimator to illuminate the slit. The zeroth order image will be observed.
17. Make sure that the vernier clamping screw (25) is tight. Use the collimator horizontal alignment screw (27) to align the collimator axis accurately with the telescope. While looking through the eyepiece, adjust the vernier knob (24) and the collimator's leveling screw (28) so that the image of the slit is positioned in the center of the field of view.
18. If needed, release the slit unit clamp screw (2) and move the slit back and forth until the slit forms a sharp image in the reticle plane of the telescope.
19. To make the collimator's axis perpendicular to the axle, re-adjust the collimator leveling screw (28) so that the slit image is symmetrical about the center of the field of view.
20. Align the collimator slit with the vertical crosshair of the reticle by rotating the slit unit in its tube, taking care not to disturb the collimator's focus. Finally, clamp the slit unit with the clamp screw (2).

**Insert the diffraction grating: *TURN THE LIGHTS OFF FOR THIS SECTION***

21. Remove the alignment mirror from the stage, and replace with the grating in its stand, ***WITH THE GRATING (LABEL) SIDE FACING THE COLLIMATOR, NOT THE TELESCOPE.*** Align the grating so that the green cross appears on the vertical crosshair, as viewed through the eyepiece. *You may need to tilt the grating back and forth to find the cross; note that it may be faint and blurry compared to its appearance with the alignment mirror.* Note that some fine adjustment on the stage level may need to be performed.
22. Loosen the telescope locking screw (17), swing the scope left and right, making sure the spectral lines are visible and not filled with garbage lines. Replace the H-tube as needed.



**Figure 1 – Components of the spectrometer (right side)**

- |  |  |
|--|--|
| 1. Slit Unit                             | 16. Telescope Locking Arm                                      |
| 2. Slit Unit Clamp Screw                 | 17. Telescope Locking Screw                                    |
| 3. Collimator Unit                       | 18. Alignment Mirror   |
| 4. Vernier Locking Arm                   | 19. Base   |
| 5. Stage                                 | 20. Rotating Telescope Mount                                   |
| 6. Stage Leveling Screws (3)             | 21. Divided Circle   |
| 7. Vernier (Double-Ended)                | 22. Illuminated Magnifier ( <i>Not Shown</i> )                 |
| 8. Telescope Unit                        | 23. Stage Clamping Screw                                       |
| 9. Eyepiece Clamping Screw               | 24. Vernier Adjustment Knob                                    |
| 10. Abbé Self-Collimating Eyepiece       | 25. Vernier Clamping Screw                                     |
| 11. Diopter Compensation Collar          | 26. Collimator Support Pillar                                  |
| 12. Telescope Leveling Screw             | 27. Collimator Horizontal Alignment Screw ( <i>left side</i> ) |
| 13. Telescope Horizontal Alignment Screw | 28. Collimator Leveling Screw                                  |
| 14. Telescope Support Pillar             | 29. Slit Width Adjustment Screw                                |
| 15. Telescope Fine Adjustment Knob       | 30. Divided Circle Clamping Screw ( <i>on left side</i> )      |

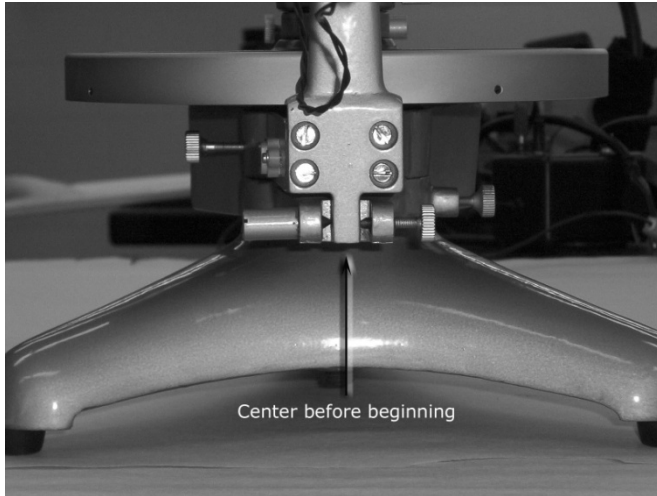


Figure 2 – The telescope support pillar is centered using (15); other settings should be centered as well before beginning

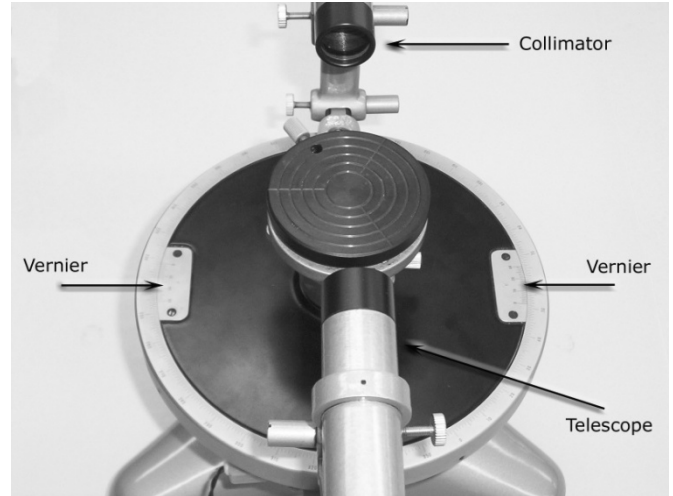


Figure 3 – Align the telescope with collimator, adjust verniers as shown

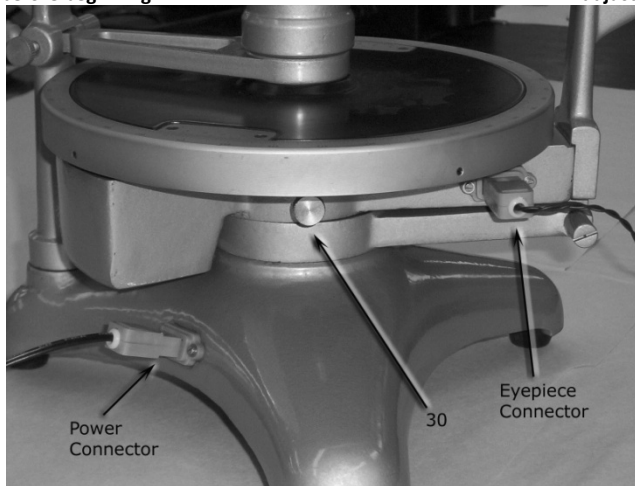


Figure 4 – The power and eyepiece connectors attach on the left side of the spectrometer



Figure 5 – Adjustments on the *right* side of the collimator



Figure 6 – Adjustments on the *left* side of the collimator