

## **ABSTRACT**

Kinematic synthesis revolves around crafting mechanisms capable of producing predetermined motion paths or trajectories. In essence, it involves the design and configuration of systems, such as linkages and cams, to achieve desired motion patterns. This process entails determining the appropriate dimensions, shapes, and layouts of components to fulfill specific motion requirements. For instance, in industrial settings, kinematic synthesis might involve devising mechanisms to facilitate tasks like lifting and relocating objects with precision. This facet is integral to fields like robotics, automation, and machinery design.

### **1. AIM OF THE PROJECT**

The aim of the project is to design a five-bar mechanism that follows a given function and then convert the designed five-bar mechanism into a four-bar mechanism to determine the path it follows. Subsequently, an error analysis is conducted, and the results are interpreted.

### **2. DESIGN PROCEDURE**

#### **2.1 FIVE BAR MECHANISM**

The inverse task method was used in the design of a 5-bar mechanism. During the application of the inverse task, link dimensions were initially determined, and necessary calculations were made considering these dimensions. As a result of these calculations, 2 input and 2 output angles were obtained. One of these different solutions was selected, and a 5-bar mechanism was drawn on a graph. By means of a button, it was observed whether the mechanism followed the desired path. As a result of the process, the 5-bar mechanism successfully followed the desired path.

## 2.1.1 FIVE BAR MECHANISM CALCULATIONS

FIVE BAR MECHANISM

All construction parameters are known.  $(x, y)$  was given  
 $\theta_b$  and  $\theta_c$  finding

Left side of five bar mechanism

$$\vec{a} + \vec{b} + \vec{c} = \vec{r_c}$$

$$\rightarrow a + b \cos \theta_b + c \cos \theta_c = x$$

$$\rightarrow b \sin \theta_b + c \sin \theta_c = y$$


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$$\left. \begin{aligned} b \cos \theta_b + c \cos \theta_c &= \frac{x-a}{k_1} \\ b \sin \theta_b + c \sin \theta_c &= y \end{aligned} \right\} \text{take square add them together}$$


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$$k_2 = \cos \theta_c = \frac{k_1^2 + y^2 - b^2 - c^2}{2bc}$$

$$\sin \theta_c = \pm \sqrt{1 - k_2^2}$$

$$\theta_c = \text{Atan2}(\sin \theta_c, \cos \theta_c) = \text{Atan2}(\pm \sqrt{1 - k_2^2}, k_2)$$

$\theta_c$  is found

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$$\begin{aligned} b \cos \theta_b + c \cos \theta_c - c \sin \theta_b \sin \theta_c &= k_1 \\ b \sin \theta_b + c \sin \theta_c + c \cos \theta_b \sin \theta_c &= y \end{aligned}$$


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$$\begin{aligned} (b + c \cos \theta_c) \cos \theta_b - c \sin \theta_c \sin \theta_b &= k_1 \\ (b + c \cos \theta_c) \sin \theta_b + c \sin \theta_c \cos \theta_b &= y \end{aligned}$$


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$$\begin{aligned} k_3 \cos \theta_b - k_4 \sin \theta_b &= k_1 \\ k_3 \sin \theta_b + k_4 \cos \theta_b &= y \end{aligned}$$


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$$\begin{aligned} k_3 &= b + c \cos \theta_c \\ k_4 &= c \sin \theta_c \end{aligned}$$

$$\begin{bmatrix} k_3 & -k_4 \\ k_4 & k_3 \end{bmatrix} \begin{bmatrix} \cos \theta_b \\ \sin \theta_b \end{bmatrix} = \begin{bmatrix} k_1 \\ y \end{bmatrix}$$

A                      B                      C

$$B = A^{-1}C \Rightarrow \cos \theta_b \text{ and } \sin \theta_b \text{ is found}$$

$$\theta_b = \text{Atan2}(\sin \theta_b, \cos \theta_b)$$

unique solution for each  $\theta_c$  occurs

For the right side of mechanism replace:

$$a = a + f$$

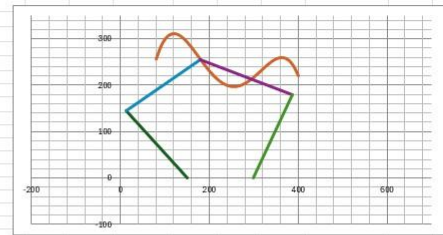
$$b = e$$

$$c = d$$

$$Q_b = Q_e$$

$Q_c = Q_d$  calculations rewritten and  $Q_e$   $Q_d$  degrees found. In this Project 1st solution was used.

x (mm)	y (mm)	a	b	d	e	f	x'	y'	B <sub>x1</sub>	B <sub>y1</sub>
80	236.243	150	200	200	200	150	180	255.0687	-1.74720948	1.747209478
90	282.484	K <sub>1</sub>	30		K <sub>1'</sub>	-120			B <sub>x1</sub>	B <sub>y1</sub>
100	299.465	K <sub>2</sub>	-0.175499529		K <sub>2'</sub>	-0.10159048			1.67256237	1.672562371
110	308.63	K <sub>11</sub>	164.9000942	164.9	K <sub>11'</sub>	177.650094	K <sub>32</sub>	199.6819		
120	311.326	K <sub>11</sub>	-196.895903	196.896	K <sub>11'</sub>	218.861787	K <sub>42</sub>	418.9653		
130	308.805	cosθ <sub>1</sub>	-0.175499529		cosθ <sub>1</sub>	-0.10159048				
140	302.224	sinθ <sub>1</sub>	-0.984479515	degree -56.4065	sinθ <sub>1</sub>	0.9648263	degree 56.99935			
150	292.643	sinθ <sub>2</sub>	0.984479515		sinθ <sub>2</sub>	0.9648263				
160	281.026	B <sub>x1</sub>	2.327323571	B <sub>y1</sub>	0.58011	B <sub>x1</sub>	1.12157326	B <sub>y1</sub>	0.684458	
170	268.244									
180	255.069									
190	242.178	A <sub>x</sub>	164.9000942	196.896	A <sub>x'</sub>	0.0025	-0.00298508	C <sub>x</sub>	30	
200	230.154		-196.895903	164.9		0.002985079	0.0025		255.0687	
210	219.483									
220	210.555	B <sub>x</sub>	-0.686400118	cosθ <sub>1</sub>						
230	203.665		0.727224091	sinθ <sub>1</sub>						
240	199.011									
250	196.698									
260	196.731									
270	199.023									
280	203.391	A <sub>x'</sub>	164.9000942	-196.896	A <sub>x'</sub>	0.0025	0.00298508	C <sub>x'</sub>	30	
290	209.553		196.895903	164.9		-0.002985079	0.0025		255.0687	
300	217.135									
310	225.665									
320	234.577									
330	243.207									
340	250.786	B <sub>x'</sub>	0.836400118							
350	256.484		0.548119369							
360	259.346									
370	258.309									
380	252.241									
390	239.904	D <sub>x</sub>	177.6500942	-218.862	D <sub>x'</sub>	0.002235716	0.00275436	E <sub>x</sub>	-120	
400	219.967		218.8617868	177.65		-0.002754363	0.00223572		255.0687	
		F <sub>x</sub>	0.43426582							
			0.900784768							
		D <sub>x'</sub>	199.6819038	-418.965	D <sub>x'</sub>	0.000927008	0.00194501	E <sub>x'</sub>	-120	
			418.9652607	199.682		-0.001945014	0.00092701		255.0687	



	XX	YY
A	150	0
B	12.72	145.4448182
C	180	255.0687
D	386.833	180.1569536
E	300	0
A	150	0

## 2.2 FOUR BAR MECHANISM

During the design stage of the 4-bar mechanism, the relationship between input and output angles was assumed to be the same as that of the 5-bar mechanism. 3 precision point was selected, based on this assumption, the link lengths of the 4-bar mechanism were calculated.

**FOUR BAR MECHANISM**

$\theta_{e1} = f(\theta_{b1}) \Rightarrow$  Found due to 5 bar mechanism  
 3 precision point was selected.  
 $\theta_{e1} = f(\theta_{b1})$   
 $\theta_{e2} = f(\theta_{b2})$   
 $\theta_{e3} = f(\theta_{b3})$   
 d link length assumed as  $\perp$ .

$a + b = c + d$   
 $a \cos \theta_b + b \cos \theta_c = c \cos \theta_d + d$   
 $a \sin \theta_b + b \sin \theta_c = c \sin \theta_d$

$b \cos \theta_c = c \cos \theta_d + d - a \cos \theta_b$   
 $b \sin \theta_c = c \sin \theta_d - a \sin \theta_b$

Take square add them together

$\frac{a^2 - b^2 + c^2 + d^2}{2ca} + \frac{d}{P_1} \cos \theta_d - \frac{d}{P_2} \cos \theta_b - \cos(\theta_d - \theta_b) = F$

$f_0 = \perp$   $P_0$   
 $P_0 f_0^i + P_1 f_1^i + P_2 f_2^i - F_i = 0$   
 $P_0 f_0^4 + P_1 f_1^4 + P_2 f_2^4 - F_i = 0$   
 $P_0 f_0^2 + P_1 f_1^2 + P_2 f_2^2 - F_2 = 0$   
 $P_0 f_0^3 + P_1 f_1^3 + P_2 f_2^3 - F_3 = 0$

$B = A^{-1}C$  }  $P_0, P_1$  and  $P_2$  was found  
 $\frac{1}{a} = P_1$   $\frac{1}{c} = P_2$   
 $b = \sqrt{-2ca P_0 + a^2 + c^2 + 1}$   
 $d = \perp$   
 Link lengths was found.

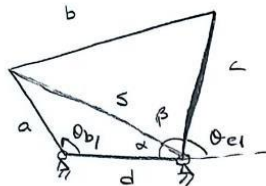
Link length of 'f' five bar mechanism must be equal to link length of 'd' for four bar mechanism. First step d link length was assumed to 1 but five bar mechanism 'f' link length is 150 mm so, four bar mechanism link lengths must be scale by multiplying each link to 150.

PRECISION POINTS			FOUR BAR LINK LENGTHS				
	Qb1	Qe1	A-1*C=B MATRIX		scale		
PP1	2,681999507	1,60753741	P0	0,84188	a	-1,70082	-255,123061
PP2	2,232612218	0,85224385	P1	-0,58795	b	1,61897	242,8459216
PP3	1,308795868	0,11685332	P2	-0,43211	c	-2,31424	-347,136567
					d	1	150
A MATRIX							
	1	-0,036732818		0,89623305			
	1	0,658295725		0,61455038			
	1	0,993180416		-0,2590133			
A-1 MARRIX							
	1,522690293	-1,717183508		1,19449321			
	-1,703449301	2,252730563		-0,5492813			
	-0,653025225	2,008331045		-1,3553058			
C MATRIX							
	0,476205309						
	0,189279135						
	0,369855771						

## 2.2.1 FOUR BAR MECHANISM DIRECT TASK

By performing the direct task, the relationship between the input and output angles of the known 4-bar mechanism is obtained. Thus, the design of the 4-bar mechanism is completed.

DIRECT TASK FOUR BAR MECHANISM



Cosinus theorem

$$\begin{aligned} \textcircled{1} \quad a^2 &= s^2 + d^2 - 2sd \cos \alpha \\ \cos \alpha &= \frac{a^2 - s^2 - d^2}{-2sd} \\ a \cos \left( \frac{a^2 - s^2 - d^2}{-2sd} \right) &= \alpha \\ \textcircled{2} \quad b^2 &= s^2 + c^2 - 2sc \cos \beta \\ \cos \beta &= \frac{b^2 - s^2 - c^2}{-2sd} \\ a \cos \left( \frac{b^2 - s^2 - c^2}{-2sd} \right) &= \beta \end{aligned}$$

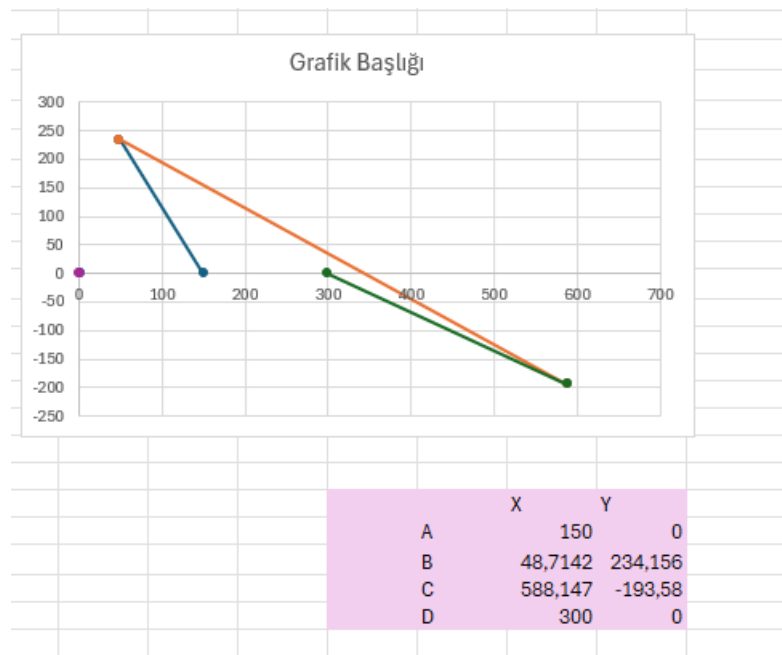
$$\text{output angle } \theta_{c1} = 180^\circ - (\alpha + \beta)$$

$$s \text{ length: } s^2 = a^2 + d^2 - 2ad \cos(\theta_{b1})$$

$$s = \sqrt{a^2 + d^2 - 2ad \cos(\theta_{b1})}$$

input degree									
derece	radyan		degree	radyan	degree	radyan	degree	radyan	
Qb1	Qb1	S	$\alpha$	$\alpha$	$\beta$	$\beta$	Qe1	Qe1	
153,6672524	2,681999507	137,81459	124,799	2,17814	147,307	2,57099	-92,105	-1,6075	
153,0942946	2,671999507	139,05319	123,875	2,16203	146,891	2,56372	-90,766	-1,5842	✓
152,5213368	2,661999507	140,30518	122,964	2,14612	146,485	2,55665	-89,449	-1,5612	✓
151,948379	2,651999507	141,57009	122,063	2,1304	146,091	2,54977	-88,154	-1,5386	✓
151,3754212	2,641999507	142,84743	121,173	2,11487	145,707	2,54306	-86,88	-1,5163	✓
150,8024634	2,631999507	144,13676	120,294	2,09953	145,333	2,53654	-85,627	-1,4945	✓
150,2295056	2,621999507	145,43763	119,425	2,08437	144,97	2,5302	-84,395	-1,473	✓
149,6565478	2,611999507	146,7496	118,567	2,06939	144,616	2,52402	-83,183	-1,4518	✓
149,08359	2,601999507	148,07225	117,719	2,05459	144,272	2,51802	-81,991	-1,431	✓
148,5106323	2,591999507	149,40517	116,881	2,03997	143,938	2,51219	-80,819	-1,4106	✓
147,9376745	2,581999507	150,74795	116,053	2,02551	143,613	2,50652	-79,666	-1,3904	✓
147,3647167	2,571999507	152,1002	115,235	2,01122	143,298	2,50101	-78,532	-1,3706	✓
146,7917589	2,561999507	153,46154	114,425	1,9971	142,991	2,49567	-77,417	-1,3512	✓
146,2188011	2,551999507	154,83158	113,626	1,98314	142,694	2,49047	-76,319	-1,332	✓
145,6458433	2,541999507	156,20997	112,835	1,96934	142,405	2,48543	-75,239	-1,3132	✓
145,0728855	2,531999507	157,59635	112,053	1,95569	142,124	2,48054	-74,177	-1,2946	✓
144,4999277	2,521999507	158,99038	111,279	1,94219	141,853	2,47579	-73,132	-1,2764	✓
143,9269699	2,511999507	160,39171	110,514	1,92884	141,589	2,47119	-72,103	-1,2584	✓
143,3540121	2,501999507	161,80002	109,758	1,91563	141,333	2,46673	-71,091	-1,2408	✓
142,7810543	2,491999507	163,215	109,009	1,90257	141,085	2,4624	-70,094	-1,2234	✓
142,2080965	2,481999507	164,63632	108,269	1,88964	140,845	2,45821	-69,114	-1,2063	✓
141,6351387	2,471999507	166,06369	107,536	1,87685	140,612	2,45415	-68,148	-1,1894	✓
141,0621809	2,461999507	167,49681	106,811	1,8642	140,387	2,45021	-67,198	-1,1728	✓
140,4892231	2,451999507	168,93539	106,093	1,85167	140,169	2,4464	-66,262	-1,1565	✓

(Relationship between input and output angle)



(Four bar mechanism)

## 2.3 ERROR CALCULATION

The polynomial approximation method was chosen for error calculation.

$$f(x, y) - g(x, y) = e$$

$$P_0 f_0 + P_1 f_1 + P_2 f_2 - F = \text{error}$$

$$\text{error} = 0 \text{ @ Precision point}$$

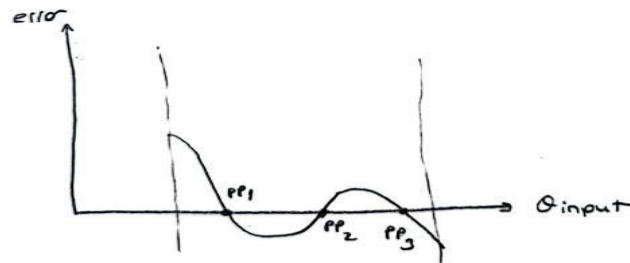
$$P_0, P_1, P_2 \text{ unknowns (3 eqn 3 precision points)}$$

$$P_0 f_0^1 + P_1 f_1^1 + P_2 f_2^1 - F_1 = 0$$

$$P_0 f_0^2 + P_1 f_1^2 + P_2 f_2^2 - F_2 = 0$$

$$P_0 f_0^3 + P_1 f_1^3 + P_2 f_2^3 - F_3 = 0$$

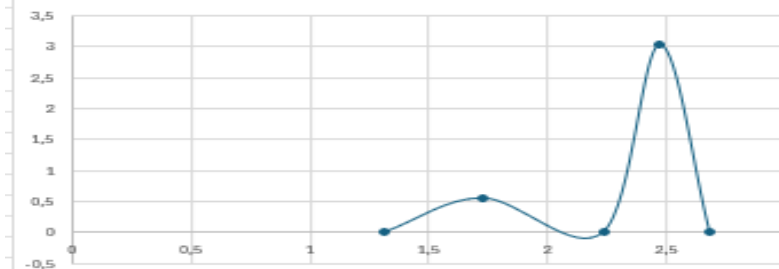
$$\begin{bmatrix} f_0 & f_1 & f_2 \\ f_0 & f_1 & f_2 \\ f_0 & f_1 & f_2 \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \\ P_3 \end{bmatrix} = \begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix}$$



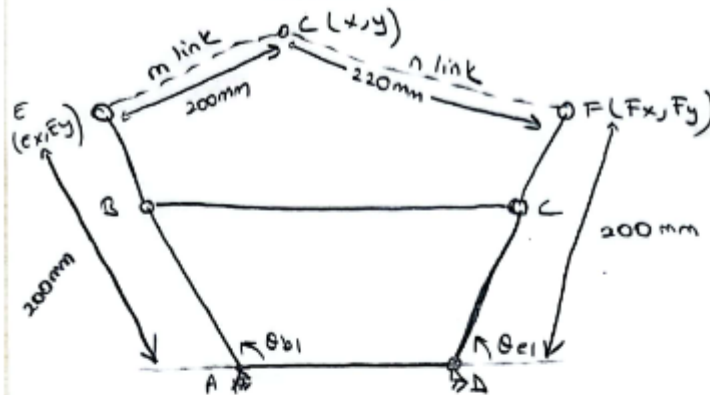
Polynomial approximation					
PRECISION POINTS					
	Qb1	Qe1	A-1*C=B MATRIX		
PP1	2,682	-1,60754	P0	1,25804	
POINT1	2,472	-1,18941	P1	-1,62618	
PP2	2,23261	-0,85152	P2	-1,92823	
POINT 2	1,72199	-0,38527			
PP3	1,3088	-0,11876			
A MATRIX					
	1	-0,03673	0,89623	error at pp1	0
	1	0,65884	0,61455	error at point 1	3,03255
	1	0,99296	-0,25901	error at pp2	0
A-1 MATRIX					
	1,52063	-1,71447	1,19383	error at point 2	0,55259
	-1,70114	2,24968	-0,54854	error at pp3	0
	-0,65064	2,00517	-1,35454		
C MATRIX					
	-0,41036				
	-0,99835				
	0,14275				

ERROR GRAPH

Grafik Başlığı



FINDING THE PATH WHICH FOUR BAR MECHANISM'S TOP POINT FOLLOWS.



$$* (x - E_x)^2 + (y - E_y)^2 = m^2 \quad m = 200 \text{ mm}$$

$$\text{Eqn (1)} \Rightarrow \underbrace{200^2 - E_x^2 - E_y^2}_{k_1} = x^2 + y^2 - 2(E_x \cdot x + E_y \cdot y)$$

$$* (x - F_x)^2 + (y - F_y)^2 = n^2 \quad n = 220 \text{ mm}$$

$$\text{Eqn (2)} \Rightarrow \underbrace{220^2 - F_x^2 - F_y^2}_{k_2} = x^2 + y^2 - 2(F_x \cdot x + F_y \cdot y)$$

$$\text{Eqn (2)} - \text{Eqn (1)} \Rightarrow \frac{k_2 - k_1}{2} = x \underbrace{(-F_x + E_x)}_j + y \underbrace{(-F_y + E_y)}_z$$

$$\frac{k_2 - k_1}{2} = jx + zy$$

$$y = \frac{\frac{k_2 - k_1}{2} - jx}{z} \quad (\text{substitute } y \text{ eqn to eqn (1) then find the } x \text{ value})$$

$$\underbrace{220^2 - F_x^2 - F_y^2}_{k_2} = x^2 + \left( \frac{\frac{k_2 - k_1}{2} - jx}{z} \right)^2 - 2(F_x \cdot x + F_y \cdot y)$$

$$\text{NOTE: } L = \frac{k_2 - k_1}{2}$$

$$0 = x^2 - k_2 + \frac{(L + j^2 x - 2Ljx)^2}{z^2} - 2F_x \cdot x - 2F_y \cdot \frac{L - jx}{z}$$

$$\Rightarrow x^2 \underbrace{(z^2 + j^2)}_a + x \underbrace{(-2Lj - 2F_x z^2 - 2F_y j z)}_b - \underbrace{(k_2 z^2 - 2F_y L z)}_c$$

$$\Rightarrow ax^2 + bx + c = 0 \quad (\text{Find the roots of the eqn})$$

$$x_1 = \frac{-b \pm \sqrt{\Delta}}{2a} \quad (x \text{ founded}) \quad y = \frac{\frac{k_2 - k_1}{2} - jx_1}{z} \quad (y \text{ founded})$$

Repeat this calculations for every position then, find the path function



L										coefficients of the equation			The path which is four bar mechanism follow				
Ex	Ey	M	K1	Fx	Fy	K2	(K2-K1)/2	J=-Fx+Ey	Z=-Fy+Ey	a	b	c	delta	x1	x2	y1	y2
-29,247	-199,87	200	-801,39	291,919	-219,85	-85151	-42175	-491,78	19,9865	242251	-5E+07	-336624126	49452941,6	197,089	-7,0505	2739,36	-2283,7
-28,35	-199,98	200	398,301	297,059	-219,98	-88235	-44317	-497,04	19,9982	247450	-5E+07	-354630853	52147238	203,703	-7,0354	2846,85	-2390,9
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
-26,505	-199,9	200	330,492	307,088	-219,89	-94253	-47292	-506,98	19,9896	257433	-5E+07	-378072985	56230029,2	211,482	-6,9445	2997,87	-2541,9
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
-24,589	-199,42	200	186,024	316,775	-219,36	-100065	-50125	-516,19	19,9418	266852	-6E+07	-398745738	60164472,9	218,625	-6,8348	3145,52	-2690,5
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
-22,603	-198,59	200	-26,328	326,113	-218,44	-105668	-52821	-524,7	19,8586	275703	-6E+07	-416601567	63939164,5	225,203	-6,7097	3290,42	-2837,1
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
-20,547	-197,44	200	-298,02	335,101	-217,18	-111060	-55381	-532,54	19,7438	283987	-6E+07	-431655215	67546341,5	231,278	-6,5721	3433,14	-2982,3
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
-18,424	-196,01	200	-620,83	343,74	-215,61	-116244	-57811	-539,75	19,6007	291711	-7E+07	-443971813	70981386	236,903	-6,4244	3574,17	-3126,4
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
-16,233	-194,33	200	-987,01	352,033	-213,76	-121220	-60116	-546,36	19,4326	298885	-7E+07	-453655818	74242347,5	242,129	-6,2687	3714,01	-3269,8
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
-13,976	-192,42	200	-1389,3	359,987	-211,66	-125992	-62301	-552,41	19,2422	305525	-7E+07	-460841079	77329494,9	246,997	-6,1068	3853,08	-3413,1
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
-11,653	-190,32	200	-1820,9	367,608	-209,35	-130565	-64372	-557,93	19,0322	311648	-8E+07	-465682179	80244911,1	251,546	-5,9403	3991,81	-3556,4
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
-9,266	-188,05	200	-2275,5	374,904	-206,86	-134943	-66334	-562,96	18,8051	317272	-8E+07	-468347073	82992129,1	255,81	-5,7706	4130,58	-3700,2
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
-6,8149	-185,63	200	-2747,6	381,886	-204,19	-139132	-68192	-567,52	18,563	322419	-8E+07	-469010987	85575814,9	259,819	-5,5987	4269,77	-3844,7
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
-4,301	-183,08	200	-3231,8	388,563	-201,39	-143138	-69953	-571,64	18,3079	327110	-8E+07	-467851473	88001492,2	263,602	-5,4258	4409,73	-3990,3
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
-1,7254	-180,42	200	-3723,6	394,946	-198,46	-146967	-71622	-575,36	18,0416	331366	-9E+07	-465044516	90275309,4	267,181	-5,2527	4550,81	-4137,3
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
0,91087	-177,66	200	-4218,6	401,045	-195,42	-150627	-73204	-578,7	17,7657	335211	-9E+07	-460761536	92403842,3	270,579	-5,08	4693,33	-4286
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
3,60677	-174,82	200	-4713,1	406,871	-192,3	-154123	-74705	-581,69	17,4816	338666	-9E+07	-455167181	94393932,1	273,814	-4,9084	4837,62	-4436,7
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
6,36123	-171,91	200	-5203,7	412,436	-189,1	-157462	-76129	-584,34	17,1908	341753	-9E+07	-448417759	96252551,4	276,905	-4,7385	4984,01	-4589,6
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3
9,17315	-168,94	200	-5687,3	417,75	-185,84	-160650	-77481	-586,69	16,8942	344492	-9E+07	-440660210	97986696,7	279,867	-4,5706	5132,8	-4745
-29,247	-199,87	200	400,696	291,919	-219,85	-85151	-42776	-491,78	19,9865	242251	-5E+07	-341906178	50054893,6	199,552	-7,0727	2769,88	-2314,3

### 3. RESULTS

In the project, the path that the mechanism needed to follow was a function in the x and y planes. This means that a 2-degree-of-freedom mechanism can follow this path with zero error. We proved this with the synthesis of the 5-bar mechanism. However, when we converted our 5-bar mechanism to a 4-bar mechanism, the degrees of freedom reduced to 1, causing the mechanism to fail to follow the required path and errors to occur. In the final step of the project, this error was calculated to reach a conclusion.



