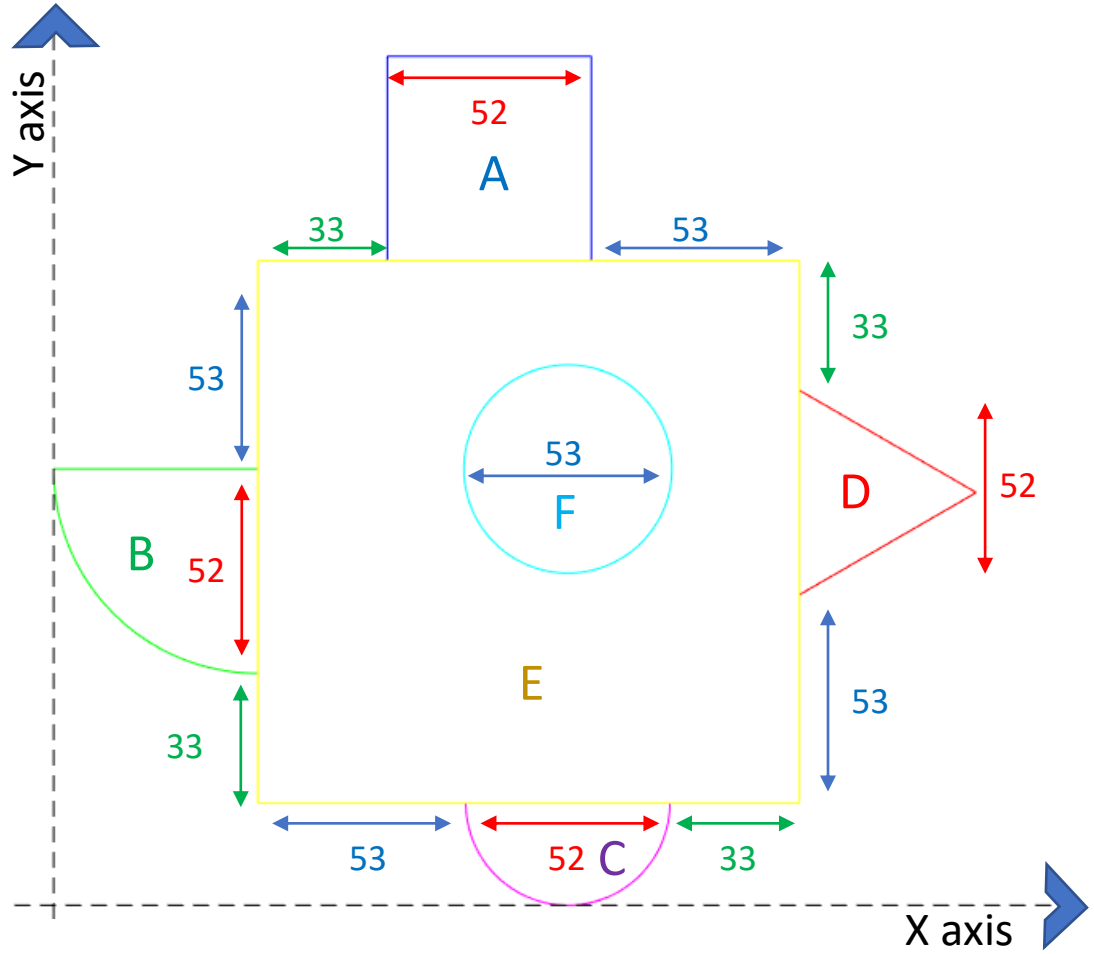
# Question

- For Team 11 we have a=53, b=52 and c=33. r= (11%3)+1= 3



# Centroid

| Figure/ Area Fi | xi | yi | Ai | xiAi | yiAi |
|---|---|---|---|---|---|
| A (Small square) | 111 | 190 | 2704 | 300144 | 513760 |
| B (Quarter Circle) | 29.93051 | 88.93051 | 2123.716634 | 63563.93 | 188863.2 |
| C (Semicircle) | 131 | 14.96526 | 1061.858317 | 139103.4 | 15890.98 |
| D (Triangle) | 205.01 | 105 | 1170.87 | 240040.1 | 122941.4 |
| E (Large square) | 121 | 95 | 19044 | 2304324 | 1809180 |
| F (Cut out Circle) | 131 | 111 | -2206.18344 | -289010 | -244886 |
| **Total** | | | **23898.26151** | **2758165** | **2405749** |

Centroid of composite figure:

$X = \sum(xiAi) / \sum(Ai)$

$= \underline{115.4128}$

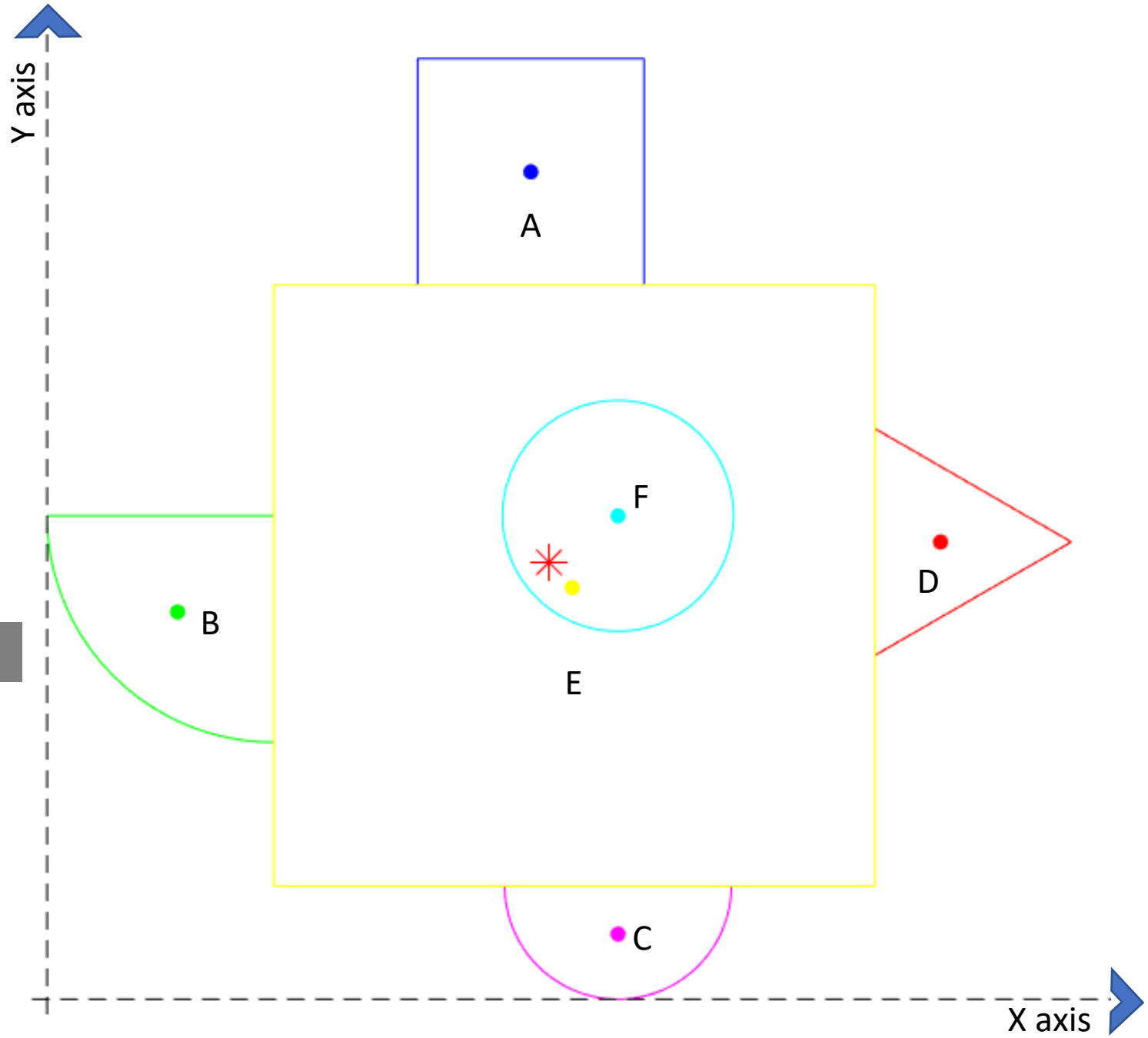
$Y = \sum(yiAi) / \sum(Ai)$

$= \underline{100.6663}$

# Centroid

Red star: Centroid of Composite area
Coordinates: G(115.4128, 100.6663)

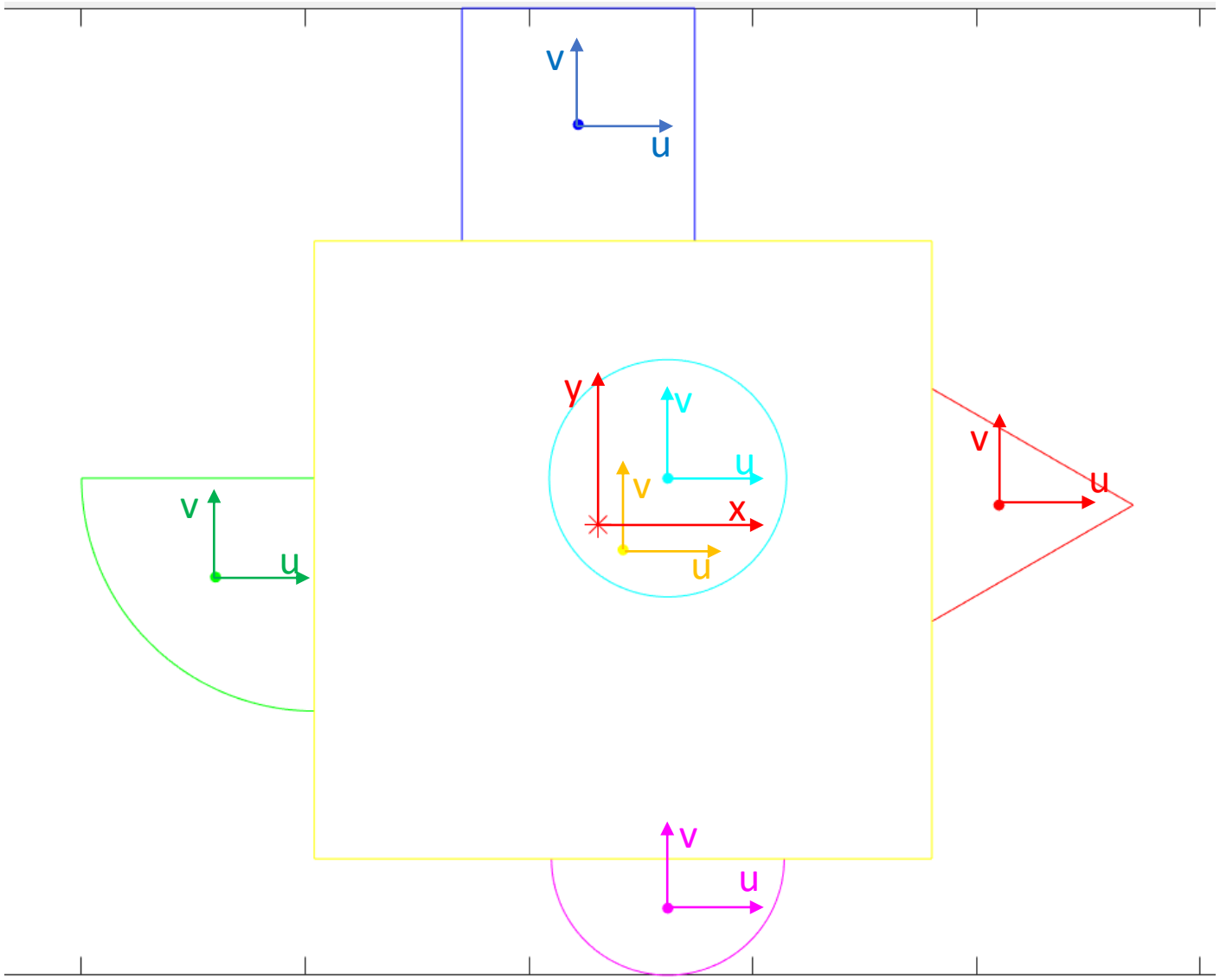
Coordinates: A(111, 190)
Coordinates: B(299.93051, 88.93051)
Coordinates: C(131,14.96526)
Coordinates: D(205.01, 105)
Coordinates: E(121,95)
Coordinates: F(131,111)



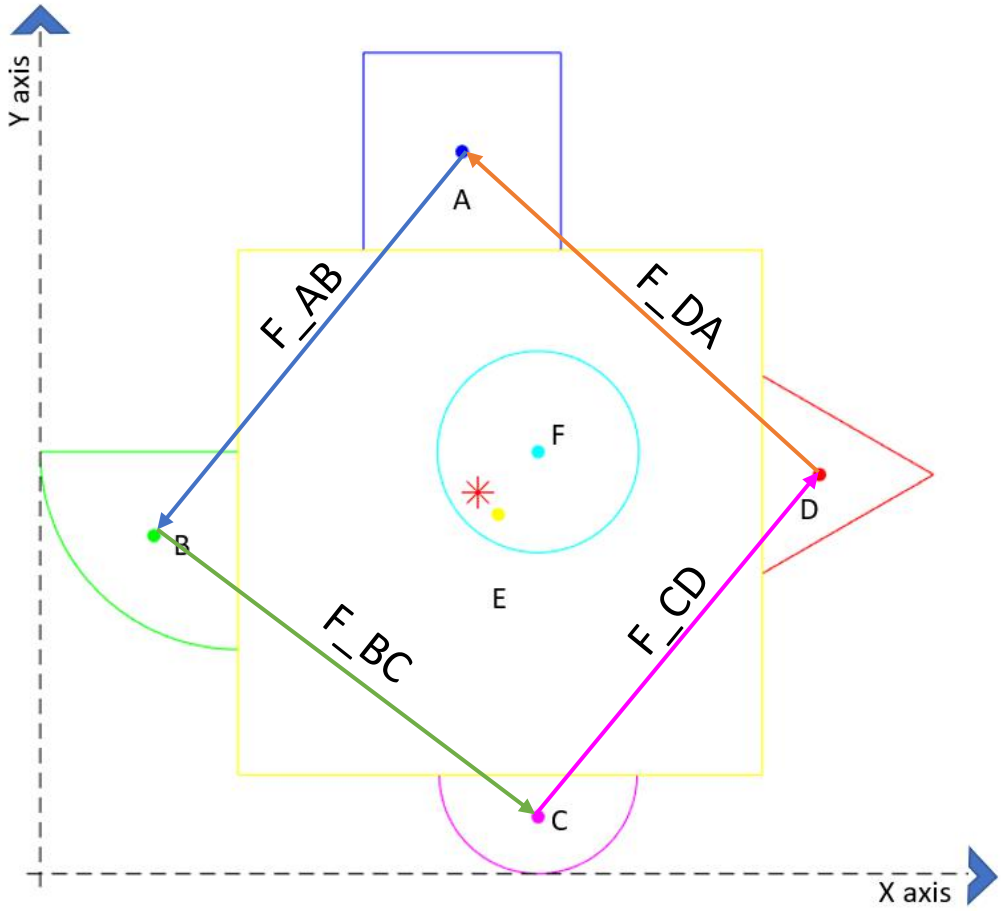
# Moment of Inertia (Area)

| Figure/ Area Fi | dxi | dyi | Iui | Ivi | Ixi | Iyi |
|---|---|---|---|---|---|---|
| A (Small square) | 4.412805 | 89.33372 | 609301.33 | 609301.33 | 22188608 | 661955.9 |
| B (Quarter Circle) | 85.48229059 | 11.7357696 | 401261.48 | 401261.48 | 693757.3363 | 7849171 |
| C (Semicircle) | 15.58719 | 85.70103 | 50175.96 | 179363.08 | 7849171 | 437352 |
| D (Triangle) | 4.333716 | 4.333716 | 131907.88 | 131888.42 | 153898.1 | 153878.6 |
| E (Large square) | 5.587195 | 5.666284 | 30222828 | 30222828 | 30834269 | 30817320 |
| F (Cut out Circle) | 15.58719 | 10.33372 | 387126.72 | 387126.72 | -622716 | -923142 |
| **Total (MOI)** | | | | **Ix= 61096988** | | **Iy= 47067095** |

# Moment of Inertia (Area)



# Resultant Force on Rigid Body



# Resultant Force on Rigid Body

| Fab=Fb-Fa | Fbc=Fc-Fb | Fcd=Fd-Fc | Fda=Fa-Fd | Resultant |
|---|---|---|---|---|
| -81.06948544 | 101.0694854 | 74.01 | -94.01 | 0 |
| -101.0694854 | -73.96525728 | 90.03474272 | 85 | 0 |

# Resultant Moment on Rigid Body about Centroid

| | R | F |
|---|---|---|
| | AB | |
| x | -4.412805151 | -81.06948545 |
| y | 89.33371584 | -101.0694854 |
| | | |
| | BC | |
| x | -85.48229059 | 101.0694855 |
| y | -11.7357696 | -73.96525725 |

| | R | F |
|---|---|---|
| | CD | |
| x | 15.58719485 | 74.01000133 |
| y | -85.70102688 | 90.03474163 |
| | | |
| | DA | |
| x | 89.59719485 | -94.01 |
| y | 4.333715844 | 85 |

| M_AB | M_BC | M_CD | M_DA | Total moment about centroid |
|---|---|---|---|---|
| 7688.238322 | 7508.847809 | 7746.122174 | 8023.17418874444 | 30966.38249 |

The moment about centroid due to the forces is 30966.38249 Nm

The body rotates in an anti-clockwise direction due to the forces

# Excel Link

All calculations in the above problems have been done with the help of excel.

R and F were also obtained from excel

The cross product of R and F has been calculated separately and then values were entered

The link for excel:

Excel

# Kinematics of Particle

- We have animated the route: A → C → B → D → A.
- We have taken extra points A_mid, C_mid where line from A to C touches and leaves the circle, respectively.
- We have also taken B_mid, D_mid where line from B to D touches and leaves the circle, respectively.

# Kinematics of Particle

Figure of the particle after completing full motion (MATLAB)

- Total distance travelled:

A → A_mid=75.1082 units

A_mid → C_mid= 13.8754 units

C_mid → C=90.0098 units

C → B=125.2466 units

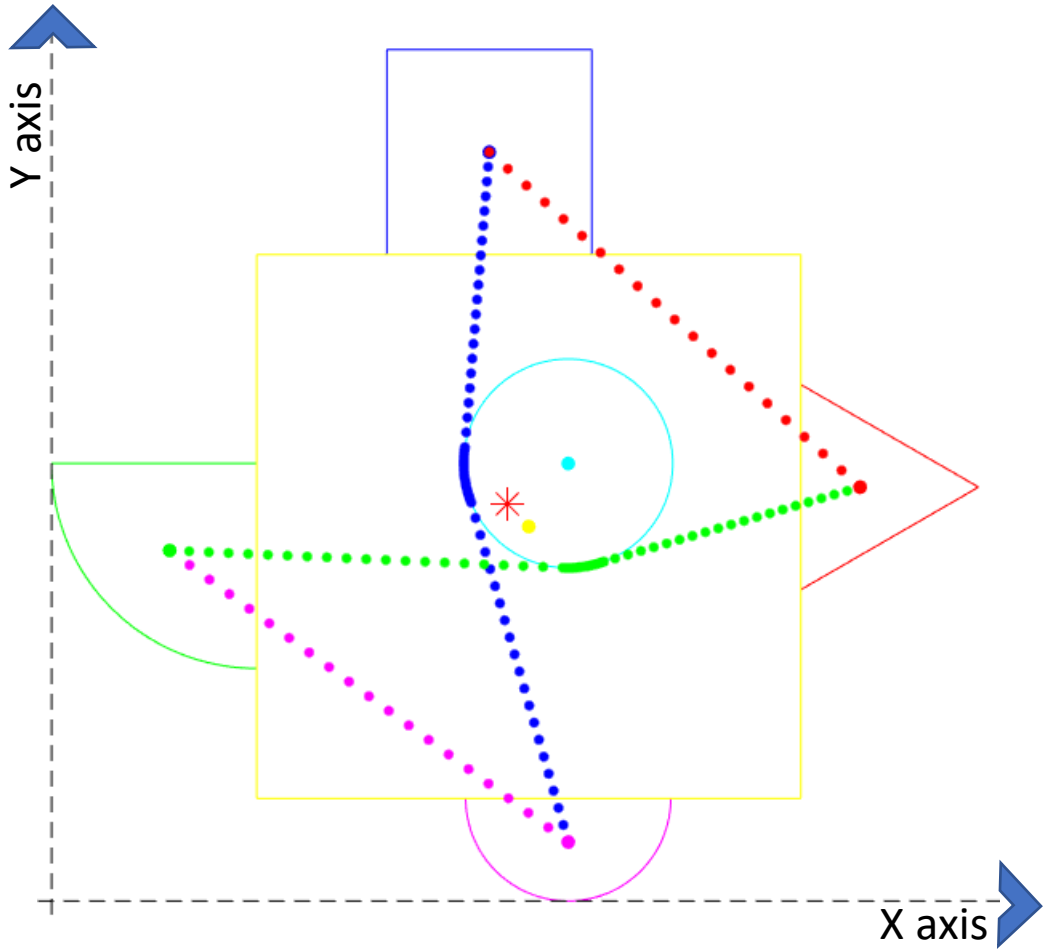
B → B_mid=99.7798 units

B_mid → D_mid=10.1753 units

D_mid → D=68.1025 units

D → A=126.7394 units

Total= 610.9754 units

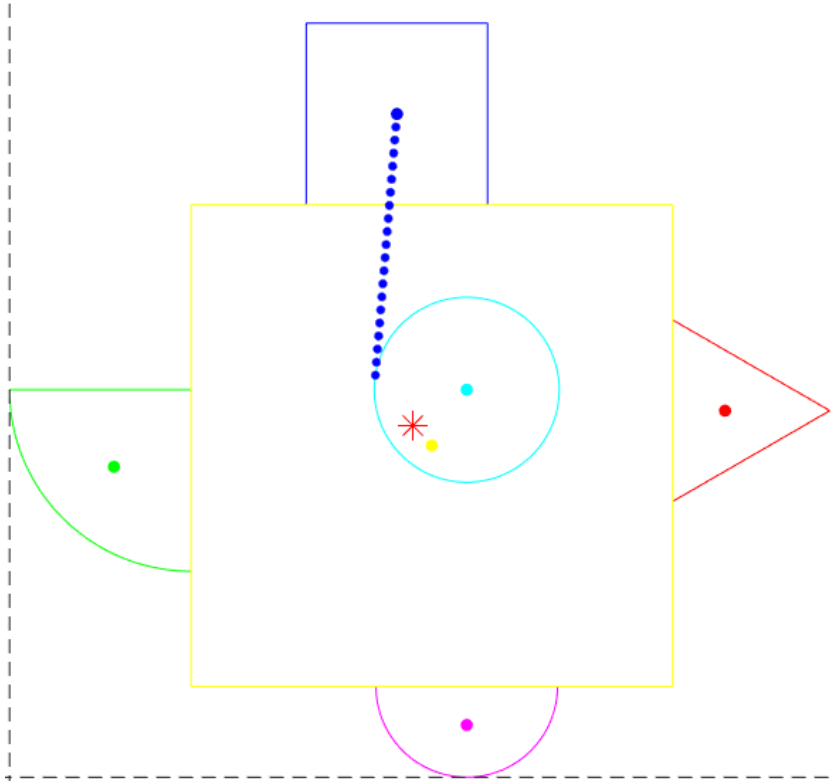



```
%Total distance
Distance=Dist_AtoA_mid+Dist_A_midtoC_mid+Dist_C_midtoC+Dist_CtoB+....
    Dist_BtoB_mid+Dist_B_midtoD_mid+Dist_D_midtoD+Dist_DtoA;
```

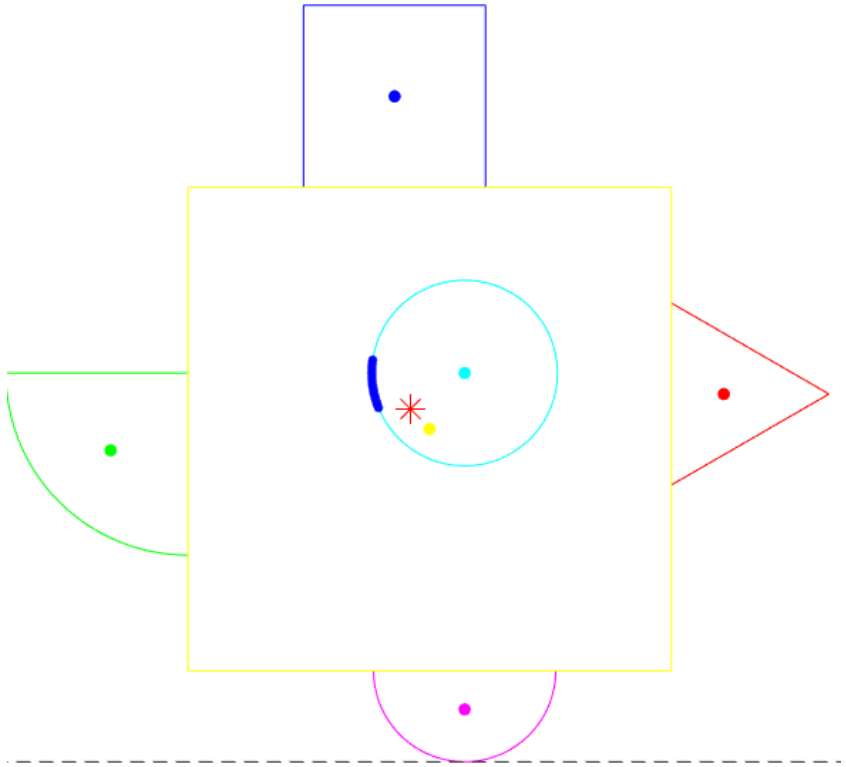
# Kinematics of Particle

- Motion between these:

A→ A_mid is linear



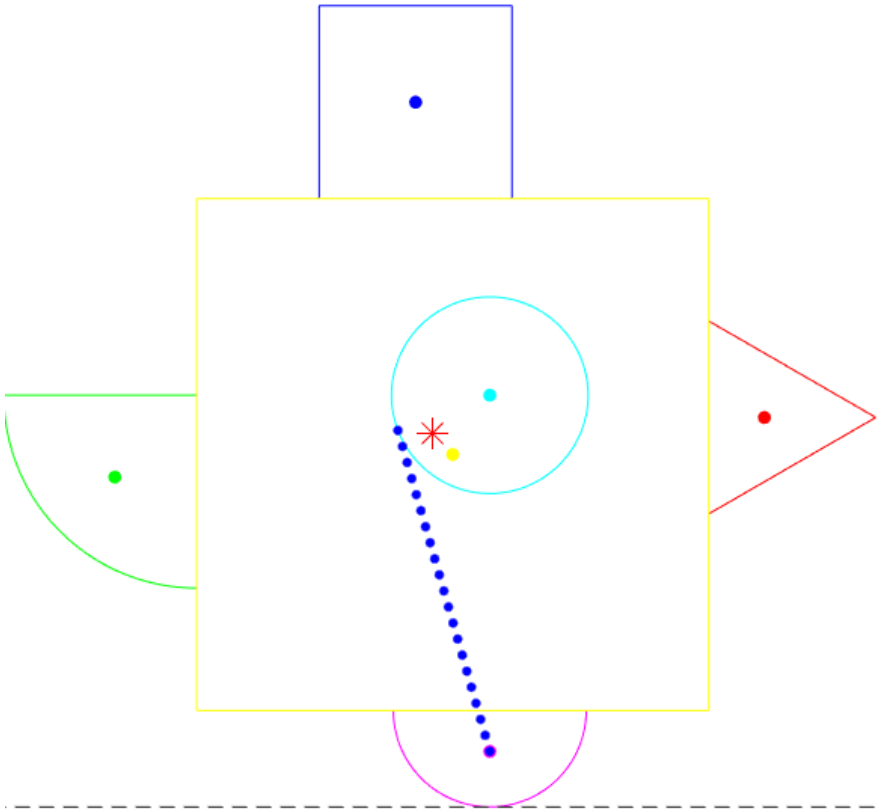
A_mid→ C_mid is circular



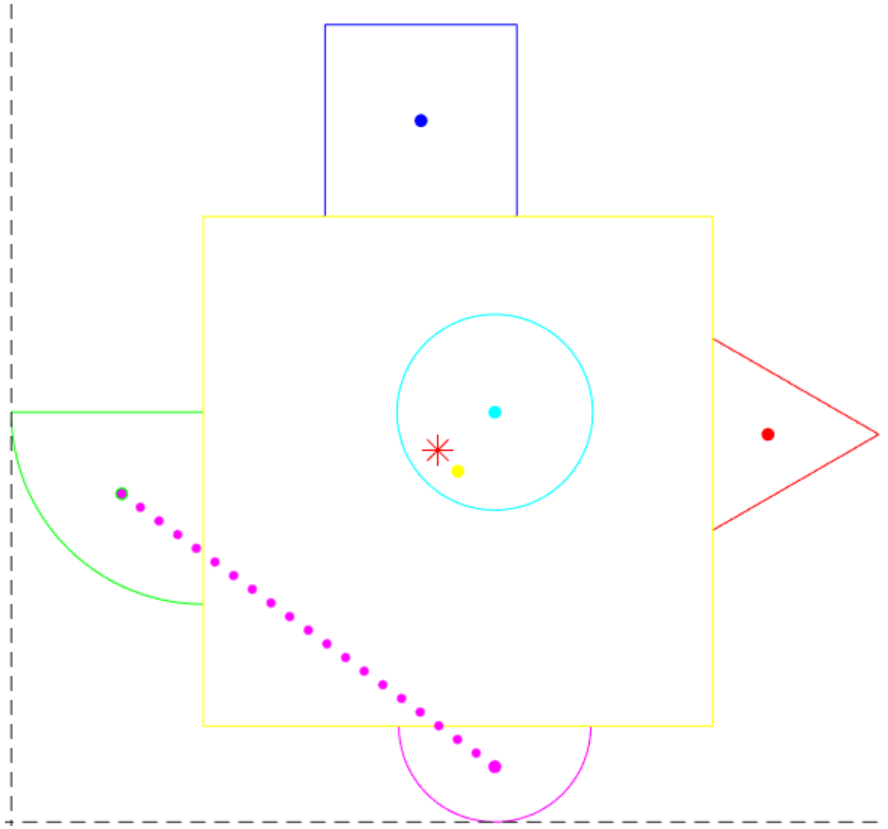
# Kinematics of Particle

- Motion between these:

C mid → C is linear



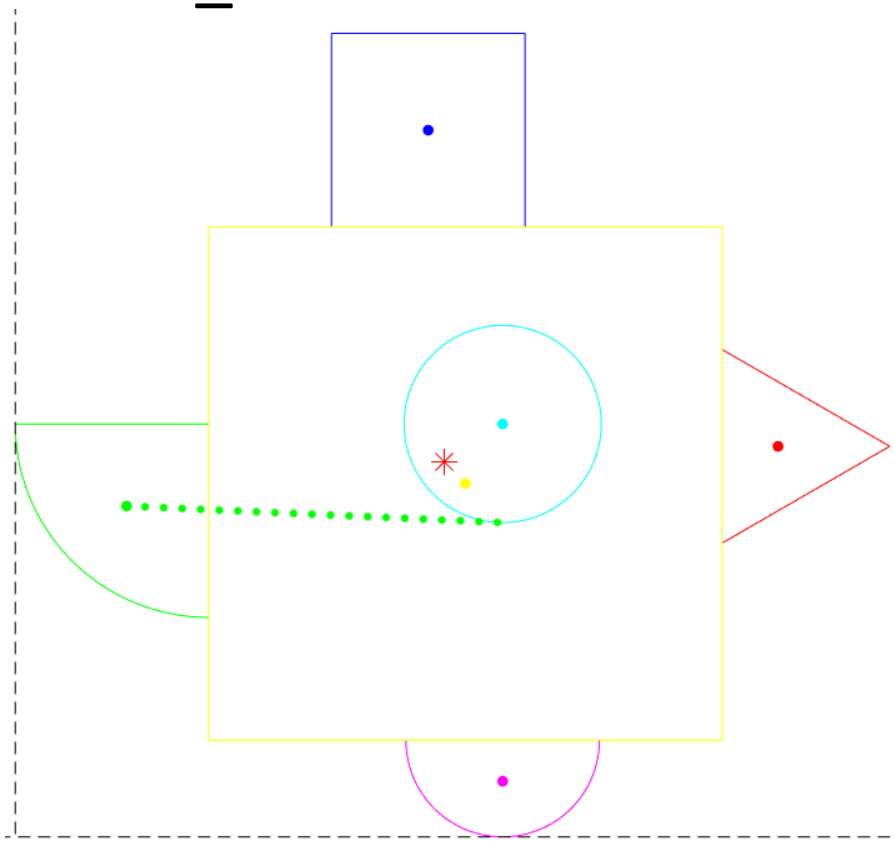
C→ B is linear



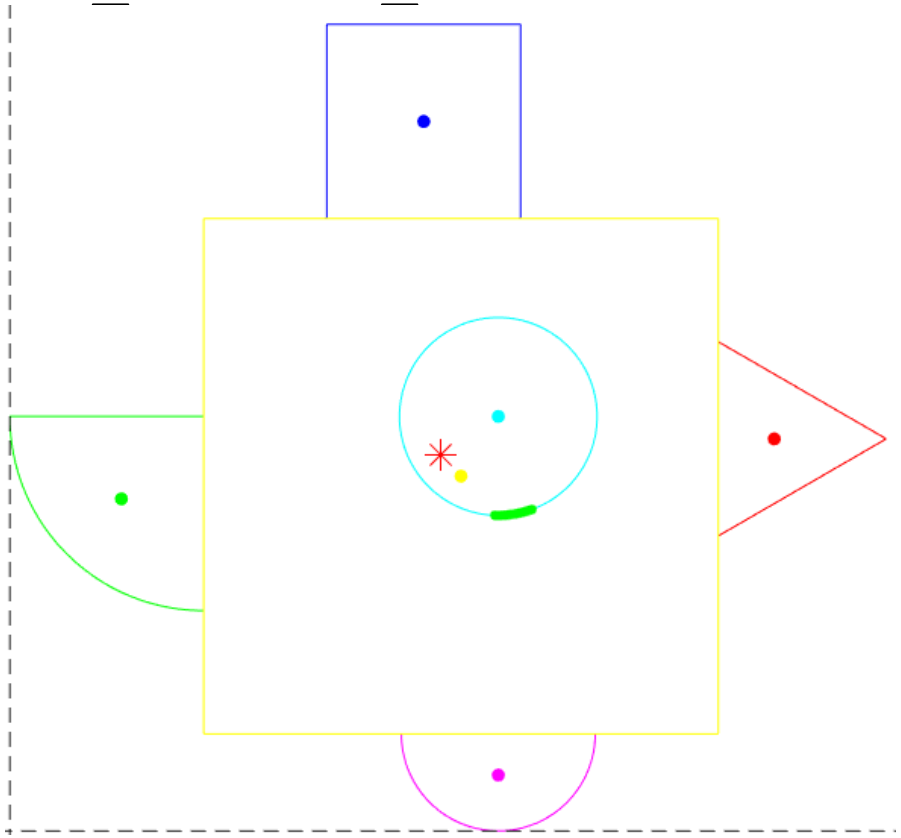
# Kinematics of Particle

- Motion between these:

B→ B_mid is linear



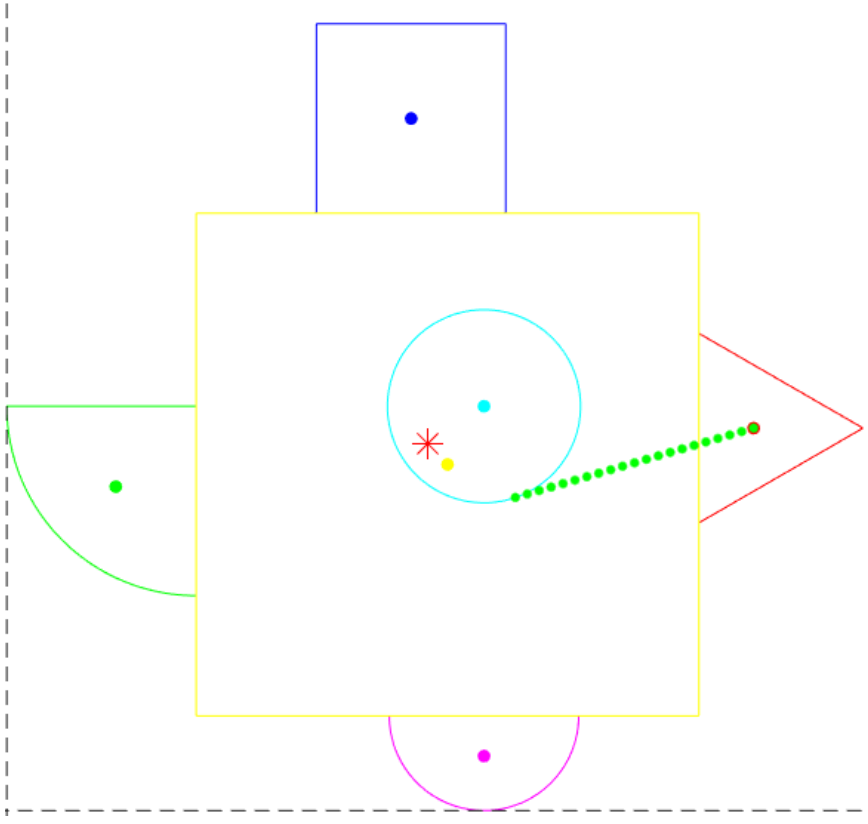
B_mid→ D_mid is circular



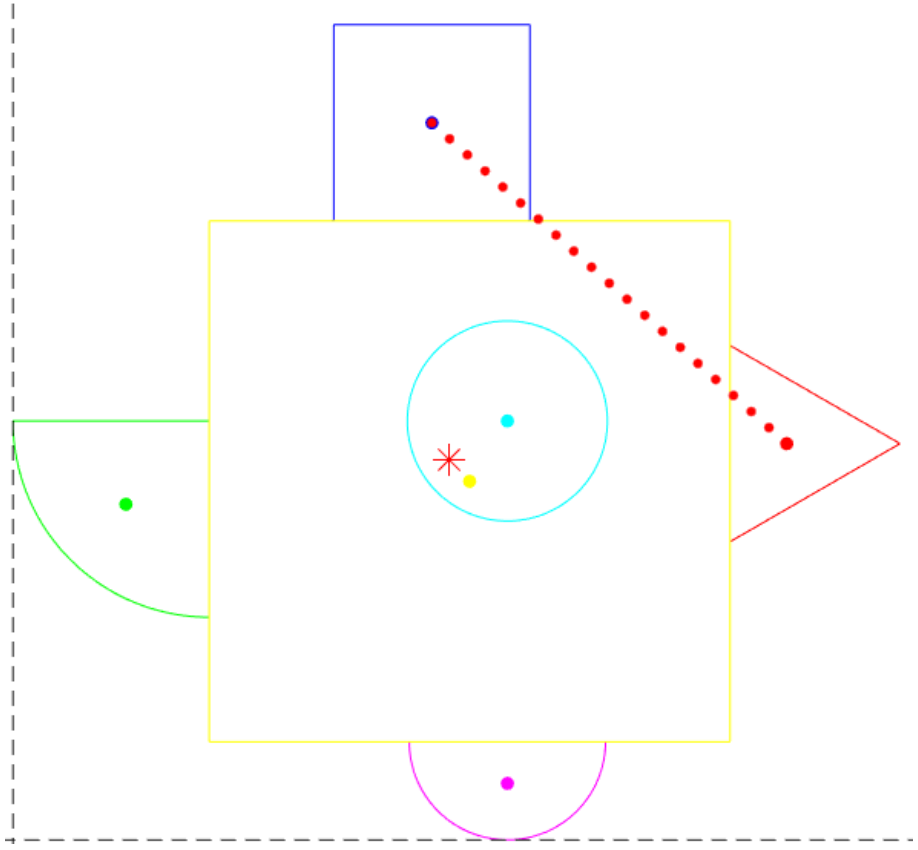
# Kinematics of Particle

- Motion between these:

D_mid→ D is linear



D→ A is linear



# Kinematics of Particle

Editor - C:\Users\angel\OneDrive\Documents\MATLAB\maths\physics\Phy proj\Phy_proj_Anima

Phy_proj_Animation.m

```
clc;clear all;clf;

% Let us plot all the figures
%Shape A: Small square with side 52 units
%Centroid of A
Ac=[111 190];
plot(Ac(1), Ac(2),'b.','MarkerSize',18);
hold on;
%Shape A plot
x_ofA=[85 85 137 137 85];
y_ofA=[164 216 216 164 164];
plot(x_ofA,y_ofA,'b');
hold on;

%Shape B: Quarter circle with radius 52
r_B=52;
Center_B_circle=[52, 111];
angle_B= 180:1:270
%Centroid of B
Bc=[29.93 88.93];
plot(Bc(1), Bc(2),'g.','MarkerSize',18);
hold on;
%Shape B plot
x_ofB = Center_B_circle(1)+r_B*cosd(angle_B) ;
y_ofB = Center_B_circle(2)+r_B*sind(angle_B) ;
plot(x_ofB ,y_ofB,'g');
plot([0 52], [111 111], 'g');
plot([52 52], [111 59], 'g');
hold on;
```

## MATLAB Program:

```
%Shape C: Semicircle with radius 26
r_C=26;
Center_C_circle=[131,26];
angle_C= 180:1:360;
%Centroid of C
Cc=[131 14.96];
plot(Cc(1), Cc(2),'m.','MarkerSize',18);
hold on;
%Shape C plot
x_ofC = Center_C_circle(1)+r_C*cosd(angle_C) ;
y_ofC = Center_C_circle(2)+r_C*sind(angle_C) ;
plot(x_ofC ,y_ofC,'m');
plot([105 157], [26 26],'m');
hold on;


%Shape D: Triangle with base 52 and height 45.03
%Centroid of D
Dc=[205.01 105];
plot(Dc(1), Dc(2),'r.','MarkerSize',18);
hold on;
%Shape D plot
x_ofD=[190 235.03 190 190];
y_ofD=[131 105 79 131];
plot(x_ofD,y_ofD,'r');
hold on;
```

# Kinematics of Particle

## MATLAB Program :

```
%Shape E: Main square with side 138 units
%Centroid of E
Ec=[121 95];
plot(Ec(1), Ec(2),'y.','MarkerSize',18);
hold on;
%Shape E plot
x_ofE=[52 52 190 190 52];
y_ofE=[26 164 164 26 26];
plot(x_ofE,y_ofE,'y');
hold on;

%Shape F: Circle cut out with radius 26.5
r_F=26.5;
Center_F_circle=[131,111];
angle_F= 0:1:360;
%Centroid of F
Fc=[131 111];
plot(Fc(1), Fc(2),'c.','MarkerSize',18);
hold on;
%Shape F plot
x_ofF = Center_F_circle(1)+r_F*cosd(angle_F) ;
y_ofF = Center_F_circle(2)+r_F*sind(angle_F) ;
plot(x_ofF ,y_ofF, 'c');
hold on;
```

```
%Now let us draw the x and y axis
plot([-10 300] , [0 0] , 'k--');
hold on;
plot([0 0] , [-10 300] , 'k--');
hold on;
axis equal;

%Now we plot centroid G of composite area
Gc=[115.4128,100.6663];
plot(Gc(1), Gc(2),'r*','MarkerSize',12);
hold on;
```

# Kinematics of Particle

## MATLAB Program :

```
%Now we animate the route
%A-->C-->B-->D-->A

%for A-->C
Ac=[111 190];
A_mid=[104.826 115.146];
C_mid=[106.26 101.503];
Cc=[131 14.96];
for lamda=0:0.05:1
x=(1-lamda)*Ac+lamda*A_mid;
plot(x(1,1),x(1,2),'b.', 'MarkerSize', 12) % plots one point
pause(0.05);
hold on
axis('equal') % command to take equal distribution of points in X and Y axis
drawnow
end
%Distance A to A_mid
Dist_AtoA_mid=sqrt((((A_mid(1)-Ac(1))^2)+((A_mid(2)-Ac(2))^2)));
```

# Kinematics of Particle

## MATLAB Program :

```
A_mid_angle=172;
C_mid_angle=202;
AngleAC=C_mid_angle-A_mid_angle;
ThetaArray = linspace((A_mid_angle*pi)/180,(C_mid_angle*pi)/180,180);
LengthOfThetaArray = length(ThetaArray);
r_F=26.5;
%For moving outside the circle
for index = 1:1:LengthOfThetaArray
    theta = ThetaArray(index);
    x = Fc(1)+r_F*cos(theta);
    y = Fc(2)+r_F*sin(theta);
    plot(x, y, 'b.','MarkerSize', 12);
    drawnow;
    pause(0);
end
%Distance A_mid to C_mid
Dist_A_midtoC_mid=r_F*((AngleAC*pi)/180);
```

# Kinematics of Particle

## MATLAB Program :

```
for lamda=0:0.05:1
x=(1-lamda)*C_mid+lamda*Cc;
plot(x(1,1),x(1,2),'b.', 'MarkerSize', 12) % plots one point
pause(0.05);
hold on
axis('equal') % command to take equal distribution of points in X and Y axis
drawnow
end
%Distance C_mid to C
Dist_C_midtoC=sqrt((((Cc(1)-C_mid(1))^2)+((Cc(2)-C_mid(2))^2)));
```

# Kinematics of Particle

## MATLAB Program :

```
%for C-->B
Cc=[131 14.96];
Bc=[29.93 88.93];
for lamda=0:0.05:1
x=(1-lamda)*Cc+lamda*Bc;
plot(x(1,1),x(1,2),'m.', 'MarkerSize', 12) % plots one point
pause(0.05);
hold on
axis('equal') % command to take equal distribution of points in X and Y axis
drawnow
end
%Distance C to B
Dist_CtoB=sqrt((((Bc(1)-Cc(1))^2)+((Bc(2)-Cc(2))^2)));
```

# Kinematics of Particle

## MATLAB Program :

```
%for B-->D
Bc=[29.93 88.93];
B_mid=[129.613 84.5363];
D_mid=[139.628 85.9438];
Dc=[205.01 105];
for lamda=0:0.05:1
x=(1-lamda)*Bc+lamda*B_mid;
plot(x(1,1),x(1,2),'g.', 'MarkerSize', 12) % plots one point
pause(0.05);
hold on
axis('equal') % command to take equal distribution of points in X and Y axis
drawnow
end
%Distance B to B_mid
Dist_BtoB_mid=sqrt((((B_mid(1)-Bc(1))^2)+((B_mid(2)-Bc(2))^2)));
```

# Kinematics of Particle

## MATLAB Program :

```
B_mid_angle=268;
D_mid_angle=290;
AngleBD=D_mid_angle-B_mid_angle;
ThetaArray = linspace((B_mid_angle*pi)/180,(D_mid_angle*pi)/180,180);
LengthOfThetaArray = length(ThetaArray);
r_F=26.5;
%For moving outside the circle
for index = 1:1:LengthOfThetaArray
    theta = ThetaArray(index);
    x = Fc(1)+r_F*cos(theta);
    y = Fc(2)+r_F*sin(theta);
    plot(x, y, 'g.','MarkerSize', 12);
    drawnow;
    pause(0);
end
%Distance B_mid to D_mid
Dist_B_midtoD_mid=r_F*((AngleBD*pi)/180);
```

# Kinematics of Particle

## MATLAB Program :

```
for lamda=0:0.05:1
x=(1-lamda)*D_mid+lamda*Dc;
plot(x(1,1),x(1,2),'g.', 'MarkerSize', 12) % plots one point
pause(0.05);
hold on
axis('equal') % command to take equal distribution of points in X and Y axis
drawnow
end
%Distance D_mid to D
Dist_D_midtoD=sqrt((((Dc(1)-D_mid(1))^2)+((Dc(2)-D_mid(2))^2)));
```

# Kinematics of Particle

## MATLAB Program :

```
%for D-->A
Dc=[205.01 105];
Ac=[111 190];
for lamda=0:0.05:1
x=(1-lamda)*Dc+lamda*Ac;
plot(x(1,1),x(1,2),'r.', 'MarkerSize', 12) % plots one point
pause(0.05);
hold on
axis('equal') % command to take equal distribution of points in X and Y axis
drawnow
end
%Distance D to A
Dist_DtoA=sqrt(((Dc(1)-Ac(1))^2)+((Dc(2)-Ac(2))^2));
```