Robot DELTA 2D

Jean Moulin
Lycée Béziers

$$\begin{cases} a^2\cos^2\alpha = (x - b\cos\beta)^2 \\ a^2\sin^2\alpha = (y - b\sin\beta)^2 \end{cases}$$

$$a^2(\cos^2\alpha + \sin^2\alpha) = x^2 + y^2 + b^2(\cos^2\beta + \sin^2\beta) - 2b(x\cos\beta + y\sin\beta)$$

$$a^2 = x^2 + y^2 + b^2 - 2b(x\cos\beta + y\sin\beta)$$

$$2b(x\cos\beta + y\sin\beta) = x^2 + y^2 + b^2 - a^2$$

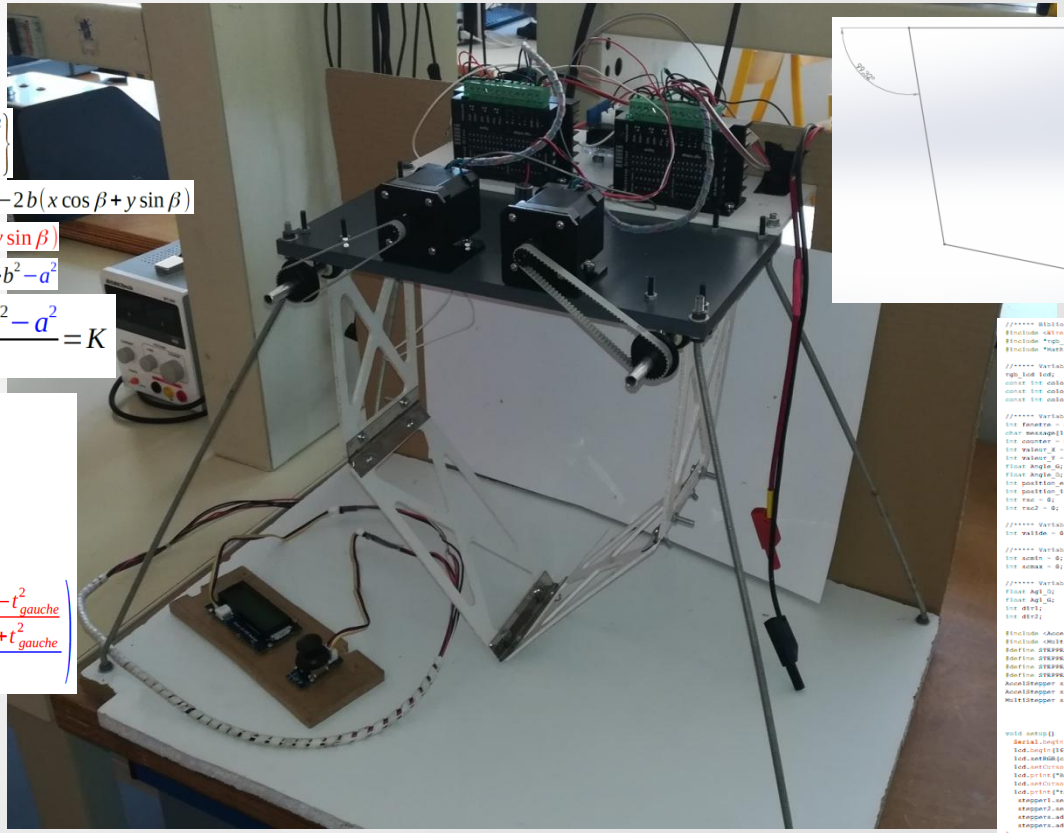
$$x\cos\beta + y\sin\beta = \frac{x^2 + y^2 + b^2 - a^2}{2b} = K$$

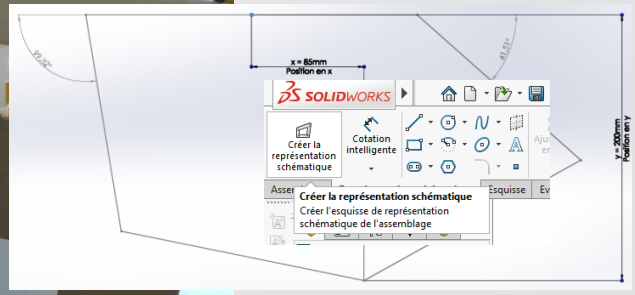
$$x_{gauche} = x + l_{demi-support}$$

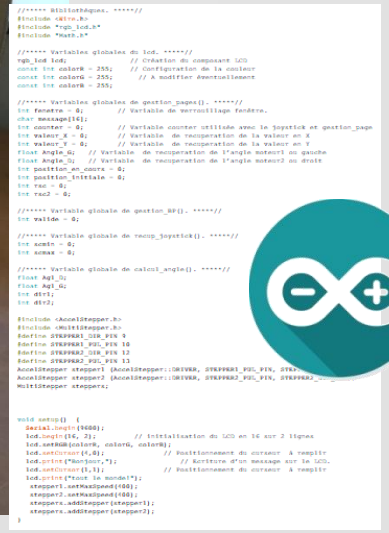
$$K_{gauche} = \frac{x_{gauche}^2 + y^2 + b^2 - a^2}{2b}$$

$$t_{gauche} = \frac{y + \sqrt{x_{gauche}^2 + y^2 - K_{gauche}^2}}{(K_{gauche} + x_{gauche})}$$

$$\alpha_{gauche} = 180 - \arccos\left(\frac{x_{gauche} - b\dfrac{1 - t_{gauche}^2}{1 + t_{gauche}^2}}{a}\right)$$







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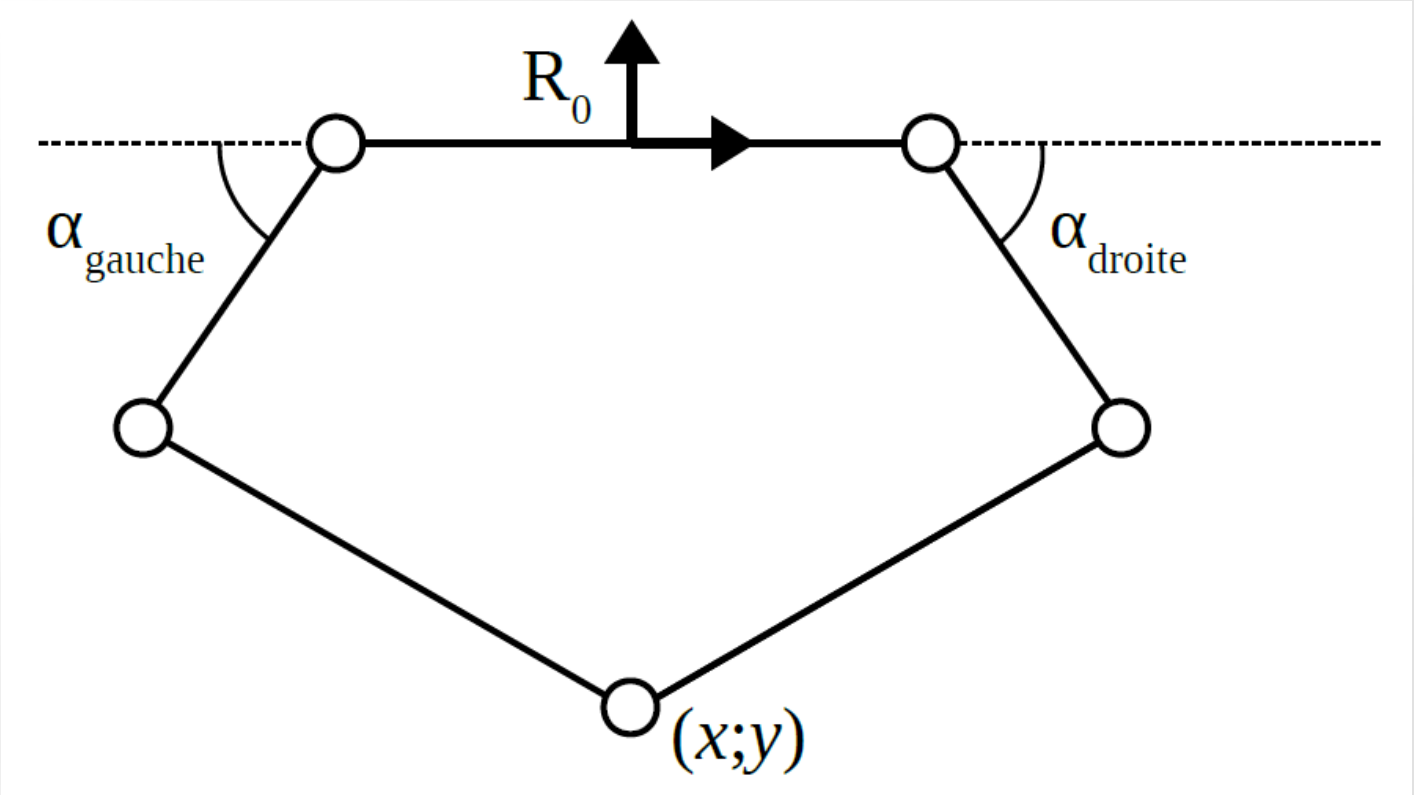
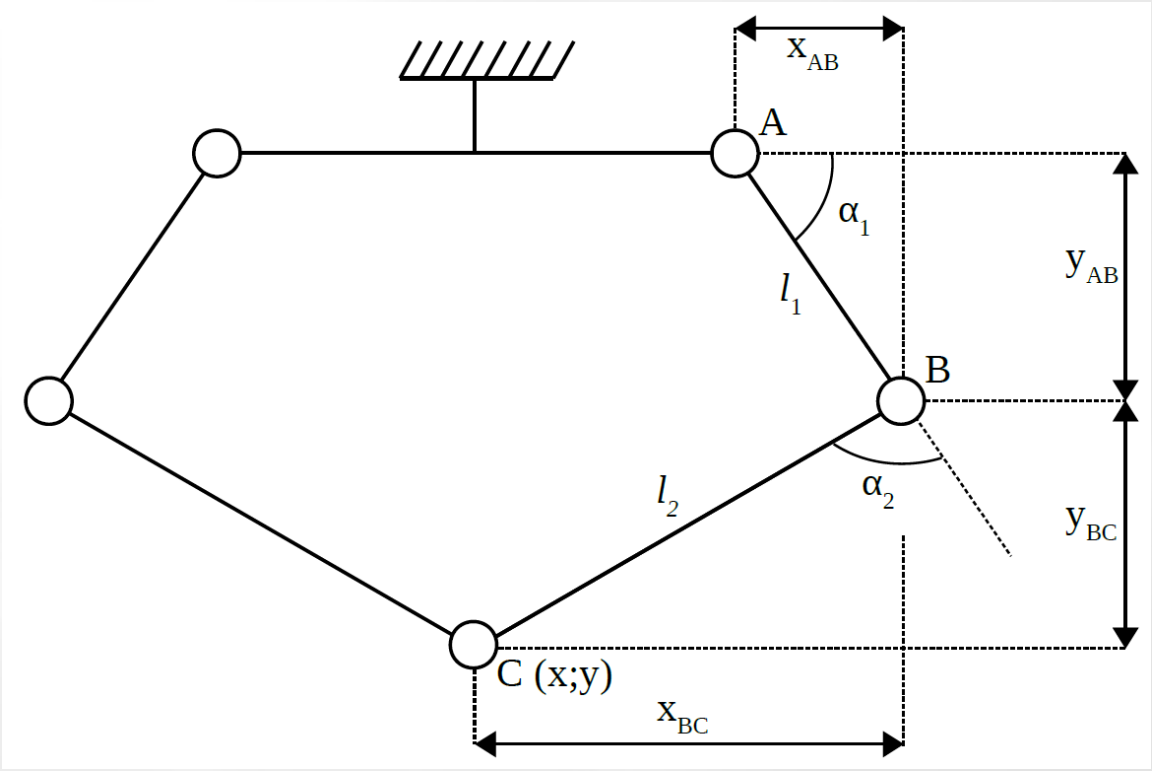

R0
αgauche
αdroite
(x;y)

Robot DELTA 2D



$$\alpha_1 ; \alpha_2 = f(x ; y)$$

$$x ; y = f(\alpha_1 ; \alpha_2)$$

$$\begin{cases} x = l_1 \cos\alpha_1 + l_2 \cos(\alpha_1 + \alpha_2) \\ y = l_1 \sin\alpha_1 + l_2 \sin(\alpha_1 + \alpha_2) \end{cases}$$

Robot DELTA 2D

$$\begin{cases} x = l_1 \cos\alpha_1 + l_2 \cos(\alpha_1 + \alpha_2) \\ y = l_1 \sin\alpha_1 + l_2 \sin(\alpha_1 + \alpha_2) \end{cases}$$

$$\begin{cases} x = a \cos\alpha + b \cos(\beta) \\ y = a \sin\alpha + b \sin(\beta) \end{cases}$$

Robot DELTA 2D

$$\left\{\begin{array}{l} a^2\cos^2\alpha=(x-b\cos\beta)^2 \\ a^2\sin^2\alpha=(y-b\sin\beta)^2 \end{array}\right\}$$

$$a^2(\cos^2\alpha+\sin^2\alpha)=x^2+y^2+b^2(\cos^2\beta+\sin^2\beta)-2b(x\cos\beta+y\sin\beta)$$

$$a^2=x^2+y^2+b^2-2b(x\cos\beta+y\sin\beta)$$

$$2b(x\cos\beta+y\sin\beta)=x^2+y^2+b^2-a^2$$

$$x\cos\beta+y\sin\beta=\frac{x^2+y^2+b^2-a^2}{2b}=K$$

Robot DELTA 2D

$$t=\tan\frac{\beta}{2} \qquad \cos\beta=\frac{1-t^2}{1+t^2} \qquad \sin\beta=\frac{2t}{1+t^2}$$

$$\cos\beta\ x+\sin\beta\ x=\frac{x\left(1-t^2\right)}{1+t^2}+\frac{y\,2t}{1+t^2}=\frac{x\left(1-t^2\right)+y\,2t}{1+t^2}=K$$

$$\frac{x\left(1-t^2\right)+y\,2t}{1+t^2}=K \qquad x\left(1-t^2\right)+y\,2t=K\,t^2+K$$

$$\left(K+x\right)t^2-2\,y\,t+K-x=0$$

Robot DELTA 2D

$$(K+x)t^2-2yt+K-x=0$$

$$\Delta=b^2-4ac$$

$$=(-2y)^2-4(K+x)(K-x)$$

$$=4y^2-4(K^2-x^2)=4(x^2+y^2-K^2)$$

$$t_1=\frac{-b-\sqrt{\Delta}}{2a} \quad =\frac{-(-2y)-\sqrt{4(x^2+y^2-K^2)}}{2(K+x)} \quad =\frac{2y-\sqrt{4}\sqrt{x^2+y^2-K^2}}{2(K+x)} \quad =\frac{y-\sqrt{x^2+y^2-K^2}}{(K+x)}$$

$$t_2=\frac{-b+\sqrt{\Delta}}{2a}=\frac{y+\sqrt{x^2+y^2-K^2}}{(K+x)}$$

Robot DELTA 2D

$$\begin{cases} x = a\cos\alpha + b\cos(\beta) \\ y = a\sin\alpha + b\sin(\beta) \end{cases} \qquad \begin{cases} a\cos\alpha = x - b\cos(\beta) \\ a\sin\alpha = y - b\sin(\beta) \end{cases}$$

$$\begin{cases} \alpha = \arccos\left(\dfrac{x - b\cos(\beta)}{a}\right) \\ \alpha = \arcsin\left(\dfrac{y - b\sin(\beta)}{a}\right) \end{cases}$$

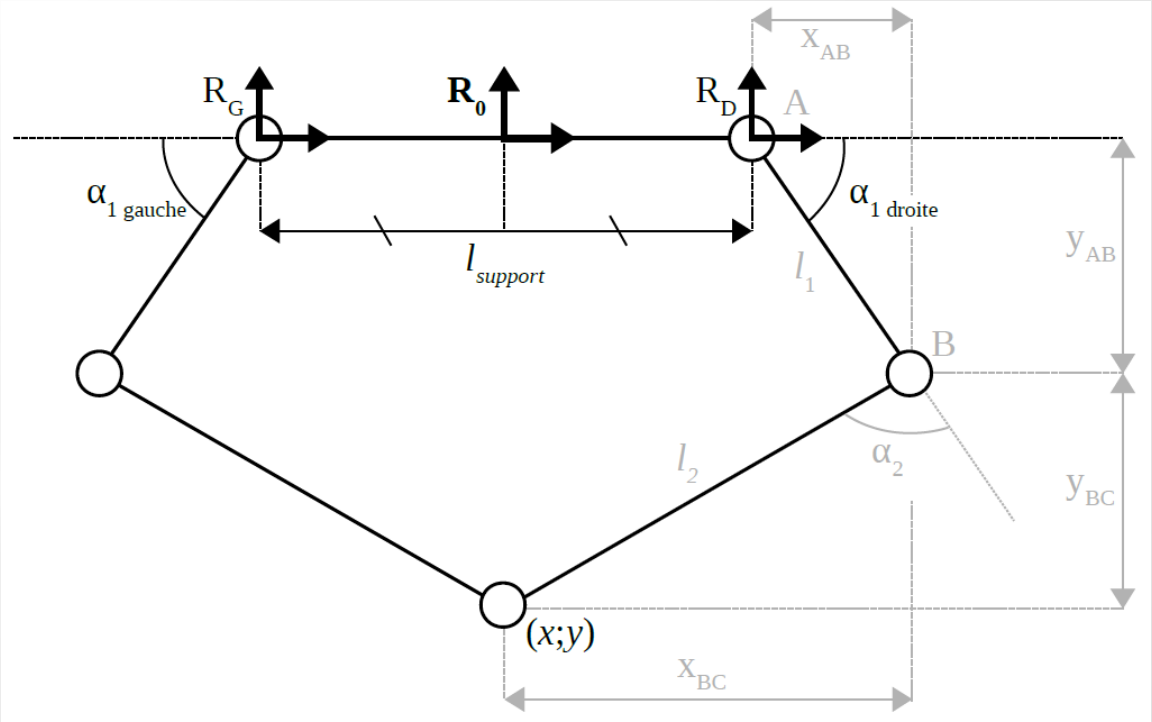
Rappel : $t = \tan\dfrac{\beta}{2}$ $\cos\beta = \dfrac{1-t^2}{1+t^2}$

$$\alpha = \arccos\left(\frac{x - b\dfrac{1-t^2}{1+t^2}}{a}\right) \qquad \alpha = \arcsin\left(\frac{y - b\dfrac{2t}{1+t^2}}{a}\right)$$

Robot DELTA 2D

$$x_{gauche} = x + l_{demi-support}$$

$$x_{droite} = x - l_{demi-support}$$



Robot DELTA 2D

x:	85	Gauche					Droite				
y:	-200	x=	210				x=	-40			
		K=	245,572193				K=	131,935829			
demi-support=	125	t1=	-0,7776023	?			t1=	-3,8672713	?	?	
bras 1=	165	t2=	-0,1004144			*180-angle	? t2=	-0,4835896		?	*180-angle
bras 2=	187	angle arccos() (t1)=	0,11396724	6,52984209		173,470158	angle arccos() (t1)=	0,72447137	41,5091519		138,490848
		angle arccos() (t2)=	1,40805826	80,6757959		99,3242041	angle arccos() (t2)=	2,8119124	161,110713		18,889287
		angle arcsin() (t1)=	-0,1139672	-6,5298421		186,529842	angle arcsin() (t1)=	-0,7244714	-41,509152		221,509152
		angle arcsin() (t2)=	-1,4080583	-80,675796		260,675796	angle arcsin() (t2)=	-0,3296803	-18,889287		198,889287

Robot DELTA 2D

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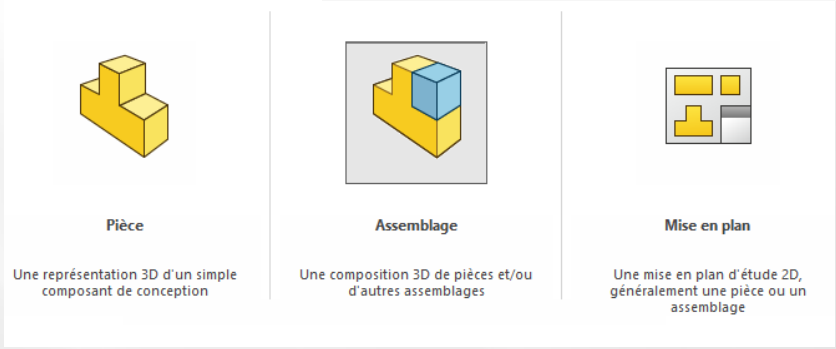
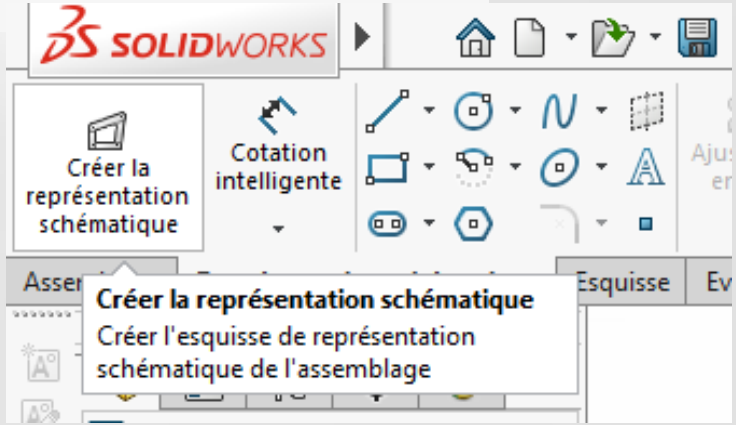
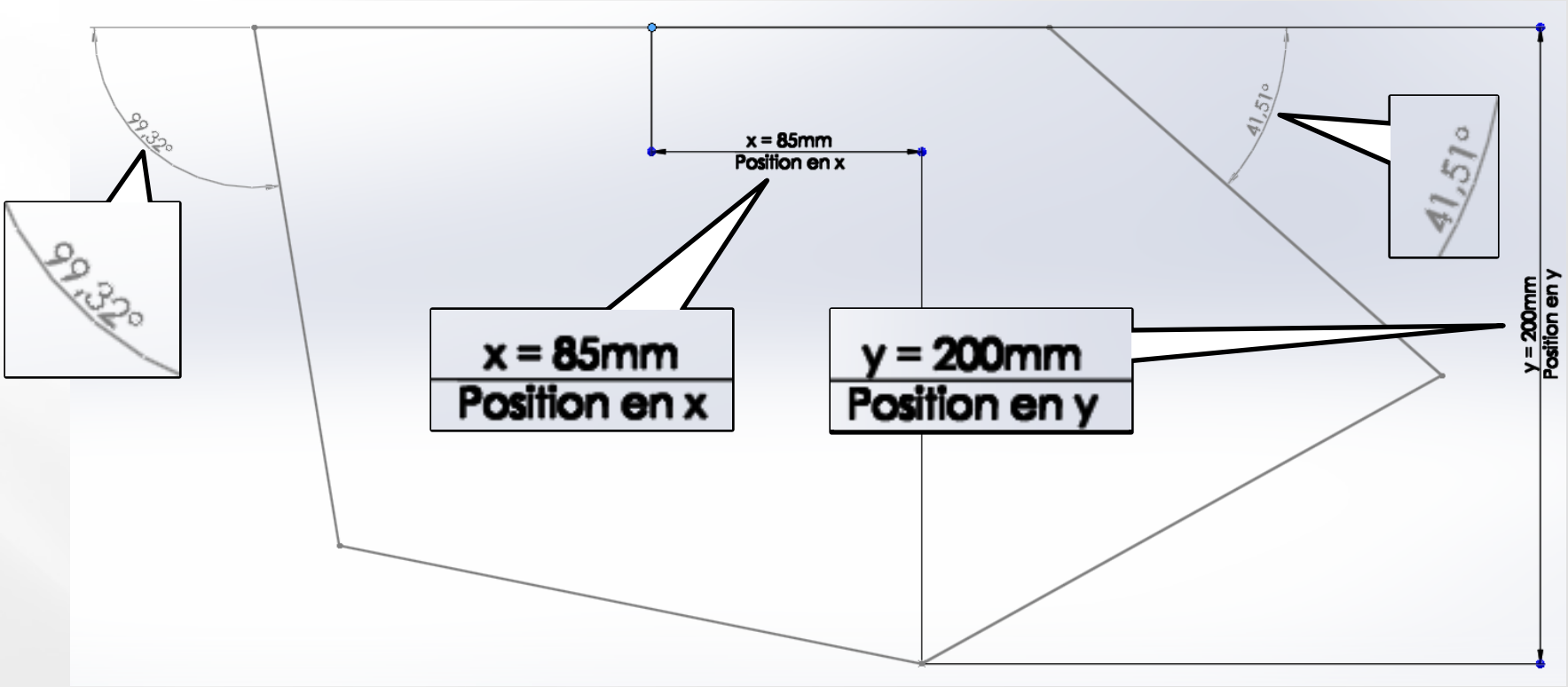
SOLIDWORKS 2018

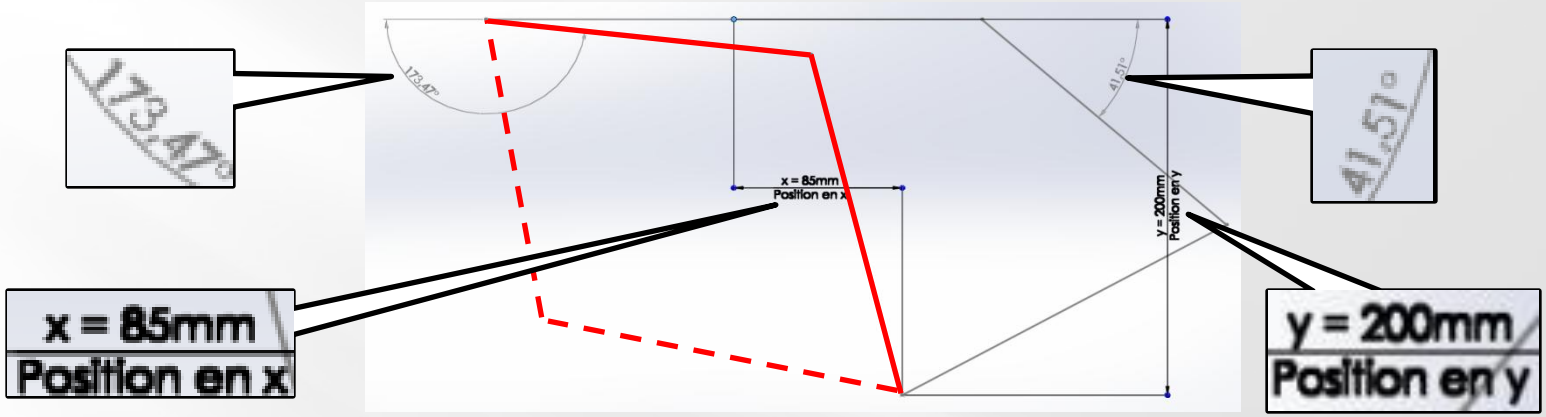




Robot DELTA 2D



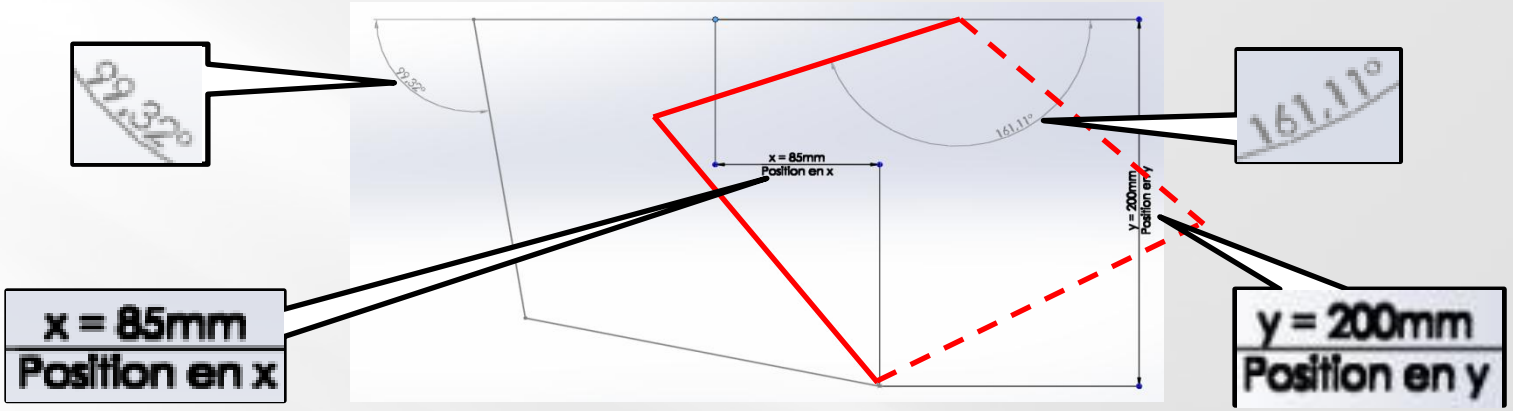
Robot DELTA 2D



x:	85	Gauche				
y:	-200	x=	210			
		K=	245,572193			
demi-support=	125	t1=	-0,7776023			
bras 1=	165	t2=	-0,1004144			*180-angle
bras 2=	187	angle arccos() (t1)=	0,11396724	6,52984209		173,470158
		angle arccos() (t2)=	1,40805826	80,6757959		99,3242041
		angle arcsin() (t1)=	-0,1139672	-6,5298421		186,529842
		angle arcsin() (t2)=	-1,4080583	-80,675796		260,675796

173,470158

Robot DELTA 2D



x:	85	Droite				
y:	-200	x=	-40			
		K=	131,935829			
demi-support=	125	t1=	-3,8672713			
bras 1=	165	t2=	-0,4835896			*180-qp
bras 2=	187	angle arccos() (t1)=	0,72447137	41,5091519		138,490848
		angle arccos() (t2)=	2,8119124	161,110713		18,889287
		angle arcsin() (t1)=	-0,7244714	-41,509152		221,509152
		angle arcsin() (t2)=	-0,3296803	-18,889287		198,889287

161,110713

Robot DELTA 2D

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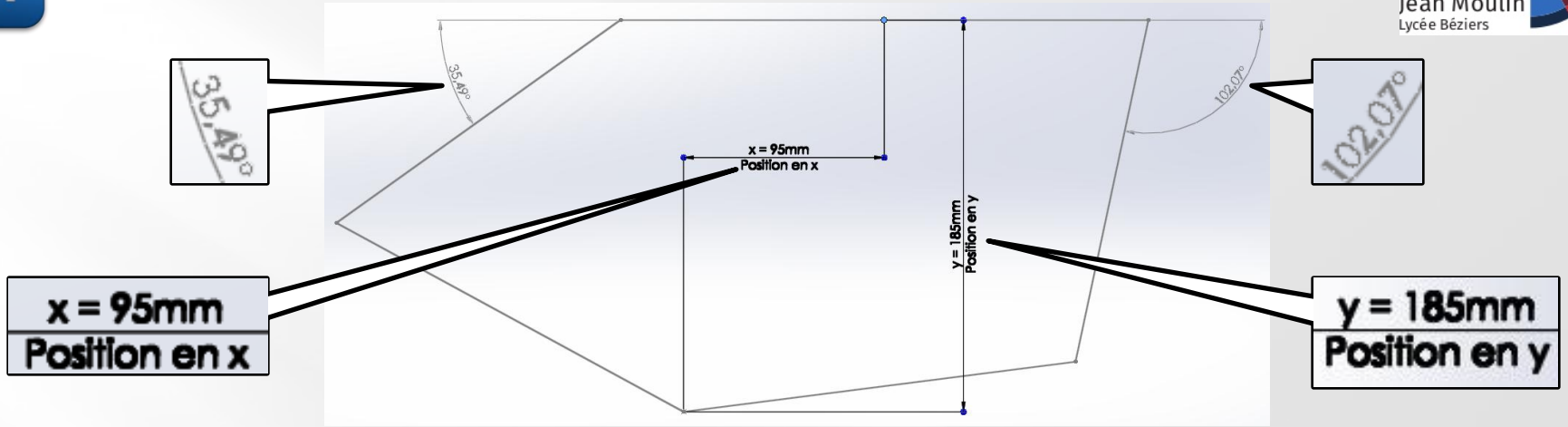
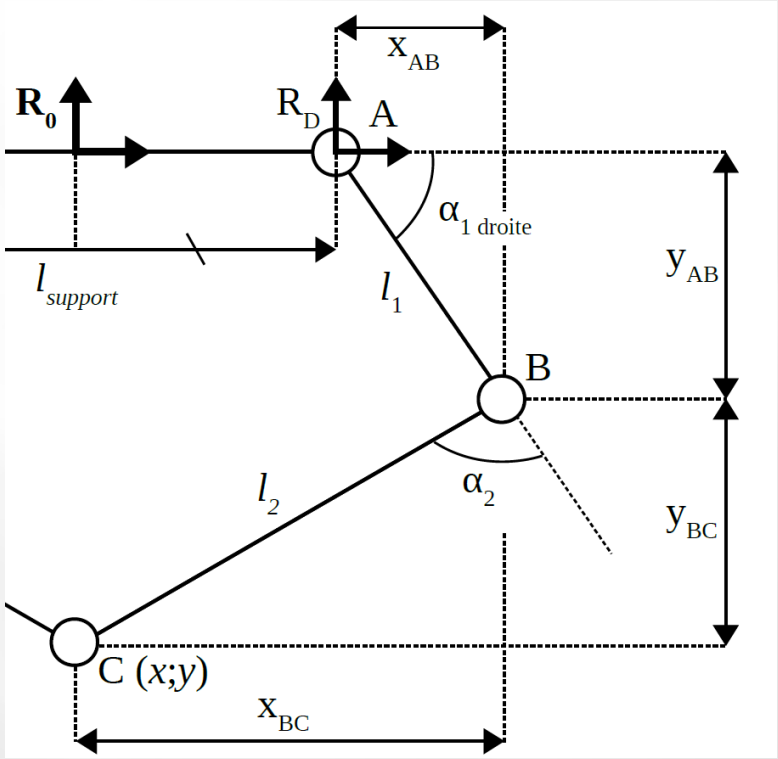


x:	-95	Gauche					Droite				
y:	-185	x=	30				x=	-220			
		K=	114,622995				K=	241,628342			
demi-support=	125	t1=	-2,3044654				t1=	-15,752219			
bras 1=	165	t2=	-0,2539106				t2=	-1,3549631			
bras 2=	187	angle arccos() (t1)=	0,29786494			*180-angle	angle arccos() (t1)=	1,78144905	102,069512		
		angle arccos() (t2)=	2,52220223	144,511543		35,488457	angle arccos() (t2)=	3,10335108	*ABS(angle)		*180-angle
		angle arcsin() (t1)=	-0,2978649	*ABS(angle)		*180-angle	angle arcsin() (t1)=	-1,3601436	77,9304879	OU	102,069512
		angle arcsin() (t2)=	-0,6193904	35,488457	OU	144,511543	angle arcsin() (t2)=	-0,0382416			

35,488457

102,069512

Robot DELTA 2D



$$x_{droite} = x - l_{demi-support}$$

$$K_{droite} = \frac{x_{droite}^2 + y^2 + b^2 - a^2}{2b}$$

$$t_{droite} = \frac{y - \sqrt{x_{droite}^2 + y^2 - K_{droite}^2}}{\left(K_{droite} + x_{droite}\right)}$$

$$\alpha_{droite} = \arccos\left(\frac{x_{droite} - b\dfrac{1 - t_{droite}^2}{1 + t_{droite}^2}}{a}\right)$$

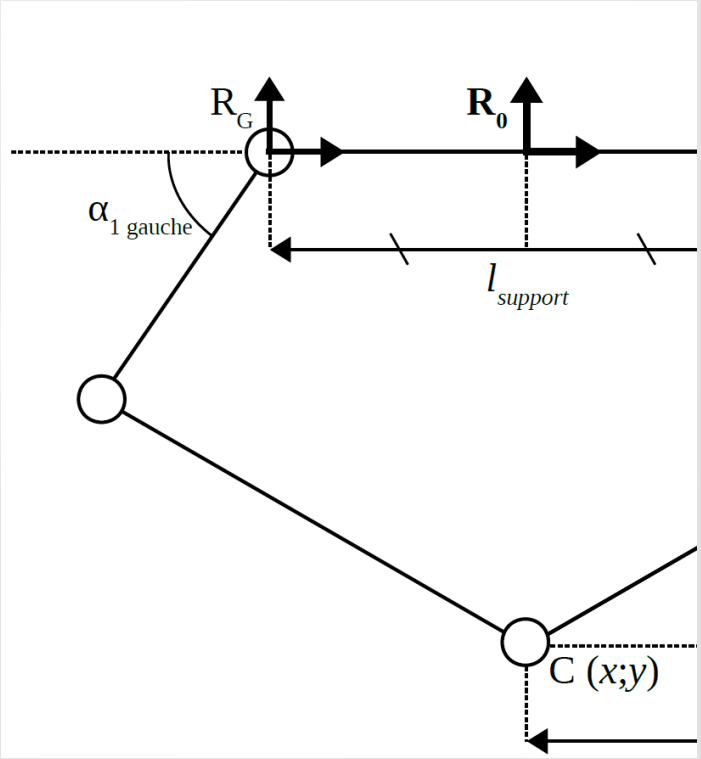
Robot DELTA 2D

$$x_{gauche} = x + l_{demi-support}$$

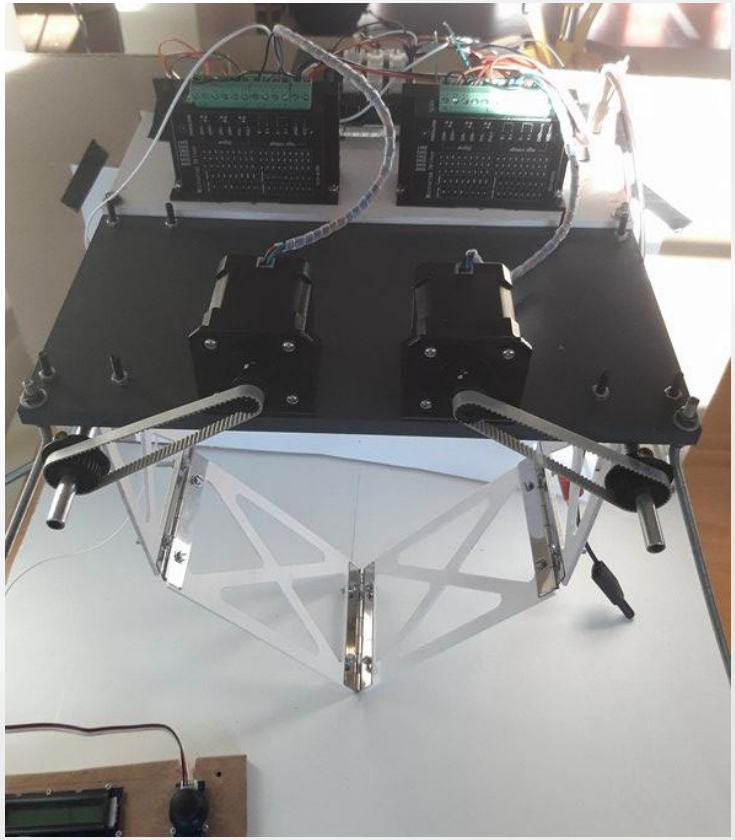
$$K_{gauche} = \frac{x_{gauche}^2 + y^2 + b^2 - a^2}{2b}$$

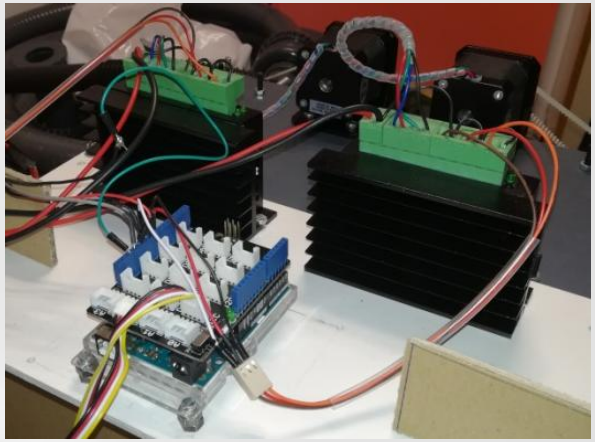
$$t_{gauche} = \frac{y + \sqrt{x_{gauche}^2 + y^2 - K_{gauche}^2}}{\left(K_{gauche} + x_{gauche}\right)}$$

$$\alpha_{gauche} = 180 - \arccos\left(\frac{x_{gauche} - b\dfrac{1 - t_{gauche}^2}{1 + t_{gauche}^2}}{a}\right)$$



Robot DELTA 2D





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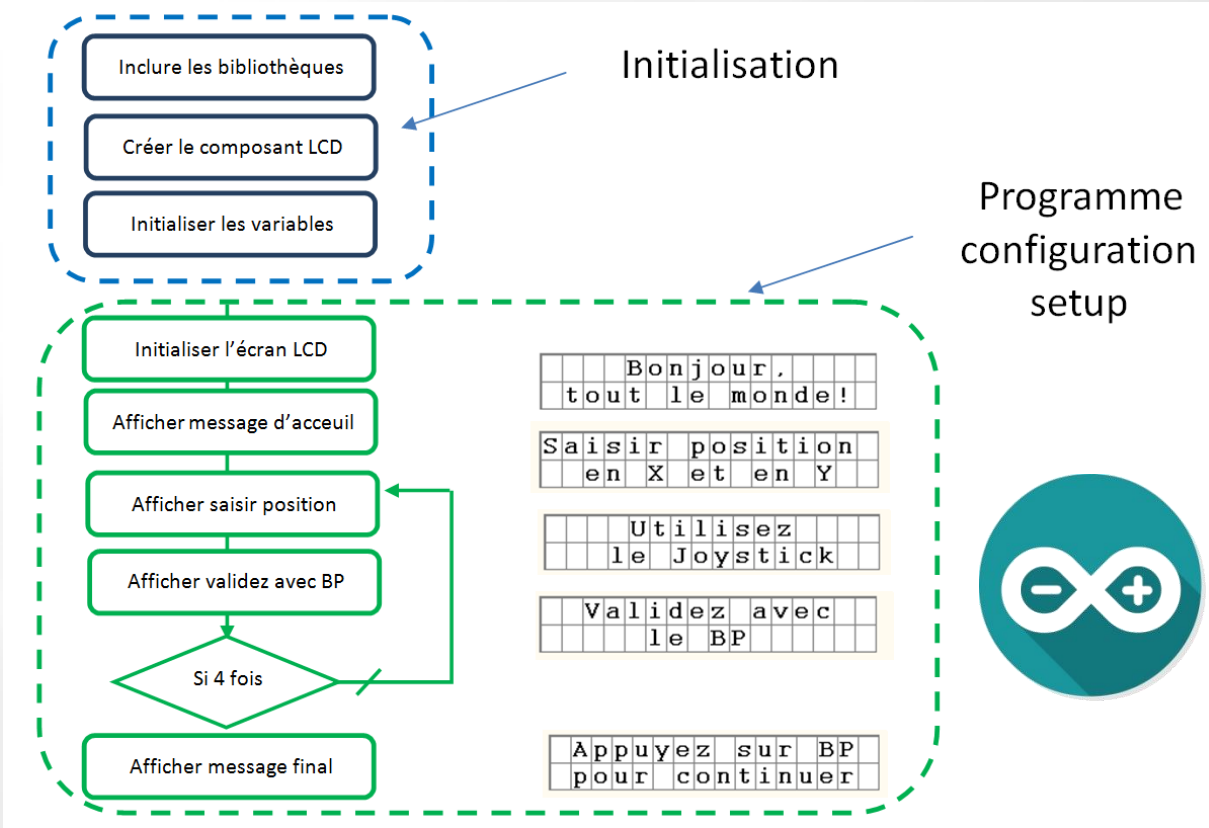


```
//***** Bibliothèques. *****//
#include <Wire.h>
#include "rgb_lcd.h"
#include "Math.h"

//***** Variables globales du lcd. *****//
rgb_lcd lcd;                  // Création du composant LCD
const int colorR = 255;       // Configuration de la couleur
const int colorG = 255;         // A modifier éventuellement
const int colorB = 255;

//***** Variables globales de gestion_pages(). *****//
int fenetre = 0;              // Variable de verrouillage fenêtre.
char message[16];
int counter = 0;              // Variable counter utilisée avec le joystick et gestion_page
int valeur_X = 0;             // Variable  de recuperation de la valeur en X
int valeur_Y = 0;             // Variable  de recuperation de la valeur en Y
float Angle_G;   // Variable  de recuperation de l'angle moteur1 ou gauche
float Angle_D;   // Variable  de recuperation de l'angle moteur2 ou droit
int position_en_cours = 0;
int position_initiale = 0;
int rac = 0;
int rac2 = 0;

//***** Variable globale de gestion_BP(). *****//
int valide = 0;

//***** Variable globale de recup_joystick(). *****//
int xcmin = 0;
int xcmax = 0;

//***** Variable globale de calcul_angle(). *****//
float Agl_D;
float Agl_G;
int dir1;
int dir2;

#include <AccelStepper.h>
#include <MultiStepper.h>
#define STEPPER1_DIR_PIN 9
#define STEPPER1_PUL_PIN 10
#define STEPPER2_DIR_PIN 12
#define STEPPER2_PUL_PIN 13
AccelStepper stepper1 (AccelStepper::DRIVER, STEPPER1_PUL_PIN, STEPPER1_DIR_PIN);
AccelStepper stepper2 (AccelStepper::DRIVER, STEPPER2_PUL_PIN, STEPPER2_DIR_PIN);
MultiStepper steppers;


void setup()  {
  Serial.begin(9600);
  lcd.begin(16, 2);         // initialisation du LCD en 16 sur 2 lignes
  lcd.setRGB(colorR, colorG, colorB);
  lcd.setCursor(4,0);               // Positionnement du curseur  A remplir
  lcd.print("Bonjour,");               // Ecriture d'un message sur le LCD.
  lcd.setCursor(1,1);               // Positionnement du curseur  A remplir
  lcd.print("tout le monde!");
   stepper1.setMaxSpeed(400);
   stepper2.setMaxSpeed(400);
   steppers.addStepper(stepper1);
   steppers.addStepper(stepper2);
}
```

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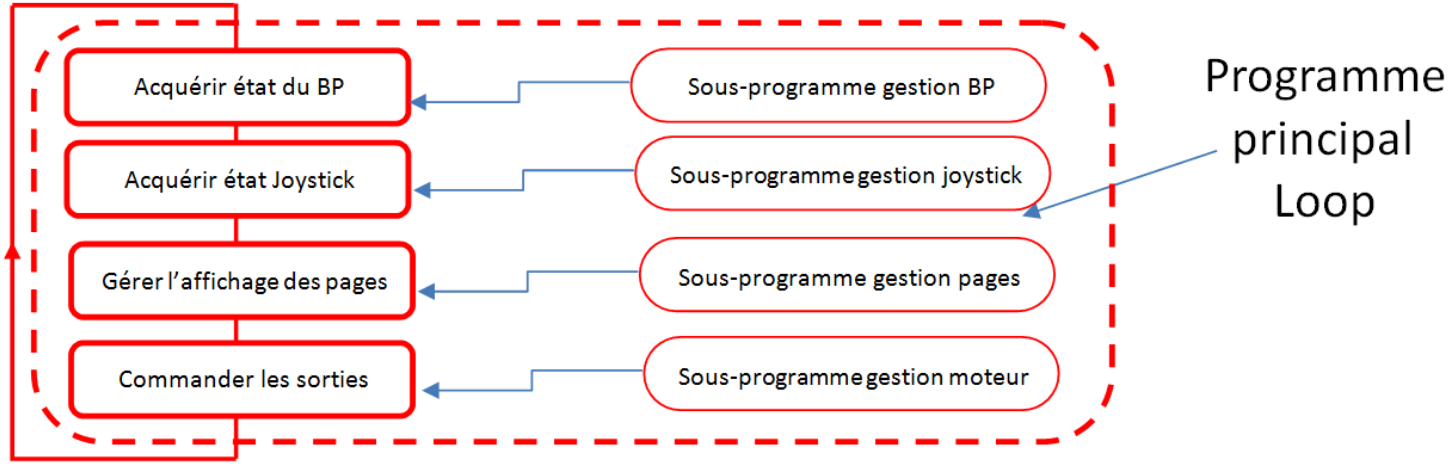

Robot_Delta_FIJNAL § | calcul_angle § | gestion_bp | gestion_mouvement | gestion_pages | recup_joystick

```
void loop() {
  recup_joystick();       // Appel de la fonction pour récupérer les données du joystick
  gestion_BP() ;          // Appel de la fonction ou sous-programme gestion_BP
  gestion_pages() ;       // Appel de la fonction gérant l'affichage des pages
  calcul_angle() ;        // Appel de la fonction ou sous-programme de calcul des angles
  gestion_mouvement() ;   // Appel de la fonction gérant le positionnement
}
```

Robot DELTA 2D

Robot DELTA 2D

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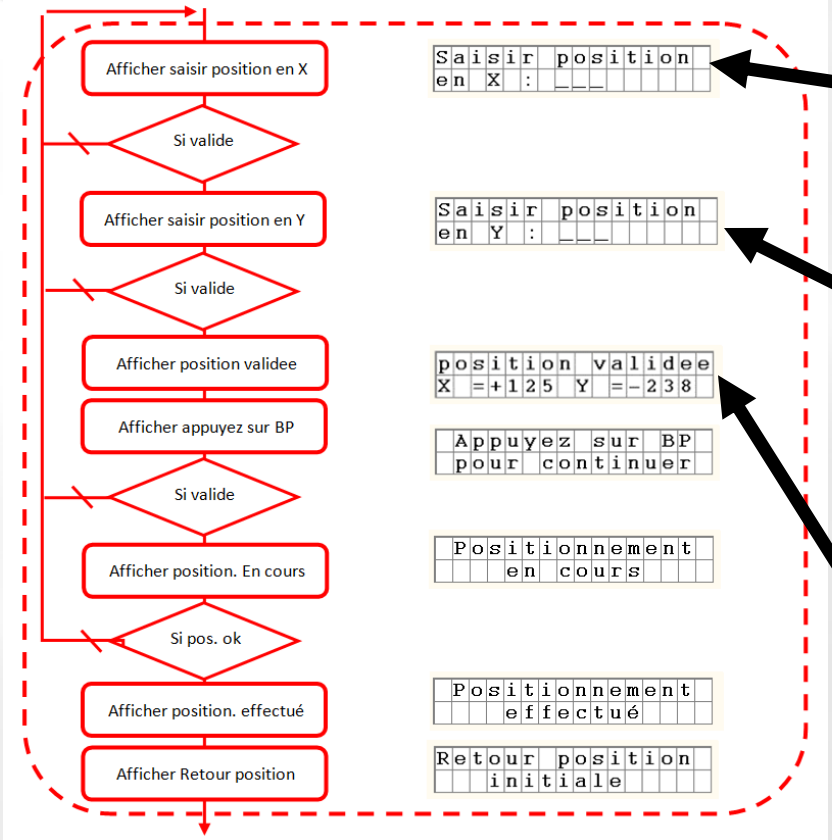
```
int x = map(val, 525, 800, 300, 10)
int y = map(val, 240, 505, 10, 300)
```

```
counter++;
delay(x);
```

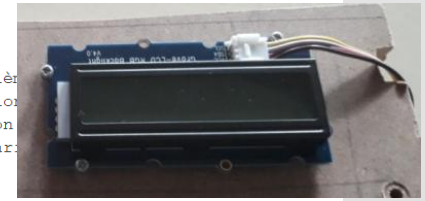
```
counter--;
delay(y);
```

```
ystick() {
re == 1) {scmin = -100; scmax = 100;}
re == 2) {scmin = -270; scmax = -180;}
if re == 2 && rsc == 0) {counter = -225; rsc = 1;}
int val = analogRead(A3);   // lecture valeur analogique du potentiometre axe X
int x = map(val, 525, 800, 300, 10);     // mappage pour gérer le temps de comptage
int y = map(val, 240, 505, 10, 300);
if (val > 525 && val <=800) {  // plage de positionnement maxi
    counter++;
    delay(x);
if (counter >= scmax) {                      // si dépassement de l'incrémentation
    counter = scmax;}  }
if (val >240 && val <=505) {   // plage de positionnement mini
    counter--;
    delay(y);
if (counter <= scmin) {                   // si dépassement de la décrémentation
    counter = scmin;}  }
if (val >505 && val <=525) {    // plage de positionnement repos
    delay(100);}
}
```

Robot DELTA 2D




```
if (valide == 2) {   // Si appui 2ième fois sur BP de "VALIDATION"
  fenetre = 1;                        // gestion des fenetres
  lcd.setCursor(0,0); lcd.print("Saisir position");
  lcd.setCursor(0,1); lcd.print("en X :");
  lcd.setCursor(7,1); lcd.print(counter);
}
if (fenetre == 1 && valide == 3)    // Si appui 3iè
  {valeur_X = counter;              //  Mémorisatio
  fenetre = 2;                      // autorisation
  counter = 0;                      // Mise à 0 var
}
if (fenetre == 2 ) {
  lcd.setCursor(0,0); lcd.print("Saisir position");
  lcd.setCursor(0,1); lcd.print("en Y :");
  lcd.setCursor(7,1); lcd.print(counter);
}
if (fenetre == 2 && valide == 4)    // Si appui 4ième fois sur BP de "VALIDATION"
  {valeur_Y = counter;              //  Mémorisation de la valeur en Y
  fenetre = 3;                      // autorisation  affichage fenetre 3
  counter = -225;                      // Mise à 0 variable counter
}
```



```
if (fenetre == 3){
  if (valide == 5){fenetre = 4;}
  lcd.setCursor(0,0); lcd.print("Position validee.");
  lcd.setCursor(0,1); lcd.print("X = ");
  lcd.setCursor(4,1); lcd.print(valeur_X);
  lcd.setCursor(8,1); lcd.print("Y =");
  lcd.setCursor(12,1); lcd.print(valeur_Y);
}
```

Robot DELTA 2D

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```
int a = 165;
int b = 187;
```

$$x_{droite} = x - l_{demi-support}$$

```
float x_d = (float) (x - 125);
```

$$\alpha_{droite} = \arccos\left(\frac{x_{droite} - b\frac{1-t^2_{droite}}{1+t^2_{droite}}}{a}\right)$$

```
float Alpha_D = (float) acos((x_d - (b*cos(Betta_D))) / a);
float Angle_D = (float) (abs((Alpha_D * 180) / PI));
```

$$x_{gauche} = x + l_{demi-support}$$

```
float x_g = (float) (x + 125);
```

$$\alpha_{gauche} = 180 - \arccos\left(\frac{x_{gauche} - b\frac{1-t^2_{gauche}}{1+t^2_{gauche}}}{a}\right)$$

```
float Alpha_G = (float) acos((x_g - (b*cos(Betta_G))) / a);
float Angle_G = (float) (180-(abs((Alpha_G * 180) / PI)));
```

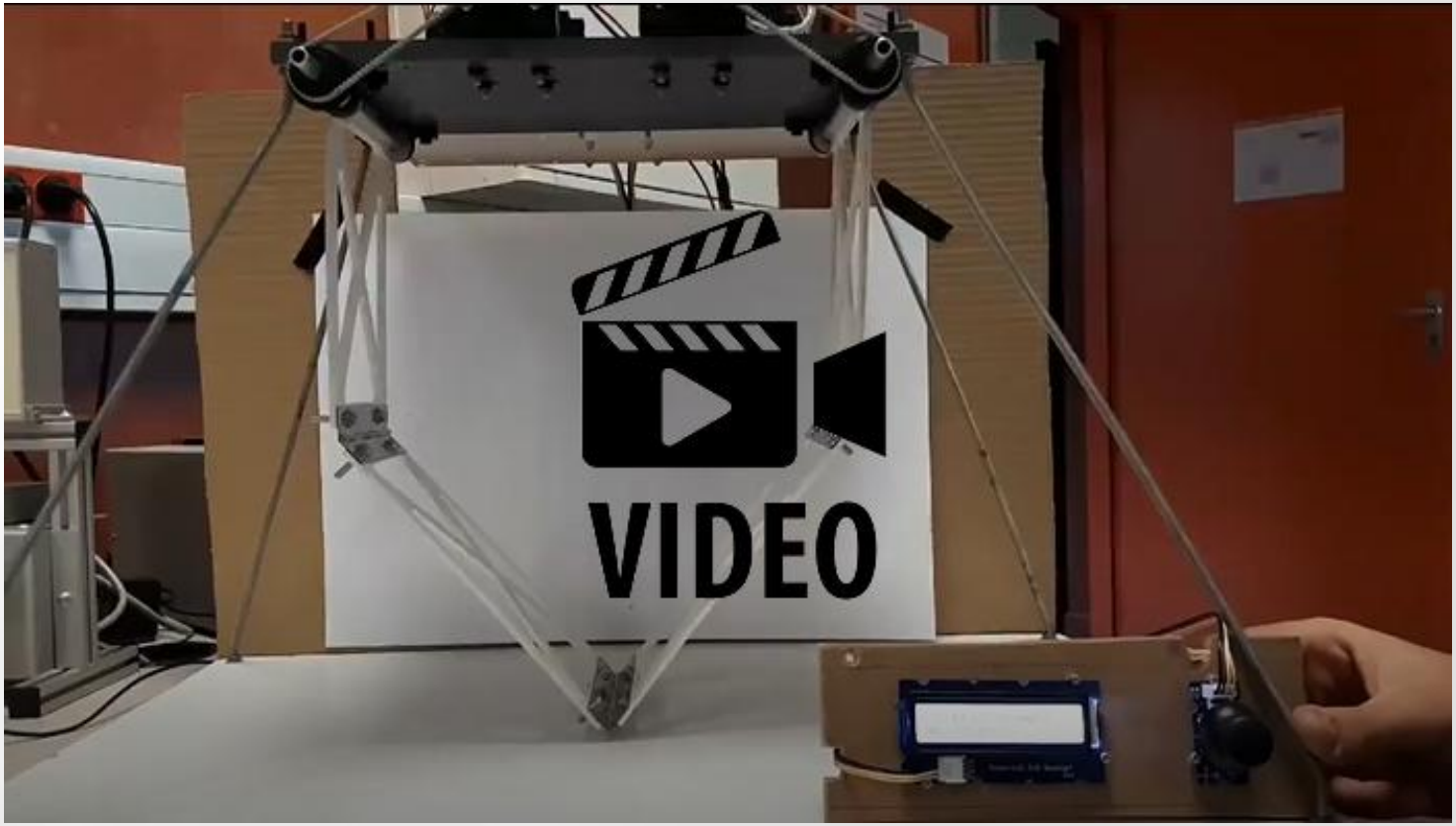
```
int a = 165;
int b = 187;
int aa = 27225;
int bb = 34969;

float x_d = (float) (x - 125);
float y_d = (float) (y);
float xx_d = (float) (x_d) * (x_d);
float yy_d = (float) (y_d) * (y_d);
float K_D = (float) ((xx_d) + (yy_d) + (34969) - (aa))/(2*b);
float a_Delta_D = (float) (K_D) + (x_d);
float b_Delta_D = (float) (-2) * (y_d);
float c_Delta_D = (float) (K_D) - (x_d);
float bb_Delta_D = (float) (b_Delta_D) * (b_Delta_D);
float Delta_D = (float) (bb_Delta_D) - (4*(a_Delta_D)) * (c_Delta_D);
float T_D = (float) ((-b_Delta_D - sqrt(Delta_D))/ (2* a_Delta_D));
float Betta_D = (float) (2 * atan(T_D));
float Alpha_D = (float) acos((x_d - (b*cos(Betta_D))) / a);
float Angle_D = (float) (abs((Alpha_D * 180) / PI));

float x_g = (float) (x + 125);
float y_g = (float) (y);
float xx_g = (float) (x_g) * (x_g);
float yy_g = (float) (y_g) * (y_g);
float K_G = (float) ((xx_g) + (yy_g) + (34969) - (aa))/(2*b);
float a_Delta_G = (float) (K_G) + (x_g);
float b_Delta_G = (float) (-2) * (y_g);
float c_Delta_G = (float) (K_G) - (x_g);
float bb_Delta_G = (float) (b_Delta_G) * (b_Delta_G);
float Delta_G = (float) (bb_Delta_G) - (4*(a_Delta_G)) * (c_Delta_G);
float T_G = (float) ((-b_Delta_G + sqrt(Delta_G))/ (2* a_Delta_G));
float Betta_G = (float) (2 * atan(T_G));
float Alpha_G = (float) acos((x_g - (b*cos(Betta_G))) / a);
float Angle_G = (float) (180-(abs((Alpha_G * 180) / PI)));
```

Robot DELTA 2D

Jean Moulin
Lycée Béziers



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Ce que j'ai appris

Manipulation des outils mathématiques et informatiques

Mise en équation des problèmes identifiés

Apport de solutions

Résolution des problèmes expérimentaux

Travail de groupe