In this laboratory, your group will develop four subroutines in the C language to implement the four cross coupling controllers developed in Assignment 3. The file names and contents are:

- ccc1.h : proportional (P) cross coupling controller for linear contours
- ccc2.h : proportional plus integral (PI) cross coupling controller for linear contours
- ccc3.h : proportional (P) cross coupling controller for circular contours
- ccc4.h : proportional plus integral (PI) cross coupling controller for circular contours

The subroutines declarations are:

```c
int = CCC1(double Xi[2],double Xf[2],double Xr[2],double X[2],int wC[2])
int = CCC2(double Xi[2],double Xf[2],double Xr[2],double X[2],int wC[2])
int = CCC3(double Xr[2],double X[2],double V[2],double Vr,int wC[2],double R)
int = CCC4(double Xr[2],double X[2],double V[2],double Vr,int wC[2],double R)
```

You will use the proportional axis controllers you developed in Laboratory 2 (i.e., AxisCtrX1.h and AxisCtrY1.h) and the linear interpolator with constant velocity you developed in Laboratory 3 (i.e., LinInt1.h). The circular interpolator will be provided. The inputs are Xi (initial axis positions [x,y] for linear segment or circular arc in m), Xf (final axis positions [x,y] in m), Xr (reference axis positions [x,y] in m), X (measured axis positions [x,y] in m), wC (axis motor digital commands [x,y]), V (reference axis velocities [x,y] in m/s), Vr (feedrate in m/s), and R (circle radius in m). The outputs are the cross coupling controller digital command (i.e., U, digital number, type integer) and the updated axis motor digital commands (i.e., wC). Data that will be saved: reference x axis position in m, reference y axis position in m, actual x axis position in m, actual y axis position in m, contour error in m, cross coupling controller digital command, x axis motor digital command, and y axis motor digital command. The subroutines need to include saturation and, where appropriate, integral antwindup. Turn in the four subroutines (make sure they are well documented), the expected performances via simulation, and the actual performances. Discuss your results.