Department of
Industrial Engineering

HOMEWORK 3 – Group Work
<div align="right">Due: Dec. 28</div>

Consider the Printed Circuit Board (PCB) given in the figure having 34 legs separated uniformly along the sides of the wafer. Suppose that a CNC machine with a robot arm makes vias (a kind of drill operation) at points $A, B, \ldots, J$. A high volume of PCB's are processed one after another.
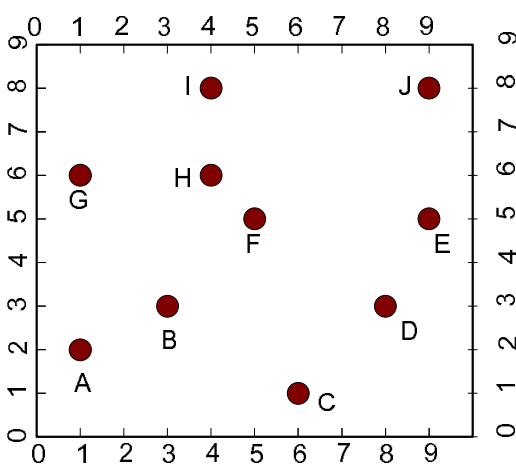
$$A = \begin{bmatrix} 1 \\ 2 \end{bmatrix}, \; B = \begin{bmatrix} 3 \\ 3 \end{bmatrix},$$

$$C = \begin{bmatrix} 6 \\ 1 \end{bmatrix}, \; D = \begin{bmatrix} 8 \\ 3 \end{bmatrix},$$

$$E = \begin{bmatrix} 9 \\ 5 \end{bmatrix}, \; F = \begin{bmatrix} 5 \\ 5 \end{bmatrix},$$

$$G = \begin{bmatrix} 1 \\ 6 \end{bmatrix}, \; H = \begin{bmatrix} 4 \\ 6 \end{bmatrix},$$

$$I = \begin{bmatrix} 4 \\ 8 \end{bmatrix}, \; J = \begin{bmatrix} 9 \\ 8 \end{bmatrix}.$$

1. Suppose that the robot arm moves in horizontal as well as vertical direction using a single motor. It switches its direction in an infinitesimal time unit. The CNC programmer uses the following logic to find the sequence of vias to be processed: Start from A, go to the closest neighbor if it has not been processed yet. Break the ties in terms of ascending lexicographical order of locations.

   (a) Find the initial tour after deciding on the appropriate metric.

   (b) Calculate the gains associated with all possible pairs once. Once all the gains are calculated, all the independent switches is made. This improvement procedure is executed only once.

2. What if the robot arm moves in any direction using its motor?

3. What if the robot arm moves in horizontal as well as vertical direction using two independent but identical motors?