**F21RO INTELLIGENT ROBOTICS TUTORIAL 1 VAL**

**QUESTION 1.**

Examine the following VAL-1 program:

```
SHIFT NIB BY 10.0, 10.0, 0.0
MOVE NIB : OFFSET
MOVES NIB
SHIFT NIB BY 80.0, 80.0, 0.0
MOVES NIB
SHIFT NIB BY 80.0, -80.0, 0.0
MOVES NIB
DEPART 20
SHIFT NIB BY -40.0, 40.0, 0.0
MOVE NIB : OFFSET
MOVES NIB
SHIFT NIB BY -80.0, 0.0, 0.0
MOVES NIB
DEPART 20
SHIFT NIB BY -50.0, -50.0, 0.0
MOVES NIB
STOP
```

If a pen is used as the end-effector of a PUMA robot executing this program and a blank piece of paper is supported in the Z=0 plane and *NIB* and *OFFSET* are initialised as follows:

$$NIB = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad OFFSET = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 20 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

i). Draw a diagram of the shape which will appear on the paper. Give precise co-ordinates for all important points and indicate the direction of travel of the Tool Centre Point.

ii). What would be the likely effects of substituting *MOVE* commands for *MOVES* commands in the program?

iii). Why is the off-line programming of robots in this manner still problematic and unreliable?

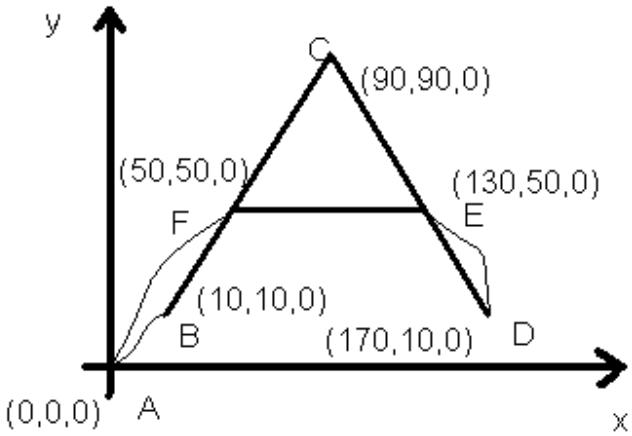
**QUESTION 2.**

Describe three other methods by which an industrial manipulator could be programmed.

**SOLUTION 1.**

(i). Important to note that *SHIFT BY* merely modifies the transform NIB.
The *MOVE, MOVES* and *DEPART* commands carry out the actual motions.

The TCP will travel along the route A-B-C-D-E-F-A




(ii). MOVES ensures straight-line motion
MOVES will result in a nice linear "A" shape

MOVE uses joint interpolation
MOVE will result in more efficient changes to joint angles
The path followed by the TCP will be wobbly and might even break the pen nib

(iii). Two key problems which are very difficult to predict in advance

DEGENERACIES
More than one solution for a given TCP position

SINGULARITIES
Dead points in space – resulting from denominators of zero in the inverse kinematics

**SOLUTION 2.**

(i). PHYSICAL SET-UP

Mechanical stops or pegs are used to mark the end points of joint motions
Used for limited sequence devices only

(ii). WALK-THROUGH

Physically dragging the arm (or a proxy arm) through the required motions
Recording desired positions along the way

(iii). LEAD-THROUGH

A teach pendant is used to provide -

- Individual joint direction
- Relative tool direction
- Absolute tool direction

Target positions are recorded