1. What is the primary limiting factor in the maximum torque capability of a stepper motor? Why is there a difference in the "peak" torque and the "continuous" torque?

2. Why does a brushless DC motor require position sensing? Why is "torque ripple" a bigger problem than with conventional PM DC motors?

3. Name three sensors that are commonly used to measure joint positions on a robot. Give the primary advantage and disadvantage of each type of sensor.

4. A question about robot safety

5. A question about robot workcells

6. Fu, Gonzalez and Lee recommend a “4-3-4” joint trajectory as shown below. What are the conditions that must be satisfied in order to solve for the unknowns in the equations that describe these trajectories?

![Figure 4.2 Position conditions for a joint trajectory.](image-url)
1. A small, 5x4 section of a much larger digitized image is given in the table below. Fill out the remaining tables with the results from the selected image processing algorithm. 

*Use the original image for each of the algorithms - not the results of the previous algorithm*

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2. For the motion profile given below, determine the velocity and displacement at all key points using graphical integration techniques. What type of motion program is this profile suited for?

![Motion Profile](image)

3. Given the motor/pulley/cable/load system shown, determine the motor torque required to accelerate the 3 lb load at 25 ft/sec² upwards. Assume no friction in the system.

Note – standard gravity acts downward
4. Design an A-T diagram that meets the following specifications:
   a) used for a Rise-Return motion program
   b) total displacement over 0.8 seconds is 12 inches
   c) maximum acceleration/deceleration of 100 inches/sec²

5. A small object (denoted by the dark squares) is located within the 15x15 grid below. The origin of the image is in the upper left-hand corner. For this single object, find
   • area (number of pixels),
   • X and Y centroids (pixels from upper left corner - \textit{round to closest integer},
   • Y and Y “second moments” of inertia - about centroidal axes
   • use the results from the previous step to find the orientation of the principal axes

Note - these calculations will be easier - and just as accurate - if you assume that the row (or column) value refers to the \textit{center} of the pixel - not the corner.