## Assignment #6: Extracting Data from Images using ImageJ

Due on April 7, 2025. This is a hard two week assignment that requires about 6 hours. It is hard because it includes calculations. A foolish thing you might do is to not start a problem until after you already are you sure you know how to do *everything*. Instead, just do the next step as best as you can, and see what happens!

You are expected to use "ImageJ" to start these problems, but then use Excel to perform additional calculations. You may not use Mathematica. You must submit a *professionally formatted* paper copy of your answers to all the questions below. In the ideal case, this document is only one side of one sheet, and contains all the answers to all the questions with units and context. You must also submit an electronic copy of your Excel work to the Google drive. Your Excel work must also be professionally formatted... don't just stick unlabeled cells or calculations anywhere you feel like it. Each problem must be on its own tab, and must include a region with a clear results summary.

**1.** Use the online pdf for this assignment to view the second page of this assignment at "high" magnification. Then use a screen shot (e.g., the "snipping tool") to *create* and *save* the image of **the wooden roof truss** shown on the next page. Open it in ImageJ. Knowing that  $L_{AE} = 12.2$  ft, determine  $L_{AB}$ ,  $L_{BC}$ ,  $L_{CD}$ ,  $L_{DE}$ , and  $L_{EF}$ .

**2. For the (bluish) isometric drawing** on the next page, the length along the back of the base is L = 12 cm. Since drawn lines have thickness, make all measurements from the center of each line. Determine: the total height *H*, the total width *W*, the diameter  $D_H$  of the holes (i.e., one result for all four holes), the radius of the large rounded channel  $R_s$ , the radius of each of the 4 rounded fillets (i.e., one result for  $R_A$  through  $R_D$ ), and the width  $W_s$  and height  $H_s$  of the front face (colored purple). When measuring curves, make sure that you recall which angle(s) must be used on isometric drawings!

**3. For the star map "stars.bmp"** on the course homepage: threshold this image (but don't "apply" the threshold) using threshold levels of 80 and 255. You should see right away that your choices for threshold levels are the primary factor affecting your results. Choosing these levels is a very difficult task for real scientists. Use an "inverted" *y* scale (i.e., make *y* increase from bottom to top). Areas are in pixels, and "intensity" is an 8-bit gray scale number (0 to 255). Don't worry about recording units for any of these questions.



- a. How many stars are present when these threshold levels are used?
- b. Find the "brightness" [(area)  $\times$  (average intensity)], x position, and y position of the brightest star.
- c. Find the brightness, x position, and y position of one of the two identical dimmest stars.
- d. For the brightest star, determine the FWHM (in pixels). This is the "diameter" of the star. See page 3 for tips about measuring this.
- e. For the entire image, create a histogram. Determine the magnitude of the brightest individual pixel (i.e., a number from 0 to 255), and the total number of perfectly black pixels (i.e., brightness zero).

**4. For the image "purple.jpg"** on the course homepage, split the image into 3 separate channels (Red, Blue, Green). For each channel, determine the best-fit cubic equation (i.e., with linest) describing each color (e.g., find the numbers *a*, *b*, *c*, and *d* for  $I_{red}(x) = a + bx + cx^2 + dx^3$ , and then again for  $I_{blue}$  and  $I_{green}$ ) where "x" is obviously the horizontal position in pixels.

**5. For the image "plot.bmp"** on the course homepage (and below), use the "multi-point" selection tool to create a list of *at least* 20 points from the red plot, more or less uniformly distributed horizontally. Make sure that the Analyze/Set-Scale... is configured to reverse *y* values. Also, make sure you first use the image itself to determine the volts-to-pixels and seconds-to-pixels ratios. Use this data in Excel to determine the best-fit cubic description of this plot. Naturally, your four coefficients will all have units!!



## Determining the Diameter of a "Star"

Consider the "plot profile" of a star or other dot (blue). This represents the intensity along any diameter that passes through the center of the star. The orange line is the background intensity; you'd like it to be at zero, but it usually isn't. The green line is the "amplitude". The magenta lines are half the amplitude. The length of the red line is called the FWHM, or "Full Width at Half Maximum". There are two ways to measure it; one is direct but requires Excel or some tool in addition to ImageJ, and the other is an indirect approximation that can be done right inside ImageJ.





## **Direct Calculation**

- a) Draw a line through the dot in ImageJ. Make sure it extends past the dot on both sides, reaching into the "black" area. Here, I show three attempts.
- b) Use Analyze/Plot Profile, then click "List" and copy the resulting data.
- c) Paste the data into Excel. Determine the amplitude using the difference between the minimum and maximum intensities. Then, divide this in half to find the HM part of FWHM.
- d) Find the two data points that straddle the HM intensity on the left side of the plot. Fit a straight line between them (perhaps using the TREND worksheet function). Use this straight line to determine the position where the linear function is equal to the HM.
- e) Repeat step d on the right side of the plot.
- f) The FWHM is your answer from part e minus your answer from part d.

## **Indirect Approximation**

- a) Use the same parts a) and b) as for the "direct" calculation.
- b) Go to Analyze/Tools/Curve Fitting. Delete whatever data is already there, then paste in your data from part b) above.
- c) In the first selector box, pick "Gaussian", then click the "Fit" button.
- d) We next want the standard deviation,  $\sigma$ , which ImageJ calls "d".
- e) If the data were really Gaussian, then FWHM =  $2.355\sigma$ . However, the data is probably not really Gaussian, so this is just an approximation.

For any single dot, it is generally appropriate to repeat the process using different angles for your initial yellow (part a)) line, each passing through the center of the dot, as seen in the three attempts above. You then average the results. Actually, "real" astronomers would perform a full 2D Gaussian fit, meaning you select an area rather than a line just to get started.

