

Assignment #6: Extracting Data from Images using ImageJ

Due on April 7, 2023. Because of the quantitative issues, this is a hard assignment!

You are expected to use “ImageJ” to solve these problems. Additional calculations may be performed in Excel, but *not* 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. You must also submit an electronic copy of your Excel work to my inbox. 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”, or the “Print Screen” button) 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 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).

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).

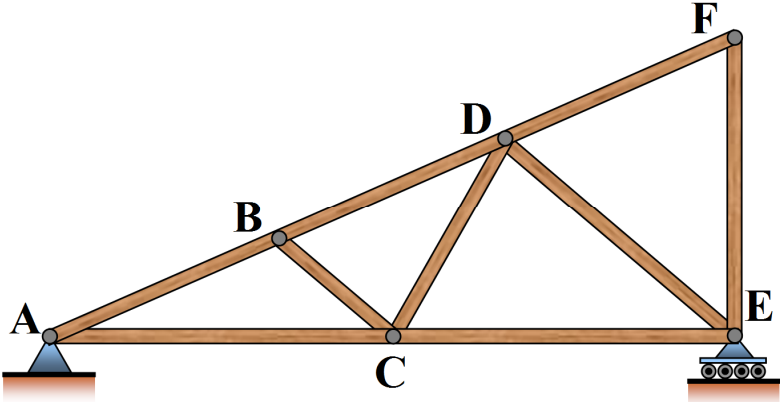


- How many stars are present when these threshold levels are used?
- Find the “brightness” [(area) \times (average intensity)], x position, and y position of the brightest star.
- Find the brightness, x position, and y position of one of the two identical dimmest stars.
- For the brightest star, determine the FWHM (in pixels). This is the “diameter” of the star. See page 3 for hints about measuring this.
- 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).

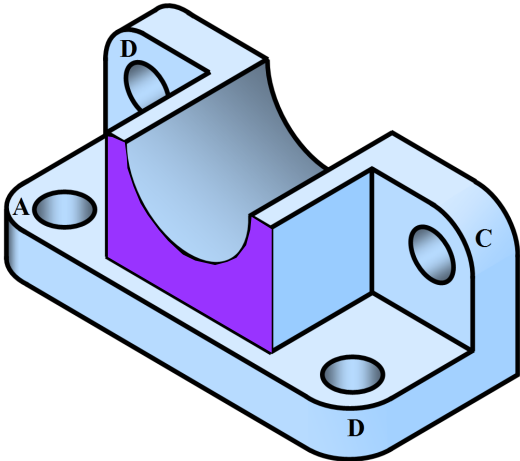
4. For the image “purple.jpg” on the course homepage, split the image into 3 separate channels (Red, Blue, Green) and for each one, determine the best-fit cubic equation describing each color (e.g., find the numbers a , b , c , and d for $I_{\text{red}}(x) = a + bx + cx^2 + dx^3$).



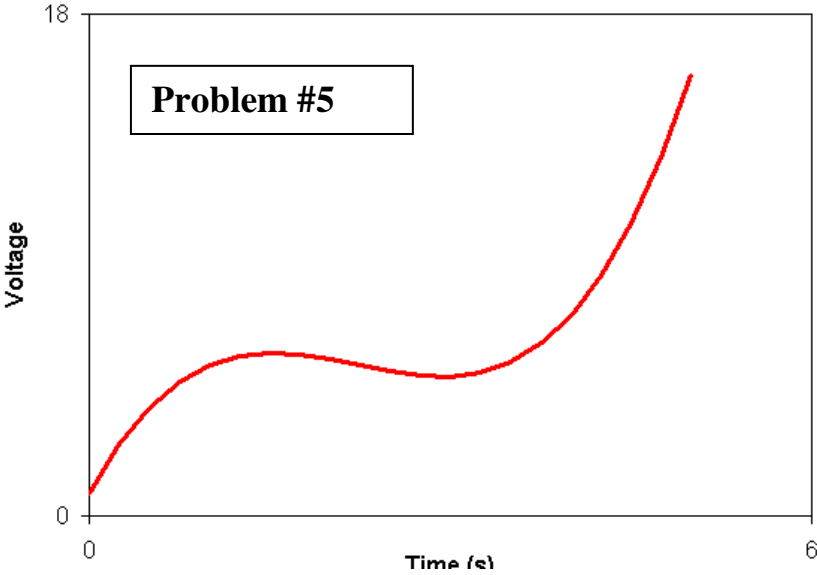
5. For the image “plot.bmp” on the course homepage (and below), use the “multi-point” selection tool to create a list of *at least* 20 points from the red plot, more or less uniformly distributed horizontally. Make sure that the Analyze/Set-Scale... is configured to reverse y values. Also, make sure you 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 coefficients will all have units!!



Problem #1



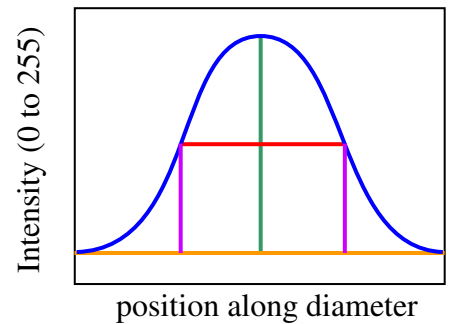
Problem #2



Problem #5

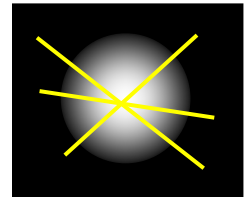
Determining the Diameter of a “Star”

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

- 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.
- Use Analyze/Plot Profile, then click “List” and copy the resulting data.
- 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.
- 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.
- Repeat step d on the right side of the plot.
- The FWHM is your answer from part e minus your answer from part d.



Indirect Approximation

- Use the same parts a) and b) as for the “direct” calculation.
- Go to Analyze/Tools/Curve Fitting. Delete whatever data is already there, then paste in your data from part b) above.
- In the first selector box, pick “Gaussian”, then click the “Fit” button.
- We next want the standard deviation, σ , which ImageJ calls “ d ”. If the data were really Gaussian, then $\text{FWHM} = 2.355\sigma$. 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. 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.