PROBLEM 1

PART 1: FOR THE CASE OF $M = +1$ AND $L = 8$, USING THE TECHNIQUE DISCUSSED IN CLASS TO DETERMINE ALL THE COMBINATIONS OF BINARY (B), TERNARY (T), QUATERNARY (Q), AND PENTAGONAL (P) LINKS THAT CAN BE USED TO MAKE UP ACCEPTABLE ISOMERS.

PART 2: TAKE ONE OF THESE ISOMERS (LECTURE 8, pp. 21-23) AND DRAW MECHANISMS WITH THE FOLLOWING ATTRIBUTES.

2.1. ONLY REVOLUTE AND PRISMATIC JOINTS
2.2. TURN A FULL JOINT (LOWER ORDER) INTO A HALF JOINT (HIGHER ORDER)
2.3. REMOVE A BINARY LINK
2.4. ADD A BINARY LINK
2.5. PARTIALLY SHRINK ONE OF THE HIGHER ORDER LINKS (TERNARY, QUATERNARY, AND PENTAGONAL)
2.6. COMPLETELY SHRINK ONE OF THE HIGHER ORDER LINKS

PART 3: CALCULATE THE FOLLOWING FOR EACH OF THE LINKAGES CONSTRUCTED ABOVE.

3.1. NUMBER OF LINKS (L)
3.2. NUMBER OF JOINTS (J)
3.3. MOBILITY.

GIVEN:

1. MECHANISM WITH MOBILITY +1
2. TOTAL NUMBER OF LINKS 8 (BINARY, TERNARY, QUATERNARY, PENTAGONAL ONLY)

ASSUMPTIONS:

1. ALL LINKS ARE RIGID
2. ~~ALL~~ THE VELOCITIES OF ALL POINTS ON THE LINKS ARE PARALLEL TO A SINGLE PLANE
3. ALL JOINTS ARE FRICTIONLESS
4. ALL JOINTS ARE FULL

FIND:

1) ALL ACCEPTABLE COMBINATIONS OF LINKS WITH $L = 8$ & $M = +1$
2) 2.1 - 2.6
3) 3.1-3.3

SOLUTION

PART 1:

THE DETERMINATION OF ACCEPTABLE ISOMERS IS BASED ON
a. ALL JOINTS ARE FULL (LOWER ORDER) JOINTS
b. THE DEGREES OF FREEDOM ARE UNIFORMLY DISTRIBUTED THROUGHOUT THE MECHANISM

GIVEN THESE CONDITIONS IT CAN BE SHOWN THAT THE MOBILITY CAN BE WRITTEN IN THE FORM

$$M = B - Q - 2P - 3 \quad (1)$$

AND THE TOTAL NUMBER OF LINKS IN THE SYSTEM IS GIVEN BY

$$L = B + T + Q + P \quad (2)$$

FOR THE CASE UNDER CONSIDERATION IN THIS PROBLEM

$$(1) \rightarrow 1 = B - Q - 2P - 3 \quad (3)$$

$$(2) \rightarrow 8 = B + T + Q + P \quad (4)$$

THE COMBINATIONS OF B, T, Q, & P CAN NOW BE WRITTEN AND CHECKED WITH (3) TO SEE IF THE PROPER MOBILITY CAN BE ACHIEVED. ~~ANOTHER~~ CONSTRAINTS ARE THAT ALL THE JOINTS OF ALL THE LINKS ARE CONNECTED IN KINEMATIC PAIRS AND a & b ARE NOT VIOLATED.

FOR $M = {}^{+}1$, $L = 8$

B	T	Q	P	M (1) $= B - Q - 2P - 3$	RESULT
8	0	0	0	$M = 8 - 0 - 2(0) - 3 = 5$	NOT ACCEPTABLE
7	1	0	0	$M = 7 - 0 - 2(0) - 3 = 4$	NOT ACCEPTABLE
7	0	1	0	$M = 7 - 1 - 2(0) - 3 = 3$	NOT ACCEPTABLE
7	0	0	1	$M = 7 - 0 - 2(1) - 3 = 2$	NOT ACCEPTABLE
6	2	0	0	$M = 6 - 0 - 2(0) - 3 = 3$	NOT ACCEPTABLE
6	0	2	0	$M = 6 - 2 - 2(0) - 3 = 1$	POSSIBLE
6	0	0	2	$M = 6 - 0 - 2(2) - 3 = -1$	NOT ACCEPTABLE
6	1	1	0	$M = 6 - 1 - 2(0) - 3 = 2$	NOT ACCEPTABLE
6	1	0	1	$M = 6 - 0 - 2(1) - 3 = 1$	POSSIBLE
6	0	1	1	$M = 6 - 1 - 2(1) - 3 = -1$	NOT ACCEPTABLE

FOR M = 1, L = 8 CONTINUED

B	T	Q	P	M = B - Q - 2P - 3	RESULT
5	3	0	0	$M = 5 - 0 - 2(0) - 3 = 2$	NOT ACCEPTABLE
5	0	3	0	$M = 5 - 3 - 2(0) - 3 = -1$	NOT ACCEPTABLE
5	0	0	3	$M = 5 - 0 - 2(3) - 3 = -4$	NOT ACCEPTABLE
5	2	1	0	$M = 5 - 1 - 2(0) - 3 = 1$	POSSIBLE
5	2	0	1	$M = 5 - 0 - 2(1) - 3 = 0$	NOT ACCEPTABLE
5	1	2	0	$M = 5 - 2 - 2(0) - 3 = 0$	NOT ACCEPTABLE
5	0	2	1	$M = 5 - 2 - 2(1) - 3 = -2$	NOT ACCEPTABLE
5	1	0	2	$M = 5 - 0 - 2(2) - 3 = -2$	NOT ACCEPTABLE
5	0	1	2	$M = 5 - 1 - 2(2) - 3 = -3$	NOT ACCEPTABLE
5	1	1	1	$M = 5 - 1 - 2(1) - 3 = -1$	NOT ACCEPTABLE
4	4	0	0	$M = 4 - 0 - 2(0) - 3 = 1$	POSSIBLE
4	3	1	0	$M = 4 - 1 - 2(0) - 3 = 0$	NOT ACCEPTABLE
4	3	0	1	$M = 4 - 0 - 2(1) - 3 = -1$	NOT POSSIBLE
4	1	3	0		
4	0	3	1		
4	1	0	3		
4	0	1	3		

THIS EQUATION WILL NOT YIELD ANY MORE ACCEPTABLE ISOMERS BECAUSE 4 BINARY LINKS ARE SUBJECT TO THE ADDITION OF -3 GIVING 1. ANY ADDITIONAL LINKS WILL CAUSE THIS SUM TO BE LESS THAN 1

THE POSSIBLE LINK COMBINATIONS FOR ACCEPTABLE ISOMERS WITH FULL JOINTS, 8 LINKS AND MOBILITY 1 ARE

	B	T	Q	P	
OK →	6	0	2	0	
	6	1	0	1	← THE IS NO WAY TO CONFIGURE THE COMBINATION OF LINKS AND ALSO SATISFY THE DISTRIBUTION OF DOF.
OK →	5	2	1	0	
OK →	4	4	0	0	

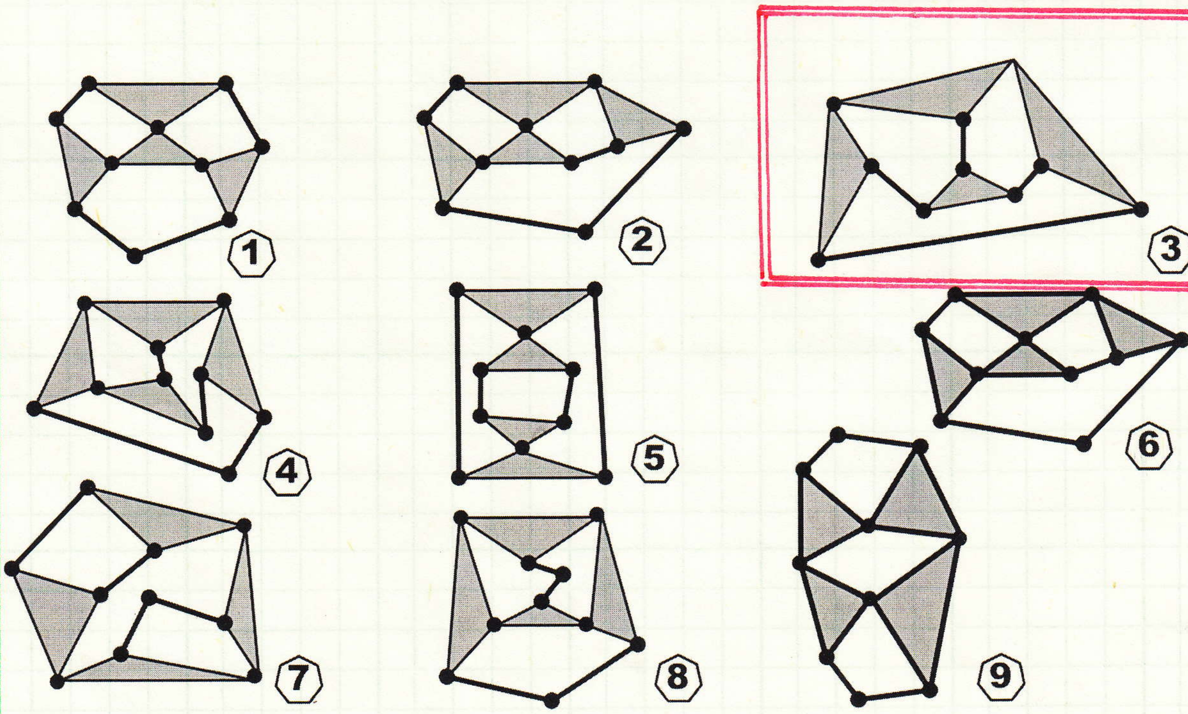
THE RESULT ABOVE AGREES WITH THE SUMMARY IN THE LECTURE THAT IS SUMMARIZED ON THE NEXT PAGE.

ALL THE ACCEPTABLE ISOMERS FOR THE THREE ACCEPTABLE CASES ABOVE ARE SUMMARIZED ON THE NEXT TWO PAGES.

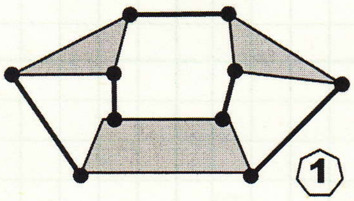
M	L	B	T	Q	P	Designation
+1	4	4	0	0	0	I
	6	4	2	0	0	II
	6	5	0	1	0	III
	8	4	4	0	0	IV
	8	5	2	1	0	V
	8	6	0	2	0	VI
	8	6	1	0	1	VII

M	L	B	T	Q	P	Designation
+1	8	4	4	0	0	IV

Isomer that will be used to answer parts 2 & 3



M	L	B	T	Q	P	Designation
+1	8	5	2	1	0	V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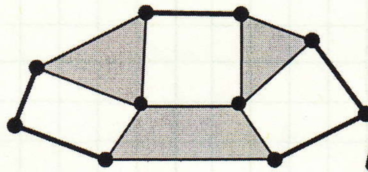
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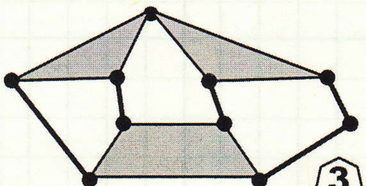
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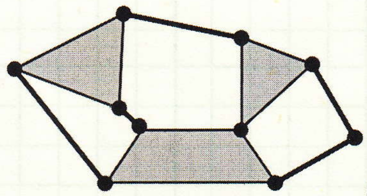
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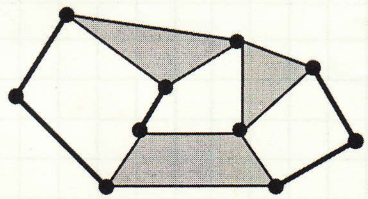
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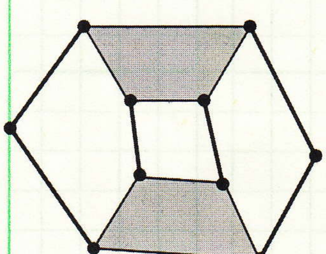
M	L	B	T	Q	P	Designation
+1	8	6	0	2	0	VI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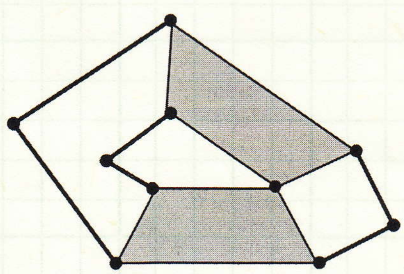
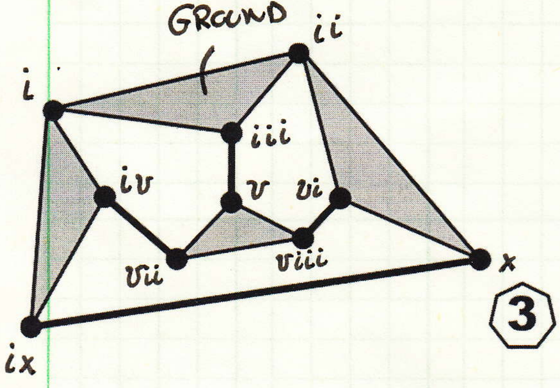

2

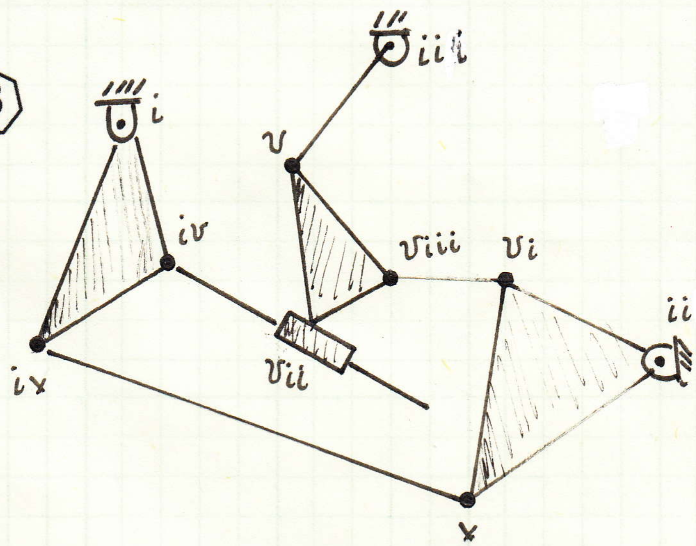
PART 2 & 3

THE ISOMER THAT WILL BE USED FOR PARTS 2 & 3 IS IV.3 FROM PAGE 4

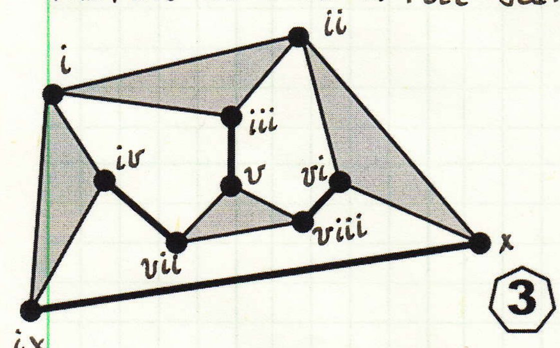
PART 2,3 - 1: CREATE A MECHANISM WITH ONLY PRISMATIC & REVOLUTE JOINTS.



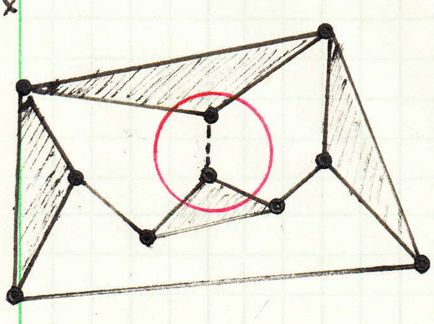
$$L = 8,\ J_2 = 10,\ M = 3(L-1) - 2J$$
$$= 3(8-1) - 2 \cdot 10$$
$$= 21 - 20 = \boxed{1}$$

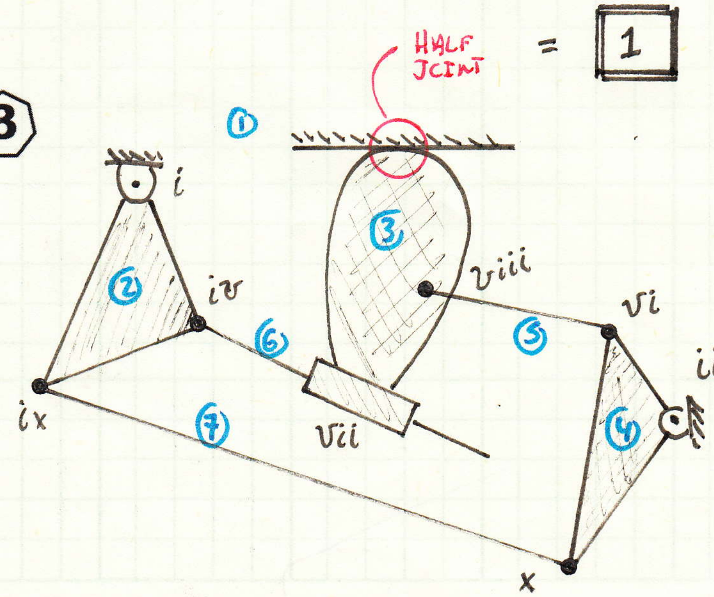


PART 2,3 - 2: TURN A FULL JOINT INTO A HALF JOINT



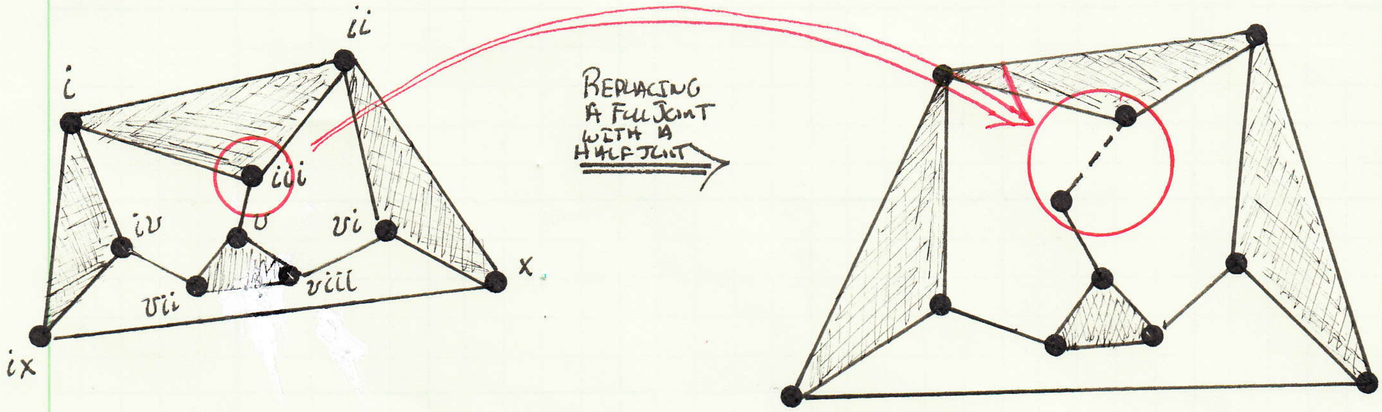
$$L = 7,\ J_2 = 8,\ J_1 = 1,\ M = 3(L-1) - 2J_2 - J_1$$
$$= 3(7-1) - 2(8) - 1$$
$$= 18 - 16 - 1$$
$$= \boxed{1}$$

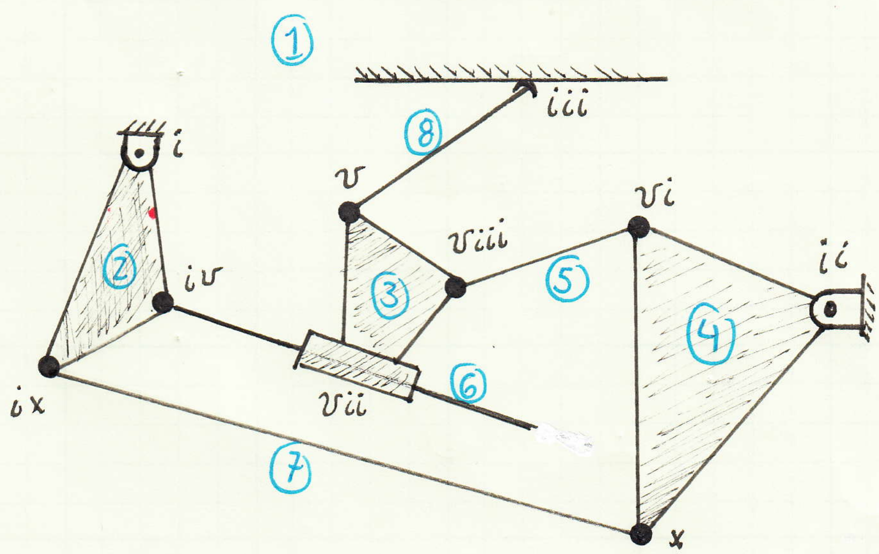




THE RULE FOR REPLACING A FULL JOINT WITH A HALF JOINT PREDICTS THAT THE DEGREE OF FREEDOM OF THE MECHANISM SHOULD INCREASE BY ONE. HOWEVER, THE MOBILITY OF THE MECHANISM SYNTHESIZED ABOVE STAYED THE SAME. THIS IS BECAUSE ABOVE A LINK WAS TURNED INTO A HALF JOINT, ~~THE~~ INSTEAD OF THE FULL JOINT BEING REPLACED BY THE HALF JOINT.

STARTING OVER WITH ISOMER IV.3



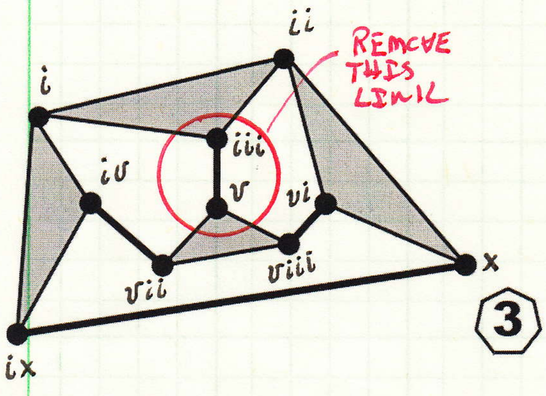


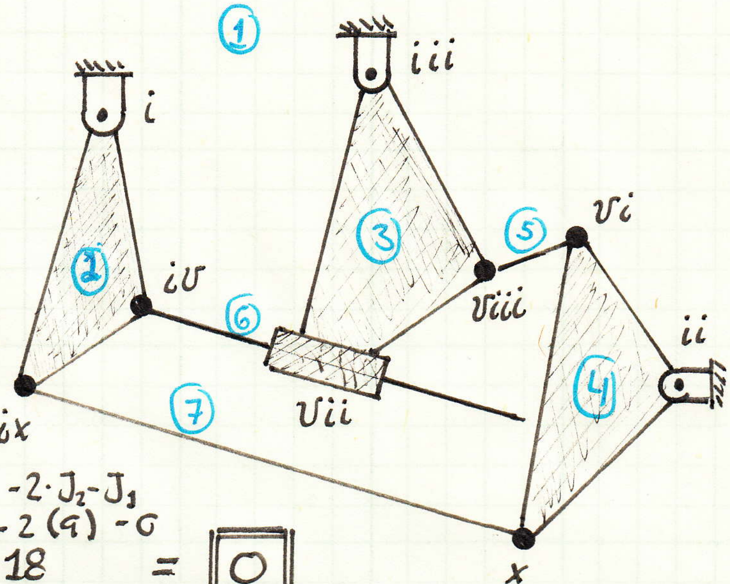
$L = 8, \quad J_2 = 9, \quad J_1 = 1$

$$
\begin{aligned}
M &= 3(L-1) - 2 \cdot J_2 - J_1 \\
&= 3(8-1) - 2 \cdot 9 - 1 \\
&= 21 - 18 - 1 \\
&= \boxed{2}
\end{aligned}
$$

NOW THAT JOINT iii WAS PROPERLY CHANGED TO A HALF JOINT, THE DEGREES OF FREEDOM FOR THE MECHANISM DO GO UP BY 1.

PART 2,3-3: REMOVE A BINARY LINK





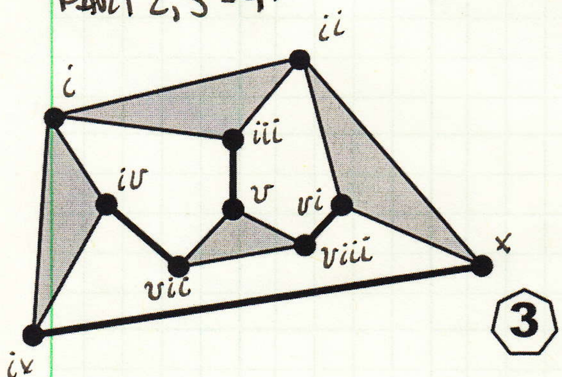
$L = 7,\ J_2 = 9,\ J_1 = 0 \qquad M = 3(L-1) - 2\cdot J_2 - J_1$

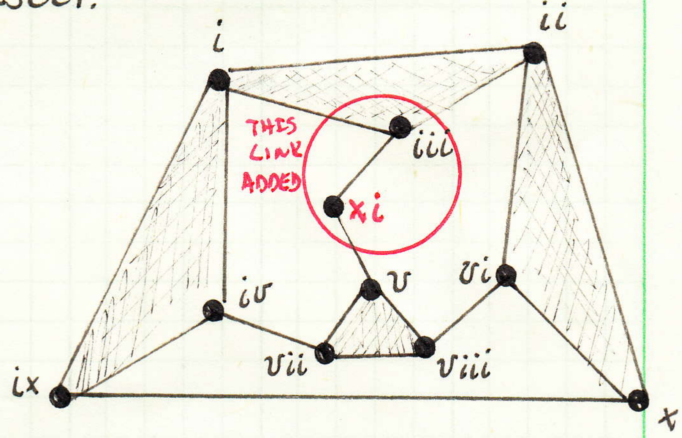
$= 3(7-1) - 2(9) - 0$

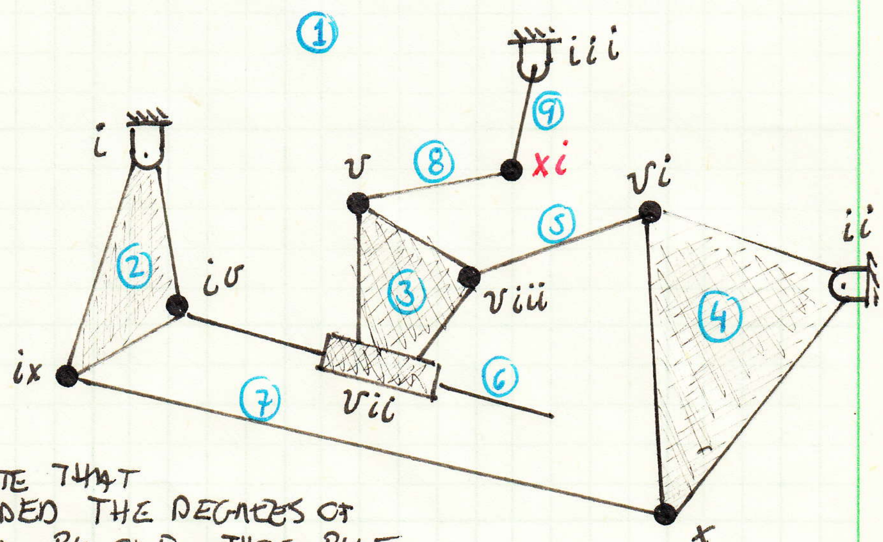
$= 18 - 18 = \boxed{0}$

THE RULES FOR ISOMERS STATES THAT IF A BINARY LINK IS REMOVED THE DEGREES OF FREEDOM WILL BE REDUCED BY ONE. THIS RULE IS CONFIRMED BY THE ABOVE RESULT.

PART 2,3-4:







$L = 9,\ J_2 = 11$

$M = 3(L-1) - 2J_2$

$= 3(9-1) - 2(11)$

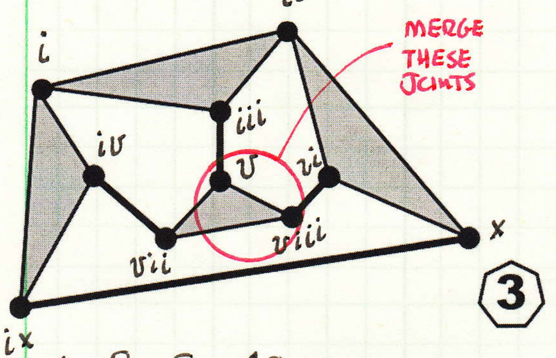
$= 24 - 22$

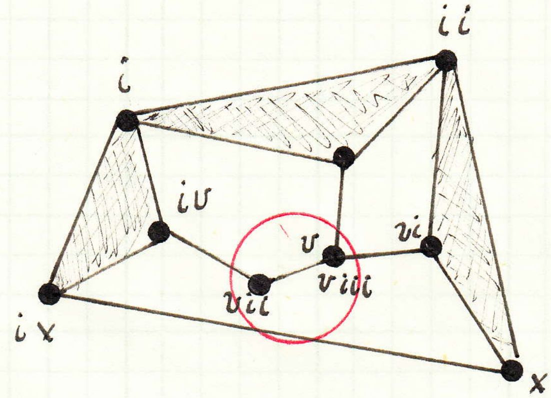
$= \boxed{2}$

THE RULES FOR ISOMERS STATE THAT IF A BINARY LINK IS ADDED THE DEGREES OF FREEDOM WILL INCREASE BY ONE. THIS RULE IS CONFIRMED BY THE ABOVE RESULT.

NOTE THAT THIS RESULT IS SIMILAR TO THE RESULT IN PART 2,3-2 WHEN AN IMAGINARY LINK WAS ADDED.

Part 2,3-5: Partially shrink one of the higher order links

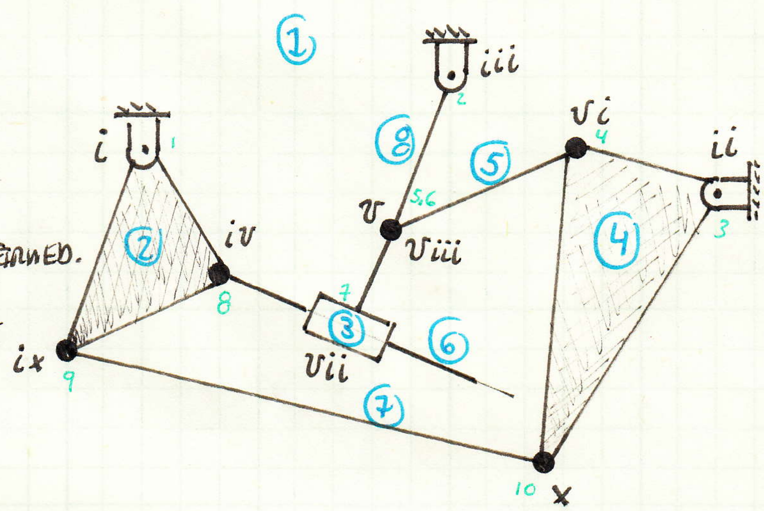




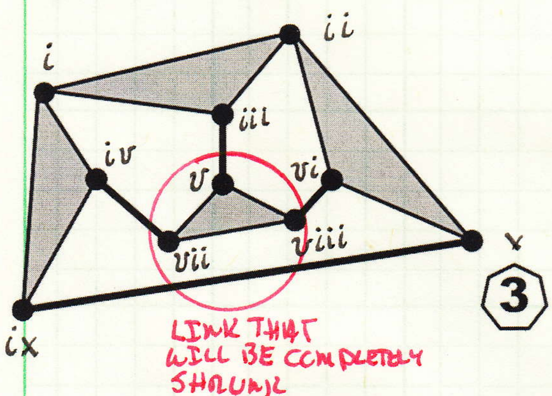
$L = 8, \; J_2 = 10$

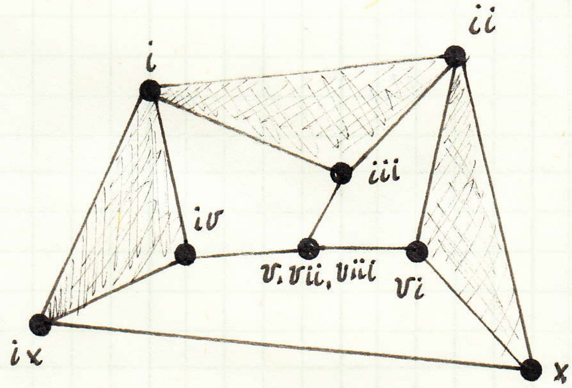
$$M = 3(L-1) - 2J_2 = 3(8-1) - 2(10) = 21 - 20 = \boxed{1}$$

The rules for partial shrinkage of a higher order link is confirmed.



Part 2.3-5: Complete shrinkage of a higher order link

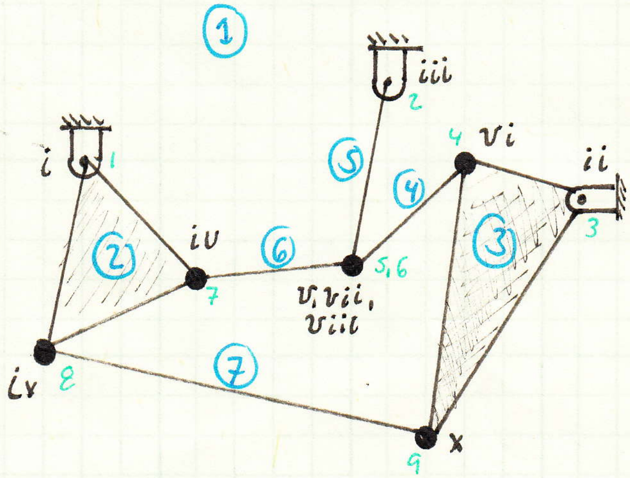




$L = 7, \; J_2 = 9$

$$M = 3(L-1) - 2 \cdot J_2 = 3(7-1) - 2 \cdot 9 = 18 - 18 = \boxed{0}$$

The rule for complete shrinkage of a higher order link is confirmed.



SUMMARY:

AN INTERESTING TAKE AWAY FROM PART 1 IS THAT IN USING THE EQUATION

$$M = B - Q - 2P - 3 = (B-3) - Q - 2P$$

IT IS CLEAR THAT THE TERM IN THE "( )" DEFINES THE FLOOR FOR THE NUMBER OF BINARY LINKS THAT CAN BE USED IN A MECHANISM. IN THE CASE OF $M=1$, THE MINIMUM NUMBER OF BINARY LINKS IS

$$1 = B - 3 \implies B = 4$$