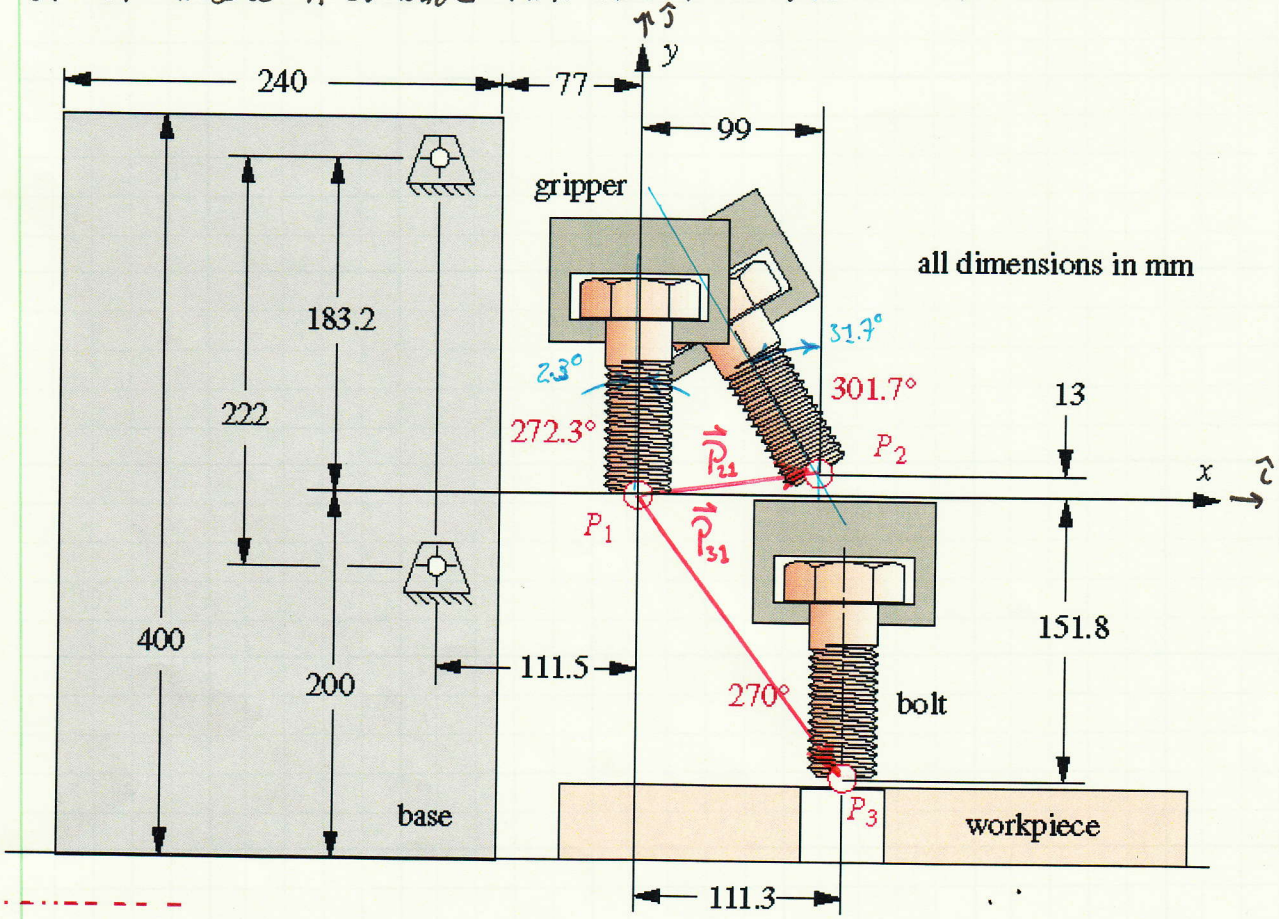
PROBLEM 5.34 | DESIGN A FOURBAR LINKAGE TO CARRY THE BOLT SHOWN BELOW IN THE FIGURE FROM POSITION 1 TO 2 TO 3 WITHOUT REGARD TO THE FIXED PIVOTS SHOWN. THE BOLT IS FED INTO THE GRIPPER IN THE Z-DIRECTION. THE GRIPPER GRABS THE BOLT, AND YOUR LINKAGE MOVES IT TO ~~POSITI~~ POSITION 3 TO BE INSERTED INTO THE HOLE. A SECOND DEGREE OF FREEDOM WITHIN THE GRIPPER ASSEMBLY (NOT SHOWN) PUSHES THE BOLT INTO THE HOLE. EXTEND THE GRIPPER ASSEMBLY AS NECESSARY TO INCLUDE THE MOVING PIVOTS. THE FIXED PIVOTS SHOULD BE ON THE BASE. HINT: TRY GUESS VALUES OF $\beta_2 = 70°$; $\beta_3 = 140°$, $\gamma_2 = -5°$, $\gamma_3 = -49°$

GIVEN:
1. THE CONFIGURATION SHOWN IN THE FIGURE
2. THE FIXED PIVOTS NEED TO BE ON THE BASE.

ASSUMPTIONS:
1. ALL COMPONENTS ARE RIGID
2. ALL JOINTS ARE FRICTIONLESS
3. ALL MOTION IS PLANAR
4. GRAVITY ACTS VERTICALLY DOWNWARD

FIND:
1) SYNTHESISE A LINKAGE THAT WILL MOVE THE BOLT AS SPECIFIED.



SOLUTION:

THE FIRST STEP IS TO LOCATE THE POINTS P_1, P_2, AND P_3 USING THE COORDINATE SYSTEM WITH AN ORIGIN AT P_1

$$(P_{1x}, P_{1y}) = (0mm, 0mm) \quad (1)$$

$$(P_{2x}, P_{2y}) = (99mm, 13mm) \quad (2)$$

$$(P_{3x}, P_{3y}) = (111.3mm, -151.8mm) \quad (3)$$

THE GIVEN INPUTS TO THE THREE POSITION ANALYSIS CAN NOW BE CALCULATED

$$\rho_{21} = \sqrt{(P_{2x}-P_{1x})^2+(P_{2y}-P_{1y})^2} = \sqrt{(99mm-0mm)^2+(13mm-0mm)^2} = 99.85mm \quad (4)$$

$$\rho_{31} = \sqrt{(P_{3x}-P_{1x})^2+(P_{3y}-P_{1y})^2} = \sqrt{(111.3mm-0mm)^2+(-151.8mm-0mm)^2} = 188.23mm \quad (5)$$

$$\delta_2 = \tan^{-1}\frac{P_{2y}-P_{1y}}{P_{2x}-P_{1x}} = \tan^{-1}\frac{13mm-0mm}{99mm-0mm} = 7.48^\circ \quad (6)$$

$$\delta_3 = \tan^{-1}\frac{P_{3y}-P_{1y}}{P_{3x}-P_{1x}} = \tan^{-1}\frac{-151.8mm-0mm}{111.3mm-0mm} = 306.25^\circ \quad (7)$$

$$\alpha_2 = 31.7^\circ - 2.3^\circ = 29.4^\circ \quad (8)$$

$$\alpha_3 = 360^\circ - 2.3^\circ = 357.7^\circ \quad (9)$$

THE SUGGESTED VALUES GIVEN IN THE PROBLEM STATEMENT ARE THE FINAL CHOSEN VALUES NEEDED TO RUN THE SYNTHESIS.

$$\beta_2 = 70^\circ \quad (10)$$

$$\beta_3 = 140^\circ \quad (11)$$

$$\gamma_2 = -5^\circ \quad (12)$$

$$\gamma_3 = -49^\circ \quad (13)$$

A PRINTOUT OF THE RESULTS OF THE THREE-POSITION ANALYTICAL SYNTHESIS USING THE VALUES IN (4)-(13) IS FOUND ON THE NEXT PAGE.

FIRST DYAD

GIVEN:		CHOSEN:		FIND:	
P12	99.85	β2	70.00	w	100.015
P13	188.23	β3	140.00	θ	150.003
δ2	7.84			z	306.948
δ3	306.25			ϕ	-49.502
α2	29.40			W1x	-86.618
α3	357.70			W1y	50.003
				Z1x	199.338
				Z1y	-233.413

	x-coord	y-coord.
O2	-112.719	183.410
A1	-199.338	233.413
A2	-189.332	119.117
A3	-78.508	89.428
P1	0.000	0.000
P2	98.917	13.620
P3	111.302	-151.797

$$\begin{bmatrix} -0.6580 & -0.9397 & -0.1288 & -0.4909 \\ 0.9397 & -0.6580 & 0.4909 & -0.1288 \\ -1.7660 & -0.6428 & -0.0008 & 0.0401 \\ 0.6428 & -1.7660 & -0.0401 & -0.0008 \end{bmatrix} \begin{Bmatrix} W1x \\ W1y \\ Z1x \\ Z1y \end{Bmatrix} = \begin{Bmatrix} 98.9167 \\ 13.6203 \\ 111.3022 \\ -151.7971 \end{Bmatrix}$$

SECOND DYAD

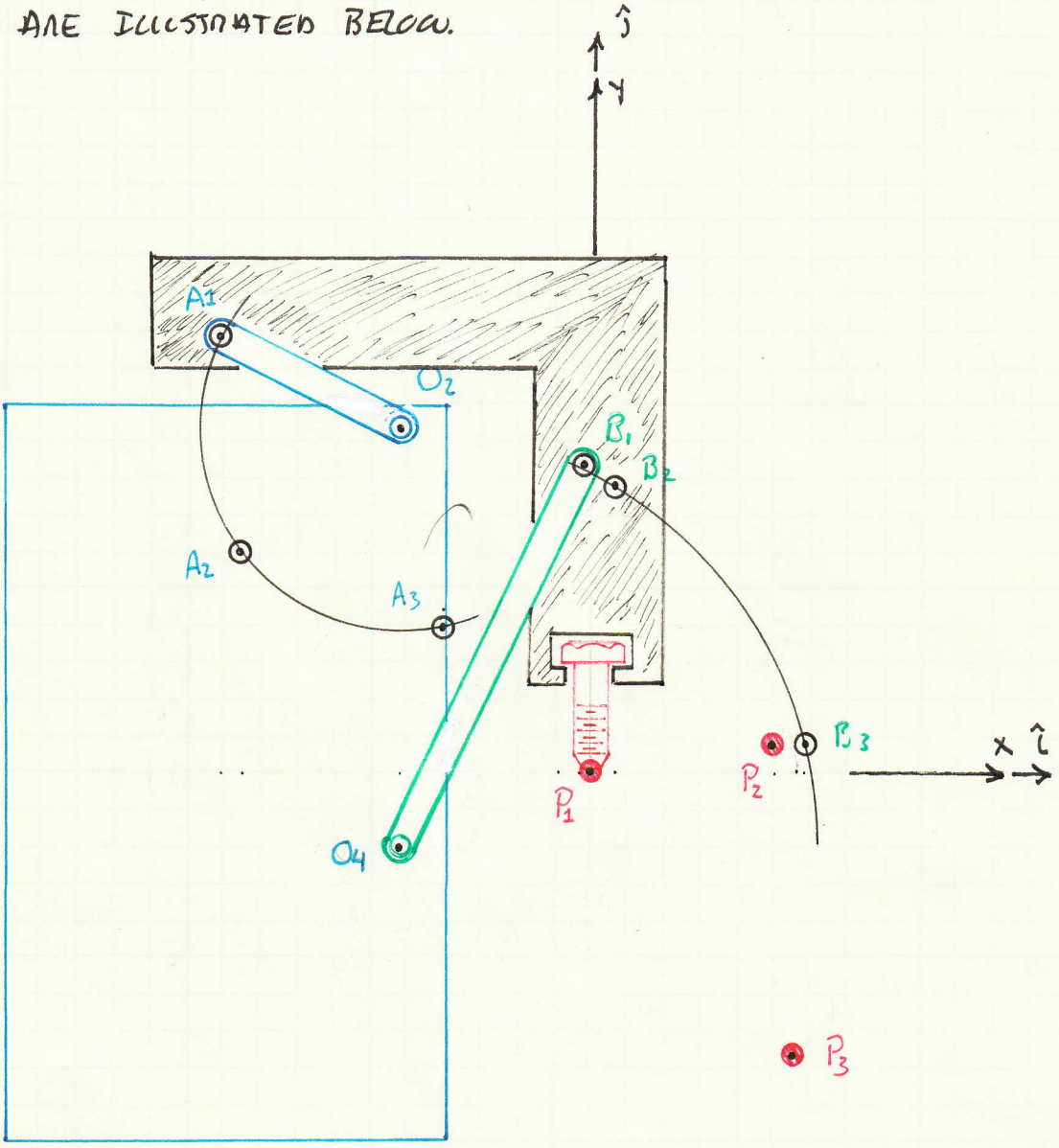
GIVEN:		CHOSEN:		FIND:	
P12	99.85	γ2	-5.00	u	231.779
P13	188.23	γ3	-49.00	σ	62.371
δ2	7.84			s	167.141
δ3	306.25			ψ	-88.427
α2	29.40			U1x	107.484
α3	357.70			U1y	205.350
				S1x	4.588
				S1y	-167.078

	x-coord	y-coord.
O4	-112.072	-38.272
B1	-4.588	167.078
B2	12.900	156.929
B3	113.423	15.330
P1	0.000	0.000
P2	98.917	13.620
P3	111.302	-151.797

$$\begin{bmatrix} -0.0038 & 0.0872 & -0.1288 & -0.4909 \\ -0.0872 & -0.0038 & 0.4909 & -0.1288 \\ -0.3439 & 0.7547 & -0.0008 & 0.0401 \\ -0.7547 & -0.3439 & -0.0401 & -0.0008 \end{bmatrix} \begin{Bmatrix} U1x \\ U1y \\ S1x \\ S1y \end{Bmatrix} = \begin{Bmatrix} 98.9167 \\ 13.6203 \\ 111.3022 \\ -151.7971 \end{Bmatrix}$$

SOLUTION DIAGRAM:

THE RESULTS FROM THE THREE POSITION SYNTHESIS ARE ILLUSTRATED BELOW.



SUMMARY:

HAVING THE PRECISION POINTS GIVEN ALONG WITH THE ORIENTATION OF BOLT SIGNIFICANTLY REDUCED THE COMPLEXITY OF THE PROBLEM.