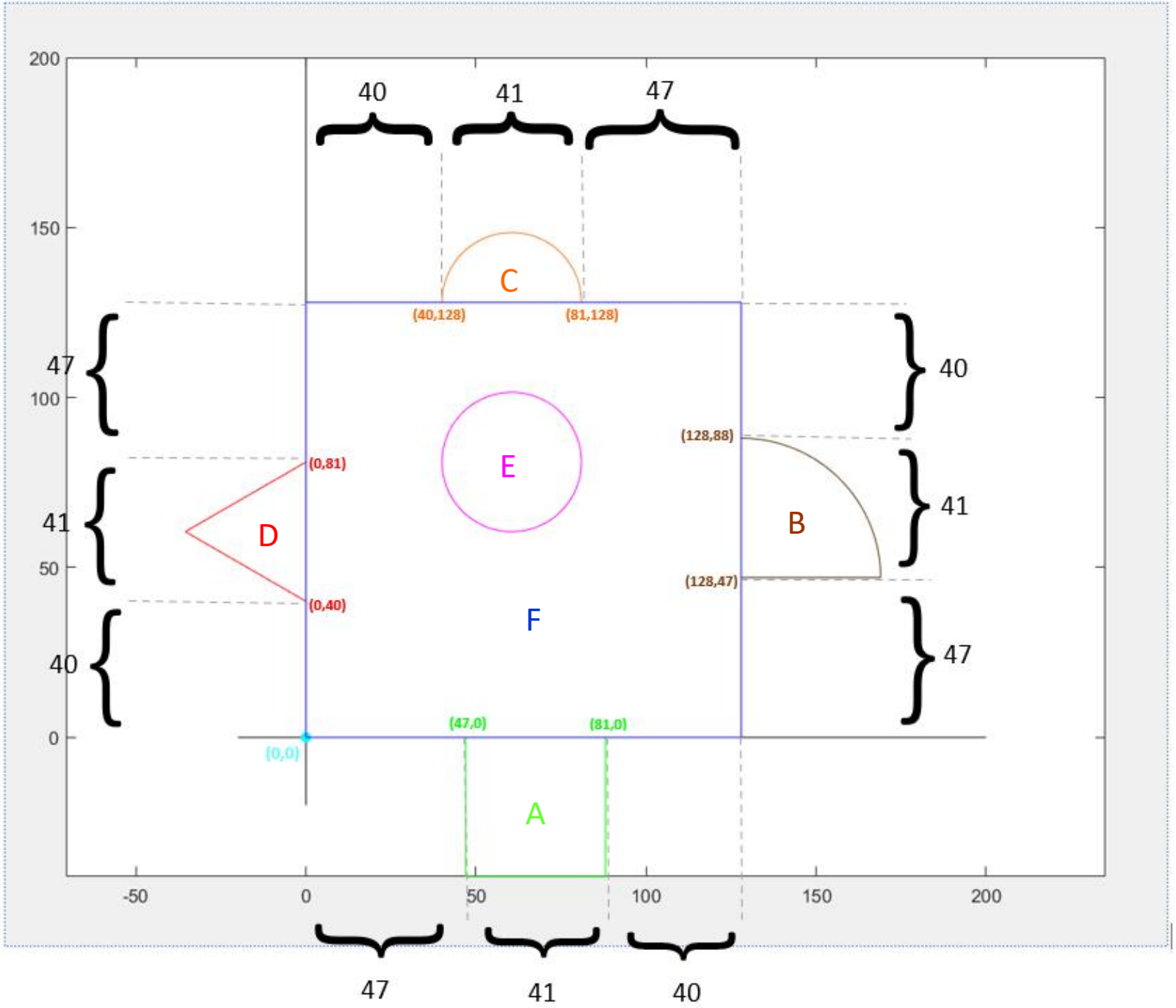
Dimensions:

- a = 47
  b = 41
  c = 40

- r = (3%3)+1
  = 1



MATLAB CODE TO PLOT THE FIGURE:

```
%Clear Command Window
clc;
%Clears Workspace
clear all;
%Clears Figure Window
clf;

% create axes (X-Axis ans Y-Axis)
plot([-20 200] , [0 0] , 'k');
hold on;
plot([0 0] , [-20 200] , 'k');
hold on;
axis equal;
% Assuming the Centroid of the whole system to be the origin
Assumed_Centroid = [0 0];
%plot(Assumed_Centroid(1) , Assumed_Centroid(2) , 'c.', 'MarkerSize', 20);
hold on;

% Plot the Small Square (A)
x = [47 88 88 47 47];
y = [0 0 -41 -41 0];
plot(x,y,'g');
hold on;
% Marking the Centroid of the Small Square
A = [67.5 -20.5];
%plot(A(1) , A(2) , 'g.', 'MarkerSize', 20);
hold on;

```

```
% Plot the Quarter Circle (B)
R = 41. ;
D = [128. 47.] ;
% angle
theeta = 90:-1:0 ;
% points of circle
xc = D(1)+R*cosd(theeta) ;
yc = D(2)+R*sind(theeta) ;
%Plot curve of Quarter Circle
plot(xc,yc, 'Color','#522701');
% plot line of Quarter Circle ([x1 x2] , [y1 y2])
plot([128 169], [47 47], 'Color','#331900');
hold on;
% Marking the Centroid of the Quarter circle
D = [145.4098 64.4098];
%plot(D(1) , D(2) , 'k.', 'MarkerSize', 20);
hold on;

% Plot the Semi Circle (C)
theeta = linspace( 0, pi, 100);
R = 20.5;
x = R*cos(theeta) + 60.50;
y = R*sin(theeta) + 128;
plot(x,y,'Color','#EE771C');
% Marking the Centroid of the Semi Circle
D = [60.5 136.7049];
%plot(D(1) , D(2) , 'y.', 'MarkerSize', 20);
hold on;

```

```
58      % Plot the Triangle (D)
59 -    D1 = plot([0 -35.5070], [40 60.5], 'Color', 'r');
60 -    hold on;
61 -    D2 = plot([-35.5070 0], [60.5 81], 'Color', 'r');
62 -    hold on;
63 -    D3 = plot([0 0], [81 40], 'Color', 'r');
64 -    hold on;
65      % Marking the Centroid of the triangle
66 -    D = [-11.8357 60.5];
67      %plot(D(1) , D(2) , 'r.', 'MarkerSize', 20);
68 -    hold on;
69
70      % Plot the circle (E)
71 -    x = 60.5;
72 -    y = 81;
73 -    radius = 20.5;
74 -    Theeta=0:0.01:2*pi;
75 -    xt=radius*cos(Theeta);
76 -    yt=radius*sin(Theeta);
77 -    plot(x+xt, y+yt,'m');
78      % Marking the Centroid of the circle
79 -    E = [60.5 81];
80      %plot(E(1) , E(2) ,'m.', 'MarkerSize', 20);
81 -    hold on;
82
```

```
83      % Plot the big Square (F)
84 -    F1 = plot([0 0],[128 0], 'b');
85 -    hold on;
86 -    F2 = plot([128 0],[128 128], 'b');
87 -    hold on;
88 -    F3 = plot([128 128],[0 128], 'b');
89 -    hold on;
90 -    F4 = plot([0 128],[0 0], 'b');
91 -    axis equal;
92 -    hold on;
93      % Marking the Centroid of the Big Square
94 -    F = [64 64];
95      %plot(F(1) , F(2) , 'b.', 'MarkerSize', 20);
96 -    hold on;
```

CENTROID

Table to find the Individual Centroids:

	Xi (Calculations)	Xi	Yi (Calculations)	Yi	Ai (Calculations)	Ai	XiAi	YiAi
Small Square (A)	47+20.5	67.5	-20.5	-20.5	41*41	1681	113467.5	-34460.5
Quarter-Circle (B)	128+17.4098	145.4098	47+17.4098	64.4098	(pi)*(41)^2/4	1319.585	191880.5909	84994.20593
Semi-Circle (C)	40+20.5	60.5	128+8.7049	136.7049	(pi)*(20.5)^2/2	659.7925	39917.44625	90196.86773
Triangle (D)	-11.8357	-11.8357	40+30.5	60.5	0.5*47*35.5070	834.4145	-9875.879698	50482.07725
Circle (E)	40+20.5	60.5	41+40	81	(pi)*(20.5)^2	1319.585	79834.8925	106886.385
Big Square (F)	64	64	64	64	128*128	16384	1048576	1048576
						∑Ai = 22198.377	∑XiAi = 1463800.55	∑YiAi = 1346675.036

CENTROID :

$$X = \sum XiAi \div \sum Ai$$

$$= 65.94178259$$

$$Y = \sum YiAi \div \sum Ai$$

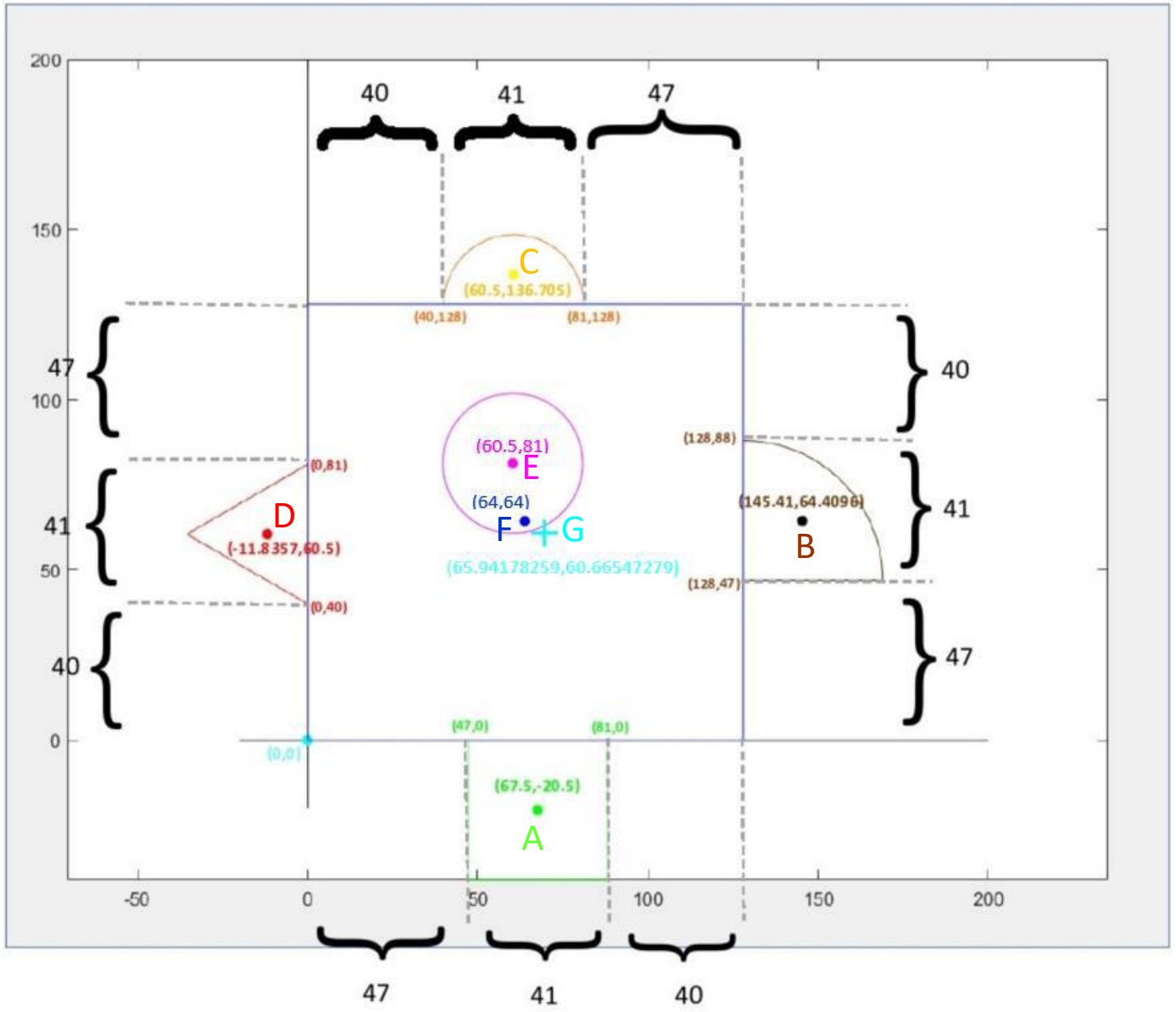
$$= 60.66547279$$

$$(X,Y) = (65.94178259,60.66547279)$$

Centroids of Individual figures:

A = (67.5 , -20.5)
B = (145.41 , 64.4098)
C = (60.5 , 136.705)
D = (-11.8357 , 60.5)
E = (60.5 , 81)
F = (64 , 64)

Here, the chosen reference frame is (0,0)



MATLAB CODE:

```
%Clear Command Window
clc;
%Clears Workspace
clear all;
%Clears Figure Window
clf;

% For the small Square (A)
X_SmallSquare = 47+20.5;
Y_SmallSquare = -20.5;
A_SmallSquare = 41*41;
XA_AA = X_SmallSquare*A_SmallSquare;
YA_AA = Y_SmallSquare*A_SmallSquare;

%For the Quarter Circle (B)
B_Radius = 41;
X_QuarterCircle = 47+41+40+(4*B_Radius)/(3*pi);
Y_QuarterCircle = 47+(4*B_Radius)/(3*pi);
A_QuarterCircle = ((pi)*(B_Radius)*(B_Radius))/
XB_AB = X_QuarterCircle*A_QuarterCircle;
YB_AB = Y_QuarterCircle*A_QuarterCircle;

%For the Semi Circle (C)
C_Radius = 20.5;
X_SemiCircle = 40+20.5;
Y_SemiCircle = 40+41+47+(4*C_Radius)/(3*pi);
A_SemiCircle = ((pi)*(C_Radius)*(C_Radius))/2;
XC_AC = X_SemiCircle*A_SemiCircle;
YC_AC = Y_SemiCircle*A_SemiCircle;

%For the Triangle (D)
X_Triangle = -11.8357;
Y_Triangle = 40+20.5;
A_Triangle = (0.5)*(47)*(35.5070);
XD_AD = X_Triangle*A_Triangle;
YD_AD = Y_Triangle*A_Triangle;

%For the Circle (E)
E_Radius = 20.5;
X_Circle = 40+20.5;
Y_Circle = 41+40;
A_Circle = (pi)*(E_Radius)*(E_Radius);
XE_AE = X_Circle*A_Circle;
YE_AE = Y_Circle*A_Circle;

% For the big Square (F)
X_BigSquare = 128/2;
Y_BigSquare = 128/2;
A_BigSquare = 128*128;
XF_AF = X_BigSquare*A_BigSquare;
YF_AF = Y_BigSquare*A_BigSquare;

%Finding the sum of the Areas, XiAi and YiAi
Sigma_A = A_SmallSquare + A_QuarterCircle + A_SemiCircle - A_Circle + A_BigSquare;
Sigma_X = XA_AA + XB_AB + XC_AC + XD_AD - XE_AE + XF_AF;
Sigma_Y = YA_AA + YB_AB + YC_AC + YD_AD - YE_AE + YF_AF;

%X Coordinate
X = Sigma_X/Sigma_A;

%Y Coordinate
Y = Sigma_Y/Sigma_A;

%Centroid of the figure
Centroid = [X Y]

%Table
A = [  X_SmallSquare  ,   Y_SmallSquare ,   A_SmallSquare , XA_AA , YA_AA ];
B = [ X_QuarterCircle , Y_QuarterCircle , A_QuarterCircle , XB_AB , YB_AB ];
C = [   X_SemiCircle  ,   Y_SemiCircle  ,   A_SemiCircle  , XC_AC , YC_AC ];
D = [    X_Triangle   ,    Y_Triangle   ,    A_Triangle   , XD_AD , YD_AD ];
E = [      X_Circle   ,      Y_Circle   ,     A_Circle    , XE_AE , YE_AE ];
F = [   X_BigSquare   ,   Y_BigSquare   ,    A_BigSquare  , XF_AF , YF_AF ];
format long;
Table = [ A ; B ; C ; D ; E ; F ]
```

OUTPUT:

Command Window

```
Centroid =

  69.649521476886164  60.502782197671102


Table =

   1.0e+06 *

   0.000067500000000  -0.000020500000000   0.001681000000000   0.113467500000000  -0.034460500000000
   0.000145400940445   0.000064400940445   0.001320254312671   0.191966218688569   0.085025619362209
   0.000060500000000   0.000136700470222   0.000660127156336   0.039937692958301   0.090239692677618
  -0.000011835700000   0.000060500000000   0.000834414500000  -0.009875879697650   0.050482077250000
   0.000060500000000   0.000081000000000   0.001320254312671   0.079875385916602   0.106940599326360
   0.000064000000000   0.000064000000000   0.016384000000000   1.048576000000000   1.048576000000000
```

MOMENT OF INERTIA (MOI)

Table to find the Individual Moment of Inertia's:

	Iu (Calculations)	Iu	Iv (Calculations)	Iv	Ai	dy	dx	A(dy)^2	A(dx)^2	Ix = Iu+A(dy)^2	Iy = Iv+A(dx)^2
Small Square (A)	(41)^4/12	235480.0833	(41)^4/12	235480.0833	1681	-81.0028	-2.1495	11029803.51	7766.80877	11265283.6	243246.8921
Quarter-Circle (B)	0.05488*(41)^4	155077.7637	((PI)*(41)^4)/16	554555.5963	1319.585	3.8981	75.7514	20051.33636	7572141.091	175129.1	8126696.687
Semi-Circle (C)	0.1098*(20.5)^4	19391.78486	((PI)*(20.5)^4)/8	69319.44953	659.7925	76.1977	9.1495	3830814.297	55233.44064	3850206.082	124552.8902
Triangle (D)	41*(35.5070)/36	40.43852778	((35.5070*(41)^3)-(35.5070*20.5*(41)^2)+(35.5070*(20.5)^2*41))/36	50982.8739	834.4145	-0.0028	-81.4852	0.00654181	5540376.954	40.44506959	5591359.828
Circle (E)	((PI)*(23.5)^4)/4	239409.3491	((PI)*(23.5)^4)/4	239409.3491	1319.585	20.4972	-9.1495	554404.1182	110466.8813	793813.4673	349876.2304
Big Square (F)	(128)^4/12	22369621.33	(128)^4/12	22369621.33	16384	3.4972	-5.6495	200383.0021	522925.6745	22570004.34	22892547.01

Ix = 37220164.55240876

Iy = 36283634.39218253

(Ix , Iy) = (37220164.55240876 , 36283634.39218253)

MATLAB CODE:

```
%Clear Command Window
clc;
%Clears Workspace
clear all;
%Clears Figure Window
clf;

% For the small Square (A)
A_SmallSquare = 41*41;
Side_of_SmallSquare = 41;
dx_A = -2.1495;
dy_A = -81.0028;
Iu_A = (1/12)*(Side_of_SmallSquare)^4;
Iv_A = (1/12)*(Side_of_SmallSquare)^4;
Area_A_dy = A_SmallSquare*(dy_A)^2;
Area_A_dx = A_SmallSquare*(dx_A)^2;
Ix_A = Iu_A + Area_A_dy;
Iy_A = Iv_A + Area_A_dx;

```

```
%For the Quarter Circle (B)
B_Radius = 41;
A_QuarterCircle = ((pi)*(B_Radius)*(B_Radius))/4;
dx_B = 75.7514;
dy_B = 3.8981;
Iu_B = (0.05488)*(B_Radius)^4;
Iv_B = (0.05488)*(B_Radius)^4;
Area_B_dy = A_QuarterCircle*(dy_B)^2;
Area_B_dx = A_QuarterCircle*(dx_B)^2;
Ix_B = Iu_B + Area_B_dy;
Iy_B = Iv_B + Area_B_dx;


%For the Semi Circle (C)
C_Radius = 20.5;
A_SemiCircle = ((pi)*(C_Radius)*(C_Radius))/2;
dx_C = 9.1495;
dy_C = 76.1977;
Iu_C = (0.1098)*(C_Radius)^4;
Iv_C = (0.1098)*(C_Radius)^4;
Area_C_dy = A_SemiCircle*(dy_C)^2;
Area_C_dx = A_SemiCircle*(dx_C)^2;
Ix_C = Iu_C + Area_C_dy;
Iy_C = Iv_C + Area_C_dx;

```

```
45      %For the Triangle (D)
46 -    b = 41;
47 -    h = 35.5070;
48 -    a = 20.5;
49 -    A_Triangle = (0.5)*(47)*(35.5070);
50 -    dx_D = -81.4852;
51 -    dy_D = -0.0028;
52 -    Iu_D = (1/36)*(b)*(h^3);
53 -    Iv_D = (1/36)*((h)*(b^3)-(h)*(a)*(b^2)+(h)*(a^2)*(b));
54 -    Area_D_dy = A_Triangle*(dy_D)^2;
55 -    Area_D_dx = A_Triangle*(dx_D)^2;
56 -    Ix_D = Iu_D + Area_D_dy;
57 -    Iy_D = Iv_D + Area_D_dx;
58
59      %For the Circle (E)
60 -    E_Radius = 20.5;
61 -    A_Circle = (pi)*(E_Radius)*(E_Radius);
62 -    dx_E = -9.1495;
63 -    dy_E = 20.4972;
64 -    Iu_E = ((pi)*(E_Radius)^4)/4;
65 -    Iv_E = ((pi)*(E_Radius)^4)/4;
66 -    Area_E_dy = A_Circle*(dy_E)^2;
67 -    Area_E_dx = A_Circle*(dx_E)^2;
68 -    Ix_E = Iu_E + Area_E_dy;
69 -    Iy_E = Iv_E + Area_E_dx;
```

```
70
71      % For the big Square (F)
72 -    Side_of_BigSquare = 128;
73 -    A_BigSquare = 128*128;
74 -    dx_F = -5.6495;
75 -    dy_F = 3.4972;
76 -    Iu_F = (1/12)*(Side_of_BigSquare)^4;
77 -    Iv_F = (1/12)*(Side_of_BigSquare)^4;
78 -    Area_F_dy = A_BigSquare*(dy_F)^2;
79 -    Area_F_dx = A_BigSquare*(dx_F)^2;
80 -    Ix_F = Iu_F + Area_F_dy;
81 -    Iy_F = Iv_F + Area_F_dx;
82
83      %Finding the sum of the Moments
84 -    Ix = Ix_A + Ix_B + Ix_C + Ix_D - Ix_E + Ix_F;
85 -    Iy = Iy_A + Iy_B + Iy_C + Iy_D - Iy_E + Iy_F;
86
87      %Moment
88 -    Moment_of_Inertia = [Ix Iy]
```

OUTPUT:

Command Window

```
Moment_of_Inertia =

   1.0e+07 *

   3.722016455240876   3.628363439218253
```

RESULTANT FORCE
AND
RESULTANT MOMENT DUE TO THESE FORCES ABOUT THE CENTROID (G):

Resultant Force:

$$\overrightarrow{F_{AB}} = [0.736829508 , 0.803039353]$$
$$\overrightarrow{F_{BC}} = [0.735493583 , 0.798414037]$$
$$\overrightarrow{F_{CD}} = [0.643525514 , 0.541039645]$$
$$\overrightarrow{F_{DA}} = [0.714408131 , 0.729394946]$$

	Xi wrt (0,0)	Xi (wrt Centroid)	Yi wrt (0.0)	Yi (wrt Centroid)
Small Square (A)	67.5	-2.1495	-20.5	-81.0028
Quarter-Circle (B)	145.4098	75.7514	64.4098	3.8981
Semi-Circle (C)	60.5	9.1495	136.7049	76.1977
Triangle (D)	-11.8357	-81.4852	60.5	-0.0028

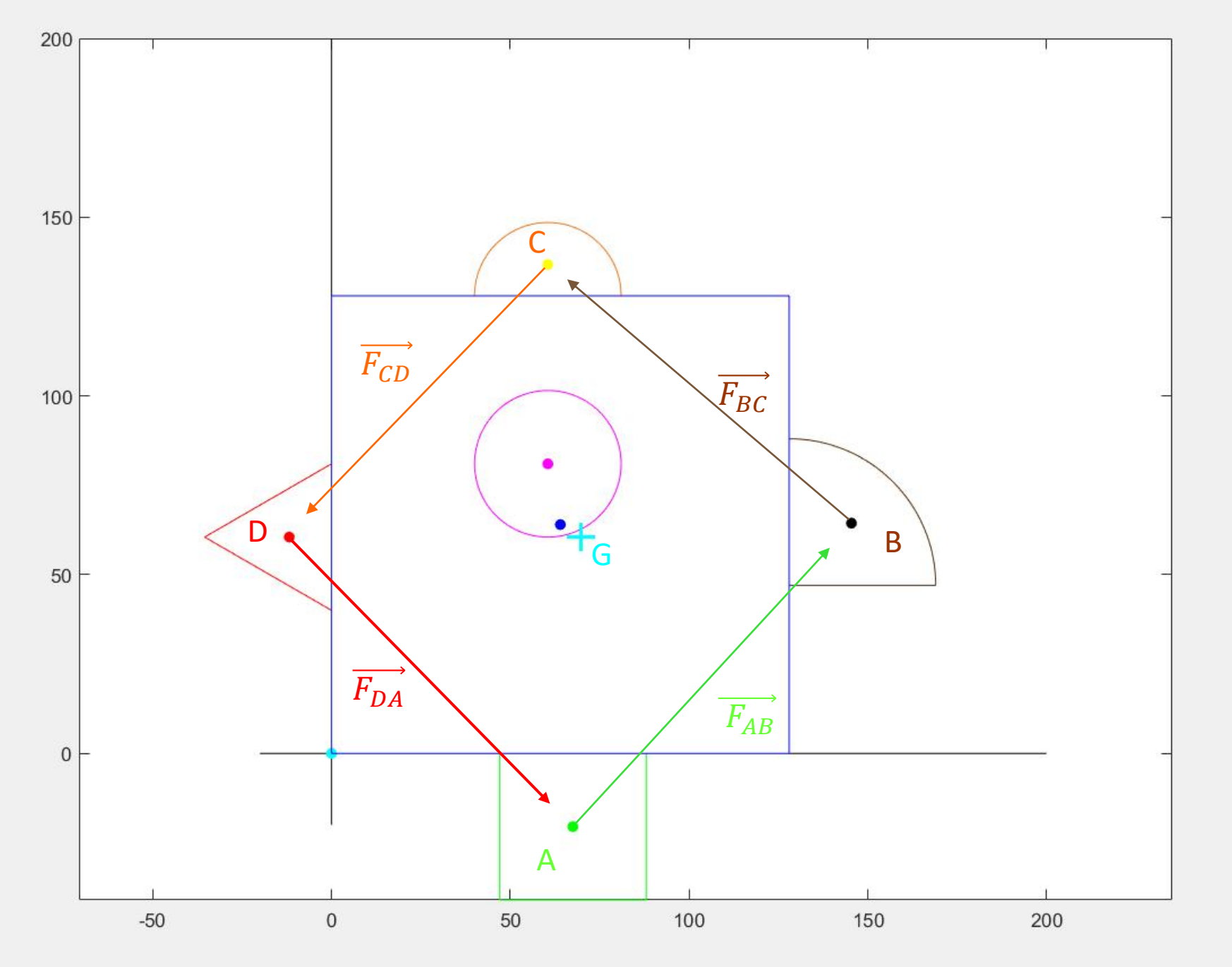
AB (y2-y1)	(3.8981) - (-81.0028)	84.9009
BC (y2-y1)	(76.1977) - (3.8981)	72.2996
CD (y2-y1)	(-0.0028) - (76.1977)	-76.2005
DA (y2-y1)	(-81.0028) - (-0.0028)	-81

AB (x2-x1)	(75.7514) - (-2.1495)	77.9009
BC (x2-x1)	(9.1495) - (75.7514)	-66.6019
CD (x2-x1)	(-81.4851) - (9.1495)	-90.6347
DA (x2-x1)	(-2.1495) - (-81.4852)	79.3357

	y2-y2/x2-x2	Magnitude (absolute value)	Radians (tan)	Degrees	Angle wrt +ve x-axis
|AB|	1.089857755	1.089857755	0.828368763	47.46203402	47.46203402
|BC|	-1.08554861	1.08554861	0.826394895	47.34893969	132.6510603
|CD|	0.840743115	0.840743115	0.699095357	40.05521341	220.0552134
|DA|	-1.020977946	1.020977946	0.795777887	45.59471436	314.4052856

	magnitude*cos(theta)	magnitude*sin(theta)
Fab	0.736829508	0.803039353
Fbc	0.735493583	0.798414037
Fcd	0.643525514	0.541039645
Fda	0.714408131	0.729394946
F	2.830256736	2.871887982

$$\vec{F} = [2.830256736 , 2.871887982]$$


200
150
100
50
0
-50
0
50
100
150
200
C
D
B
A
G
$\overrightarrow{F_{CD}}$
$\overrightarrow{F_{BC}}$
$\overrightarrow{F_{DA}}$
$\overrightarrow{F_{AB}}$

MATLAB CODE:

```
%Clear Command Window
clc;
%Clears Workspace
clear all;
% Centroid of individual figures wrt Centroid of Composite figure
A = [-2.1495 -81.0028];
B = [75.7514 3.8981];
C = [9.1495 76.1977];
D = [-81.4852 -0.0028];

% X2-X1
AB_x = [B([1])- A([1])];
BC_x = [C([1])- B([1])];
CD_x = [D([1])- C([1])];
DA_x = [A([1])- D([1])];
% Y2-Y1
AB_y = [B([2])- A([2])];
BC_y = [C([2])- B([2])];
CD_y = [D([2])- C([2])];
DA_y = [A([2])- D([2])];

% Magnitude (slope, y2-y1/x2-x1)
Magnitude_AB = abs(AB_y/AB_x);
Magnitude_BC = abs(BC_y/BC_x);
Magnitude_CD = abs(CD_y/CD_x);
Magnitude_DA = abs(DA_y/DA_x);

% Angles tan(theta) = ..... , theta = tanInverse(.....)
ThetaAB = atand(Magnitude_AB);
ThetaBC = atand(Magnitude_BC);
ThetaCD = atand(Magnitude_CD);
ThetaDA = atand(Magnitude_DA);

% Angles wrt +ve x-axis
Theta_AB = ThetaAB;
Theta_BC = 180 - ThetaBC;
Theta_CD = 180 + ThetaCD;
Theta_DA = 360 - ThetaDA;

x1 = abs(Magnitude_AB*cosd(Theta_AB)); y1 = abs(Magnitude_AB*sind(Theta_AB));
x2 = abs(Magnitude_BC*cosd(Theta_BC)); y2 = abs(Magnitude_BC*sind(Theta_BC));
x3 = abs(Magnitude_CD*cosd(Theta_CD)); y3 = abs(Magnitude_CD*sind(Theta_CD));
x4 = abs(Magnitude_DA*cosd(Theta_DA)); y4 = abs(Magnitude_DA*sind(Theta_DA));

% Individual forces
F_AB = [x1 y1];
F_BC = [x2 y2];
F_CD = [x3 y3];
F_DA = [x4 y4];

% Resultant force acting on the composite area
F = F_AB + F_BC + F_CD + F_DA;
```

OUTPUT:

Command Window

```
F_AB =

   0.736829507791347   0.803039353307117


F_BC =

   0.735493583165179   0.798414037218294


F_CD =

   0.643525514224553   0.541039645374983


F_DA =

   0.714408131226849   0.729394946151289


F =

   2.830256736407927   2.871887982051683
```

Result Moment due to the forces:

Moment = r x F
Here, r is GA (Xi and Yi of A wrt X and Y of Centroid), GB (Xi and Yi of B wrt X and Y of Centroid), GC (Xi and Yi of C wrt X and Y of Centroid) and GD (Xi and Yi of D wrt X and Y of Centroid).
We have the Force (F_{ab}, F_{bc}, F_{cd} and F_{da} from the previous part, so we can apply the moment formula for each and find the Resultant Moment due to all the forces

CENTROD	X (x1)	65.94178259
	Y (y1)	60.66547279

	Xi wrt (0,0) (y2)	Yi wrt (0.0) (x2)
Small Square (A)	67.5	-20.5
Quarter-Circle (B)	145.4098	64.4098
Semi-Circle (C)	60.5	136.7049
Triangle (D)	-11.8357	60.5

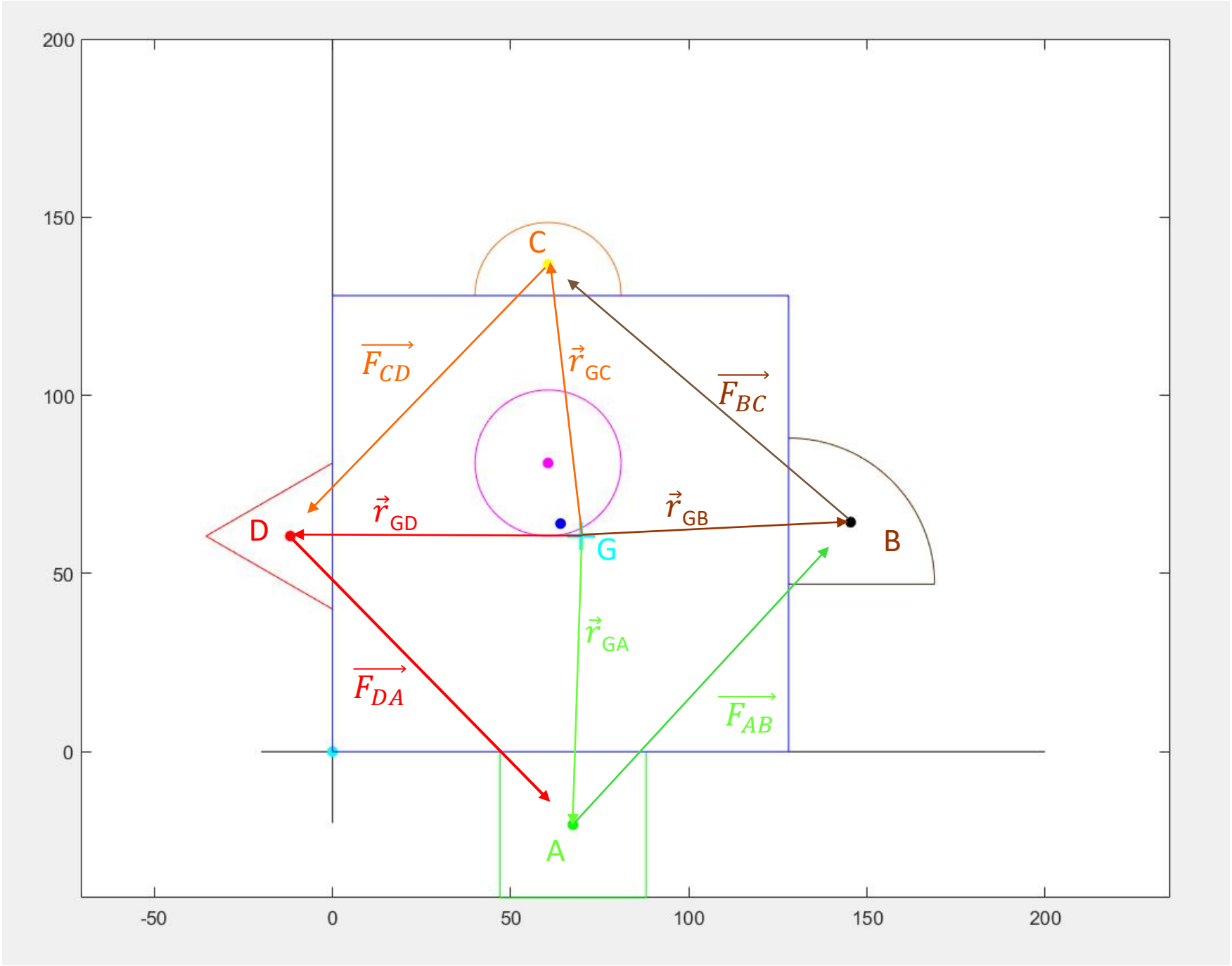
GA (y2-y1)	1.55821741	GA (x2-x1)	-81.16547279
GB (y2-y2)	79.46801741	GB (x2-x2)	3.744327208
GC (y2-y1)	-5.44178259	GC (x2-x1)	76.03942721
GD (y2-y1)	-77.77748259	GD (x2-x1)	-0.165472792

CROSS PRODUCT			
GA	X	Fab	(0,0,-66.33)
GB	X	Fbc	(0,0,-55.46)
GC	X	Fcd	(0,0,44.64)
GD	X	Fda	(0,0,55.44)

	mag*cos(theta)	mag*sin(theta)
Fab	0.736829508	0.803039353
Fbc	0.735493583	0.798414037
Fcd	0.643525514	0.541039645
Fda	0.714408131	0.729394946

G	(0 , 0 , -21.71)

As seen from the diagram, and the moment obtained, we can conclude that the figure moves in a clockwise direction.


200
150
100
50
0
-50
0
50
100
150
200
C
D
B
G
A
$\overrightarrow{F_{CD}}$
$\vec{r}_{GC}$
$\overrightarrow{F_{BC}}$
$\vec{r}_{GD}$
$\vec{r}_{GB}$
$\vec{r}_{GA}$
$\overrightarrow{F_{DA}}$
$\overrightarrow{F_{AB}}$

MATLAB CODE:

```
%Clear Command Window
clc;
%Clears Workspace
clear all;

% Centroid of individual figures wrt Centroid of Composite figure
A = [-2.1495 -81.0028];
B = [75.7514 3.8981];
C = [9.1495 76.1977];
D = [-81.4852 -0.0028];

% X2-X1
AB_x = [B([1])- A([1])];
BC_x = [C([1])- B([1])];
CD_x = [D([1])- C([1])];
DA_x = [A([1])- D([1])];
% Y2-Y1
AB_y = [B([2])- A([2])];
BC_y = [C([2])- B([2])];
CD_y = [D([2])- C([2])];
DA_y = [A([2])- D([2])];

% Magnitude (slope, y2-y1/x2-x1)
Magnitude_AB = abs(AB_y/AB_x);
Magnitude_BC = abs(BC_y/BC_x);
Magnitude_CD = abs(CD_y/CD_x);
Magnitude_DA = abs(DA_y/DA_x);

% Angles tan(theta) = ..... , theta = tanInverse(.....)
ThetaAB = atand(Magnitude_AB);
ThetaBC = atand(Magnitude_BC);
ThetaCD = atand(Magnitude_CD);
ThetaDA = atand(Magnitude_DA);

% Angles wrt +ve x-axis
Theta_AB = ThetaAB;
Theta_BC = 180 - ThetaBC;
Theta_CD = 180 + ThetaCD;
Theta_DA = 360 - ThetaDA;

x1 = abs(Magnitude_AB*cosd(Theta_AB)); y1 = abs(Magnitude_AB*sind(Theta_AB));
x2 = abs(Magnitude_BC*cosd(Theta_BC)); y2 = abs(Magnitude_BC*sind(Theta_BC));
x3 = abs(Magnitude_CD*cosd(Theta_CD)); y3 = abs(Magnitude_CD*sind(Theta_CD));
x4 = abs(Magnitude_DA*cosd(Theta_DA)); y4 = abs(Magnitude_DA*sind(Theta_DA));

% Individual forces
F_AB = [x1 y1 0];
F_BC = [x2 y2 0];
F_CD = [x3 y3 0];
F_DA = [x4 y4 0];

% Resultant force acting on the composite area
F = F_AB + F_BC + F_CD + F_DA
```

```
    % Centroid of individual figures wrt initial (0,0)
    A = [67.5 -20.5 0];
    B = [145.40984 64.4098 0];
    C = [60.5 136.7049 0];
    D = [-11.8357 60.5 0];

    % Centroid of composite figure
    G = [65.94178259 60.66547279 0];

    % X2-X1
    GA_x = [A([2])- G([2])];
    GB_x = [B([2])- G([2])];
    GC_x = [C([2])- G([2])];
    GD_x = [D([2])- G([2])];
    % Y2-Y1
    GA_y = [A([1])- G([1])];
    GB_y = [B([1])- G([1])];
    GC_y = [C([1])- G([1])];
    GD_y = [D([1])- G([1])];

    GA = [GA_x GA_y 0];
    GB = [GB_x GB_y 0];
    GC = [GC_x GC_y 0];
    GD = [GD_x GD_y 0];

    % Individual Moments
    M_A = cross(GA , F_AB);
    M_B = cross(GB , F_BC);
    M_C = cross(GC , F_CD);
    M_D = cross(GD , F_DA);

    % Resultant moment acting on the composite area about the centroid(G)
    M = M_A + M_B + M_C + M_D

```

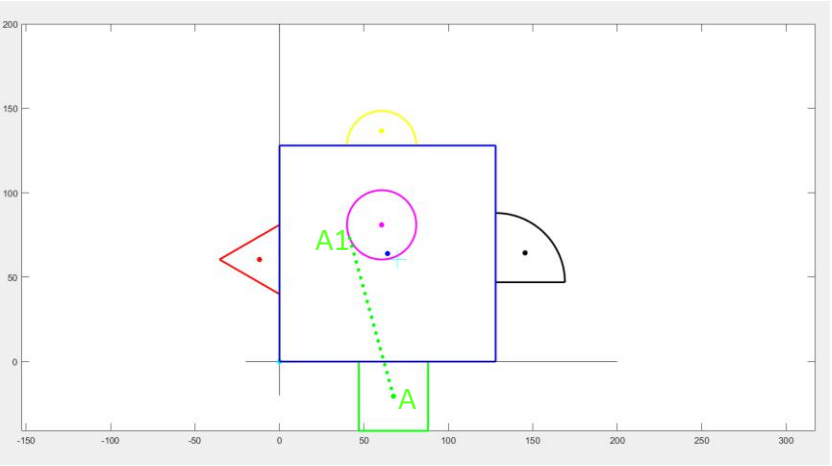
OUTPUT:

Command Window

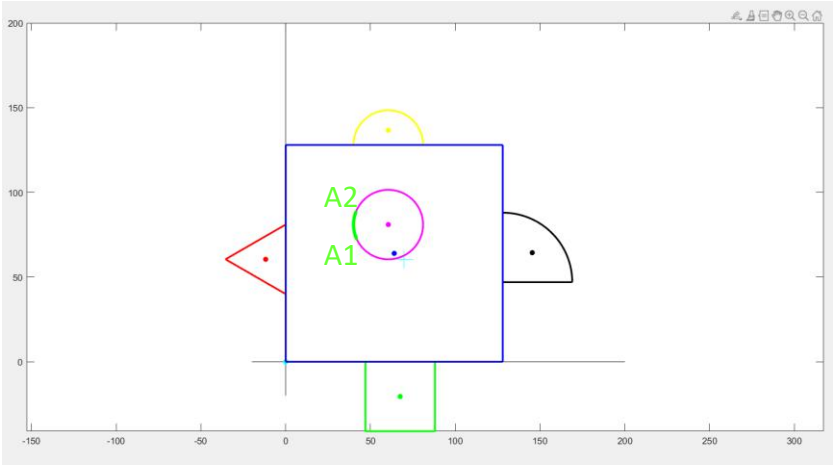
```
M_A =

                   0                   0 -66.327209347390180


M_B =

                   0                   0 -55.458722887254609


M_C =

                   0                   0   44.642270671743226


M_D =

                   0                   0   55.444170971899133


M =

                   0                   0 -21.699490591002437
```

KINEMATCS OF PARTICLES

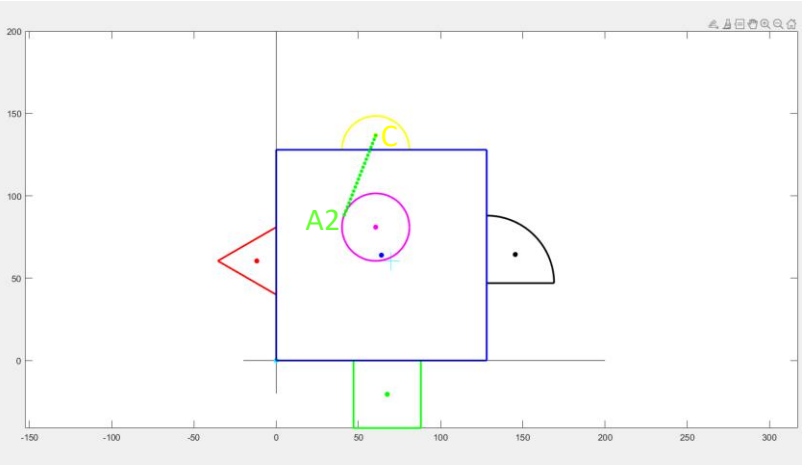
A → A1 → A2 → C



The particle has a Linear movement from A to A1

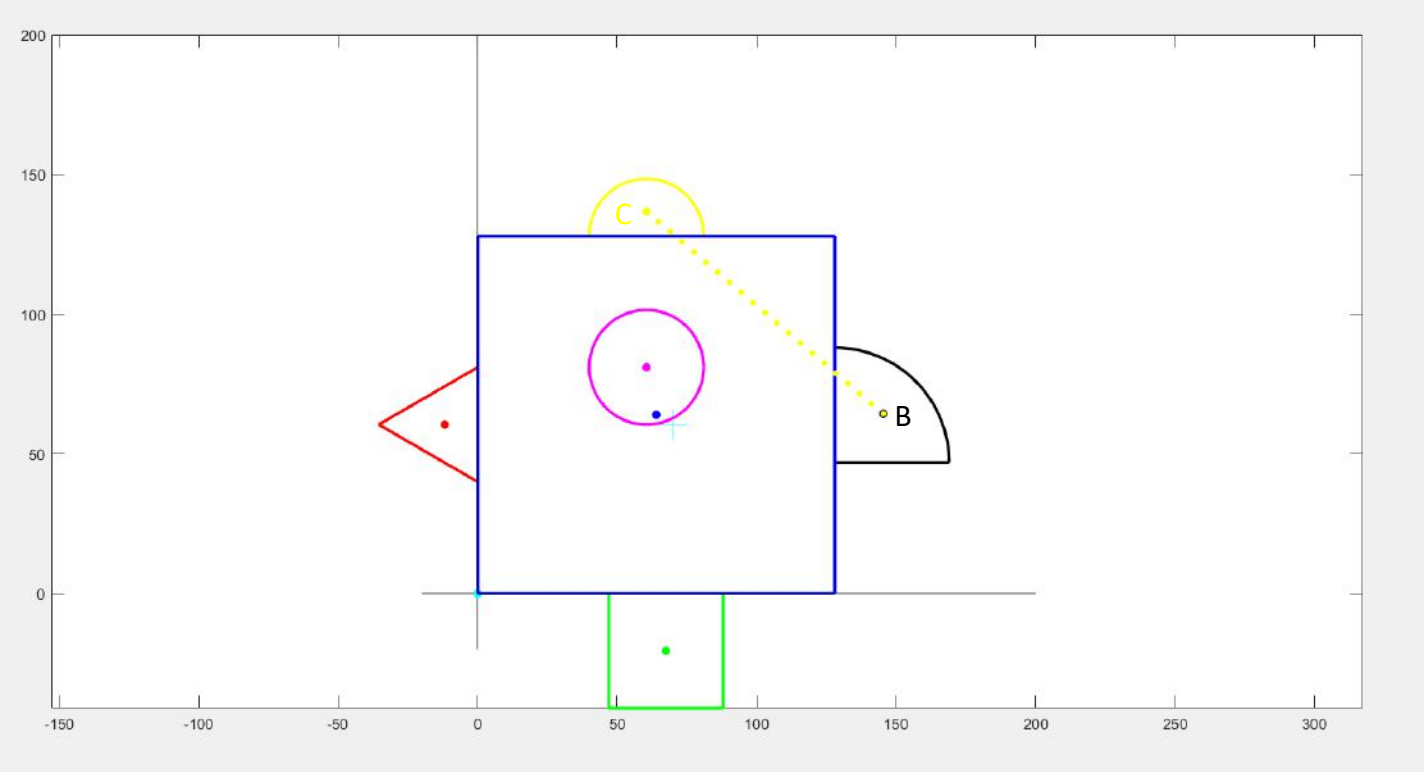


The particle has a Circular movement from A1 to A2



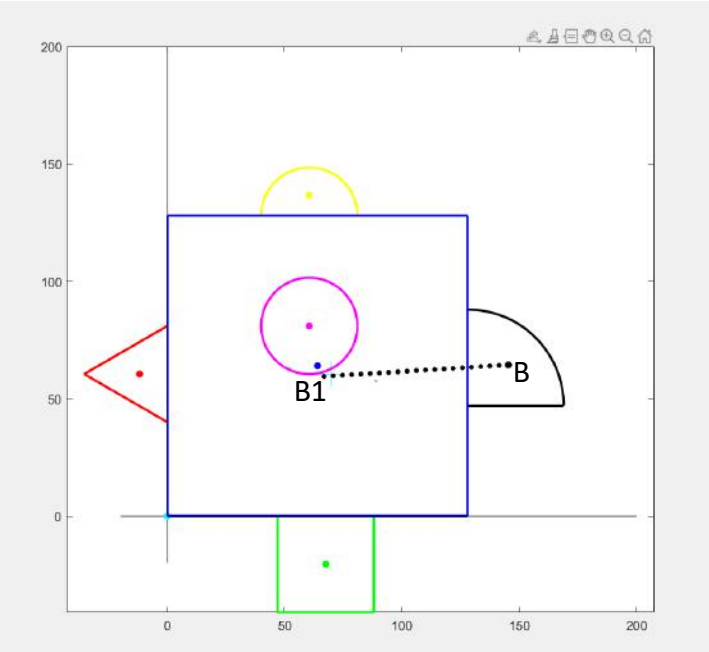
The particle has a Linear movement from A2 to C

C ⟶ B

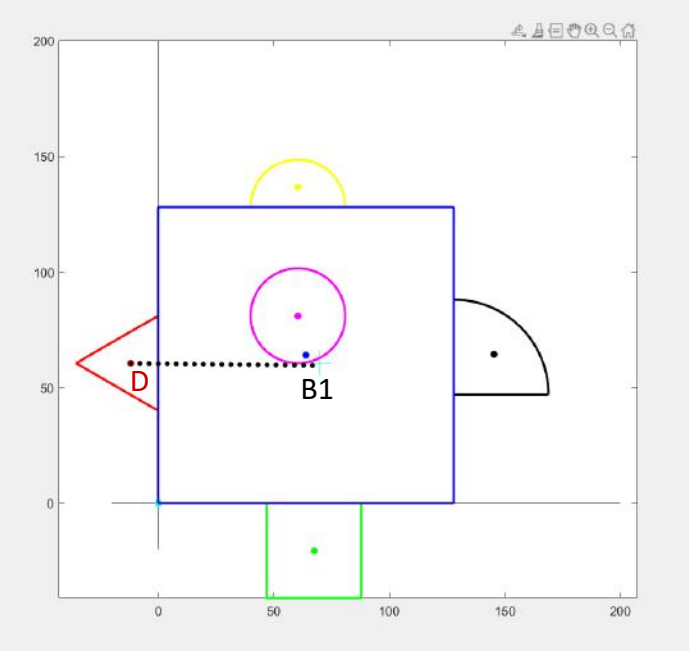


The particle has a Linear movement from C to B

B ⟶ B1 ⟶ D

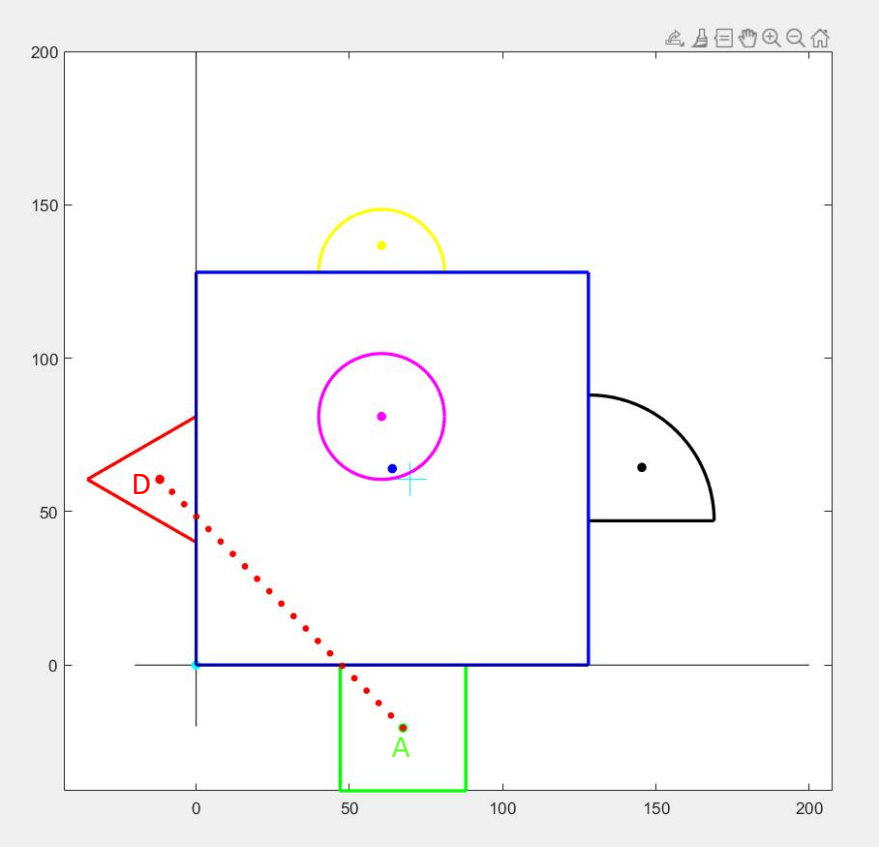


The particle has a Linear movement from B to B1



The particle has a Linear movement from B1 to D

D ⟶ A



The particle has a Linear movement from D to A

MATLAB CODE:

```
%Clear Command Window
clc;
%Clears Workspace
clear all;
%Clears Figure Window
clf;

% create axes (X-Axis ans Y-Axis)
plot([-20 200] , [0 0] , 'k');
hold on;
plot([0 0] , [-20 200] , 'k');
hold on;
axis equal;

% Assuming the Centroid of the whole system to be the origin
Assumed_Centroid = [0 0];
plot(Assumed_Centroid(1) , Assumed_Centroid(2) , 'c.', 'MarkerSize', 20);
hold on;

% Centroid of the Whole figure
Centroid = [69.6495  60.5028];
plot(Centroid(1) , Centroid(2) , 'c.', 'MarkerSize', 20);
hold on;

% Plot the Small Square (A)
x = [47 88 88 47 47];
y = [0 0 -41 -41 0];
plot(x,y,'g', 'LineWidth',2);
hold on;
% Marking the Centroid of the Small Square
A = [67.5 -20.5];
plot(A(1) , A(2) , 'g.', 'MarkerSize', 20);
hold on;

% Plot the Quarter Circle (B)
R = 41. ;
D = [128. 47.] ;
% angle
theeta = 90:-1:0 ;
% points of circle
xc = D(1)+R*cosd(theeta) ;
yc = D(2)+R*sind(theeta) ;
%Plot curve of Quarter Circle
plot(xc,yc, 'k', 'LineWidth',2);
% plot line of Quarter Circle ([x1 x2] , [y1 y2])
plot([128 169], [47 47], 'k', 'LineWidth',2);
hold on;
% Marking the Centroid of the Quarter circle
D = [145.4098 64.4098];
plot(D(1) , D(2) , 'k.', 'MarkerSize', 20);
hold on;
```

```
    % Plot the Semi Circle (C)
    theeta = linspace( 0, pi, 100);
    R = 20.5;
    x = R*cos(theeta) + 60.50;
    y = R*sin(theeta) + 128;
    plot(x,y,'y', 'LineWidth',2);
    % Marking the Centroid of the Semi Circle
    D = [60.5 136.7049];
    plot(D(1) , D(2) , 'y.', 'MarkerSize', 20);
    hold on;

    % Plot the Triangle (D)
    D1 = plot([0 -35.5070], [40 60.5], 'Color', 'r', 'LineWidth',2);
    hold on;
    D2 = plot([-35.5070 0], [60.5 81], 'Color', 'r', 'LineWidth',2);
    hold on;
    D3 = plot([0 0], [81 40], 'Color', 'r', 'LineWidth',2);
    hold on;
    % Marking the Centroid of the triangle
    D = [-11.8357 60.5];
    plot(D(1) , D(2) , 'r.', 'MarkerSize', 20);
    hold on;

    % Plot the circle (E)
    x = 60.5;
    y = 81;
    radius = 20.5;
    Theeta=0:0.01:2*pi;
    xt=radius*cos(Theeta);
    yt=radius*sin(Theeta);
    plot(x+xt, y+yt,'m', 'LineWidth',2);
    % Marking the Centroid of the circle
    E = [60.5 81];
    plot(E(1) , E(2) ,'m.', 'MarkerSize', 20);
    hold on;

    % Plot the big Square (F)
    F1 = plot([0 0],[128 0], 'b', 'LineWidth',2);
    hold on;
    F2 = plot([128 0],[128 128], 'b', 'LineWidth',2);
    hold on;
    F3 = plot([128 128],[0 128], 'b', 'LineWidth',2);
    hold on;
    F4 = plot([0 128],[0 0], 'b', 'LineWidth',2);
    axis equal;
    hold on;
    % Marking the Centroid of the Big Square
    F = [64 64];
    plot(F(1) , F(2) , 'b.', 'MarkerSize', 20);
    hold on;
```

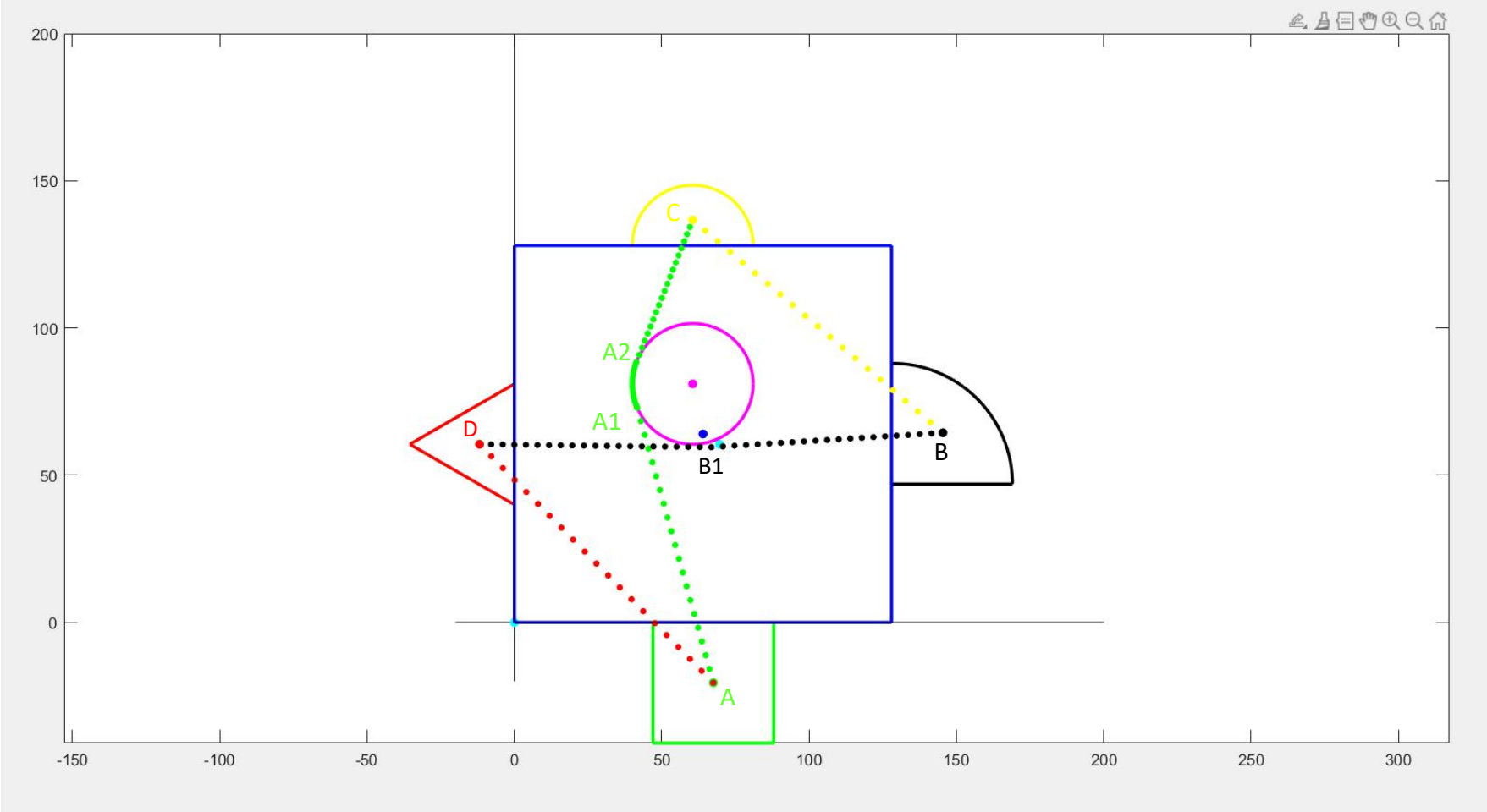
```
% Animation
% From A to C
A=[67.5;-20.5];
A1=[41.6056;73.047];
for lambda=0:0.05:1
    x=(1-lambda)*A+ lambda*A1;
    plot(x(1,1), x(2,1), 'g.', 'MarkerSize', 14)
    pause(0.05);
    hold on
    % Command taken for equal distribution of points in x and y
    axis('equal')
    plot([0,200],[0,0],'k') % plot line from(0,0) to (200,0)
    plot([0,0],[0,150],'k') % plot line from (0,0) to (0,150)
    drawnow
end
ThetaArray = linspace((((360-156.42)*pi)/180),(159.46*pi)/180,180);
LengthOfThetaArray = length(ThetaArray);
r = 20.5;
%For moving outside the circle
for index = 1:1:LengthOfThetaArray
    theta = ThetaArray(index);
    x = 60.5+r*cos(theta);
    y = 81+r*sin(theta);
    plot(x, y, 'g.','MarkerSize', 12);
    drawnow;
    pause(0);
end
```

```
A2=[41.3991;88.4435];
C=[60.5;136.705];
for lambda=0:0.05:1
    x=(1-lambda)*A2+ lambda*C;
    plot(x(1,1), x(2,1), 'g.', 'MarkerSize',14)
    pause(0.05);
    hold on
    % Command taken for equal distribution of points in x and y
    axis('equal')
    plot([0,200],[0,0],'k') % plot line from(0,0) to (200,0)
    plot([0,0],[0,150],'k') % plot line from (0,0) to (0,150)
    drawnow
end

% From C to B
C=[60.5;136.705];
B=[145.41;64.4098];
for lambda=0:0.05:1
    x=(1-lambda)*C+ lambda*B;
    plot(x(1,1), x(2,1), 'y.', 'MarkerSize', 14)
    pause(0.05);
    hold on
    % Command taken for equal distribution of points in x and y
    axis('equal')
    plot([0,200],[0,0],'k') % plot line from(0,0) to (200,0)
    plot([0,0],[0,150],'k') % plot line from (0,0) to (0,150)
    drawnow
end
```

```
% From B to D
B=[145.41;64.4098];
B1=[66.8361;59.5108];
for lambda=0:0.05:1
    x=(1-lambda)*B+ lambda*B1;
    plot(x(1,1), x(2,1), 'k.', 'MarkerSize', 14)
    pause(0.05);
    hold on
    % Command taken for equal distribution of points in x and y
    axis('equal')
    plot([0,200],[0,0],'k') % plot line from(0,0) to (200,0)
    plot([0,0],[0,150],'k') % plot line from (0,0) to (0,150)
    drawnow
end
B1=[66.8361;59.5108];
D=[-11.8357;60.5];
for lambda=0:0.05:1
    x=(1-lambda)*B1+ lambda*D;
    plot(x(1,1), x(2,1), 'k.', 'MarkerSize', 14)
    pause(0.05);
    hold on
    % Command taken for equal distribution of points in x and y
    axis('equal')
    plot([0,200],[0,0],'k') % plot line from(0,0) to (200,0)
    plot([0,0],[0,150],'k') % plot line from (0,0) to (0,150)
    drawnow
end

```

```
% From D to A
D=[-11.8357;60.5];
A=[67.5;-20.5];
for lambda=0:0.05:1
    x=(1-lambda)*D+ lambda*A;
    plot(x(1,1), x(2,1), 'r.', 'MarkerSize', 14)
    pause(0.05);
    hold on
    % Command taken for equal distribution of points in x and y
    axis('equal')
    plot([0,200],[0,0],'k') % plot line from(0,0) to (200,0)
    plot([0,0],[0,150],'k') % plot line from (0,0) to (0,150)
    drawnow
end
```

OUTPUT:



Distance travelled by the particle:

MATLAB CODE:

```
%Clear Command Window
clc;
%Clears Workspace
clear all;

% From A to C
A=[67.5;-20.5];
A1=[41.6056;73.047];
A2=[41.3991;88.4435];
C=[60.5;136.705];

% From C to B
C=[60.5;136.705];
B=[145.41;64.4098];

% From B to D
B=[145.41;64.4098];
B1=[66.8361;59.5108];
D=[-11.8357;60.5];

% From D to A
D=[-11.8357;60.5];
A=[67.5;-20.5];

%Distance from A to C
d1 = norm(A-A1);
d2 = norm(A1-A2);
d3 = norm(A2-C);
D1 = d1+d2+d3


%Distance from C to B
D2 = norm(C-B)

%Distance from B to D
d4 = norm(B-B1);
d5 = norm(B1-D);
D3 = d4+d5

%Distance from D to A
D4 = norm(D-A)

Distance_travelled_by_particle = D1+D2+D3+D4
```

OUTPUT:

Command Window

```
D1 =

     1.643665299661436e+02


D2 =

     1.115181780833959e+02


D3 =

     1.574044943453363e+02


D4 =

     1.133805684166824e+02


Distance_travelled_by_particle =

     5.466697708115581e+02
```