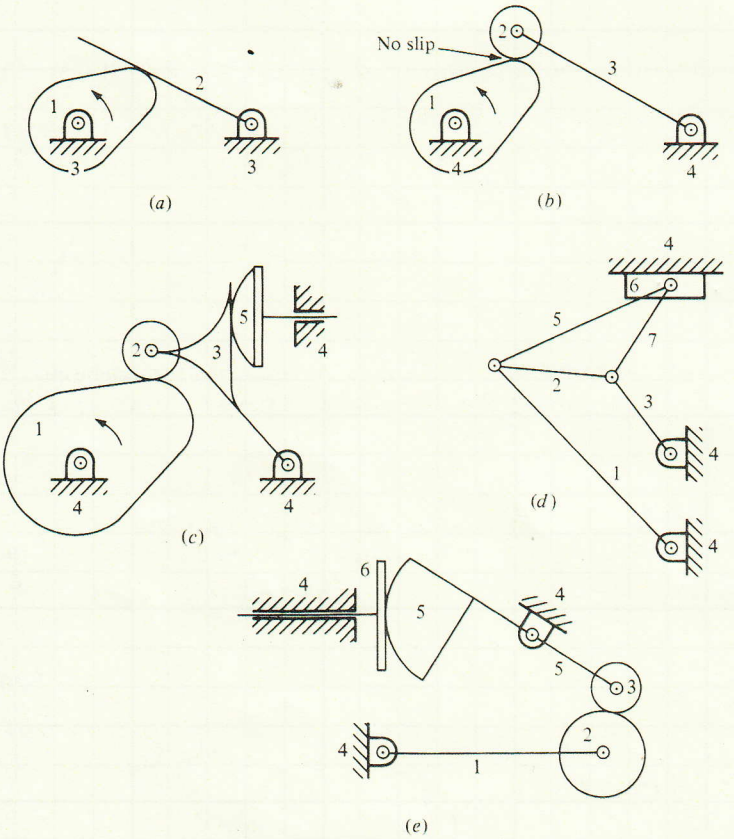
PROB 1.2 | DETERMINE THE DEGREE OF FREEDOM OF EACH OF THE FOLLOWING MECHANISMS. IF THE DEGREE OF FREEDOM IS NOT 1, MAKE RECOMMENDATIONS FOR CHANGING THE MECHANISM.

GIVEN:
1. MECHANISMS (a) - (e) BELOW

ASSUMPTIONS:
1. ALL MECHANISMS ARE PLANAR
2. ALL LINKS ARE RIGID
3. ALL JOINTS ARE FRICTIONLESS

FIND:
1. DETERMINE THE DEGREE OF FREEDOM FOR MECHANISMS (a) - (e)
2. IF THE MECHANISM DOES NOT HAVE MOBILITY 1, MAKE RECOMMENDATIONS TO CHANGE THE MECHANISM TO MOBILITY 1.

FIGURES:



LINKS ARE DRAWN IN RED
HALF JOINTS ARE DRAWN IN BLUE
FULL JOINTS ARE DRAWN IN GREEN

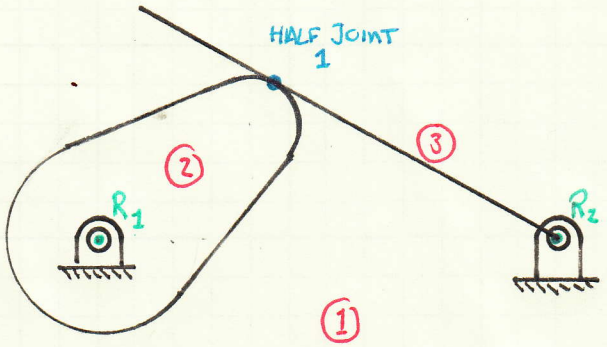
SOLUTION:

(a) FROM KUTZBACH'S EQUATION

$$M = 3(L-1) - 2 \cdot f_1 - f_2$$

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

$$= 6 - 4 - 1 = \boxed{1}$$

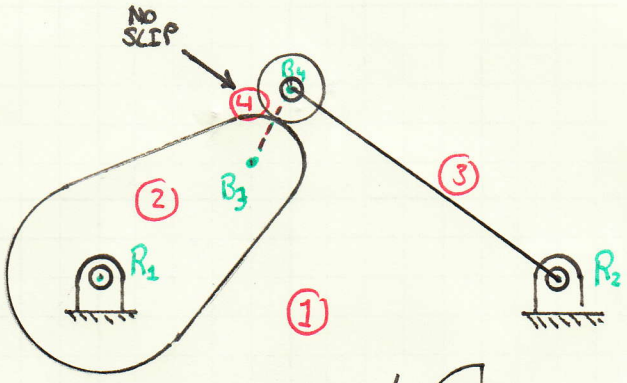


(b) THE ROLLER (4) IS ACTUALLY ADDED JUST TO PREVENT WEAR THAT WOULD BE PRESENT IN (a) ABOVE

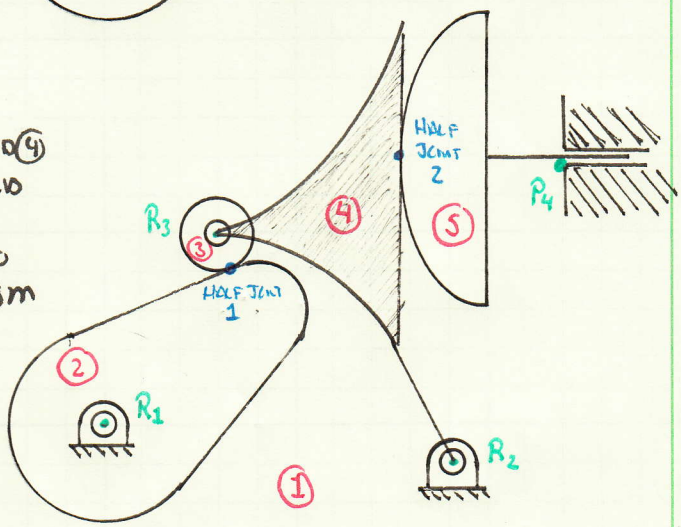
$$M = 3(L-1) - 2 \cdot f_1 - f_2$$

$$= 3(4-1) - 2 \cdot (4) - 0$$

$$= 3(3) - 2 \cdot (4) - 0 = \boxed{1}$$



(c) THE TYPE OF JOINT BETWEEN LINKS (3) AND (4) IS NOT CLEAR FROM THE FIGURE. IT COULD BE A HALF OR FULL JOINT. IN EITHER CASE, LINK 3 (THE ROLLER) IS PRESENT TO REDUCE WEAR. HOLDING THE MECHANISM FIXED AND JUST ROTATING (3) CAUSES NO CHANGE TO THE MECHANISM; THEREFORE, IT IS CONSIDERED REDUNDANT.



FIRST CONSIDER THE JOINT BETWEEN (2) & (3) TO BE A HALF JOINT.

$$M = 3(L-1) - 2 \cdot f_1 - f_2 = 3(5-1) - 2 \cdot 4 - 2 = 12 - 8 - 2 = \boxed{2}$$

THIS IS CONSIDERED A PARADOX RESULT

NOW CONSIDER THE JOINT BETWEEN (2) & (3) TO BE A FULL JOINT

$$M = 3(L-1) - 2 \cdot f_1 - f_2 = 3(5-1) - 2 \cdot 5 - 1 = 12 - 10 - 1 = \boxed{1}$$

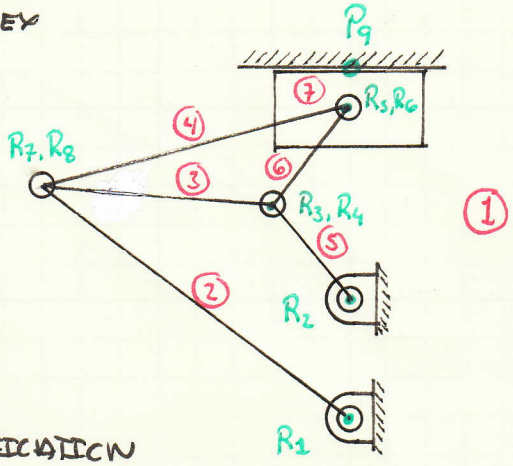
NOW CONSIDER THE ROLLER (3) REMOVED FROM THE MECHANISM, R_3 BECOMES A HALF JOINT BETWEEN (4) & (2)

$$M = 3(L-1) - 2 \cdot f_1 - f_2 = 3(4-1) - 2(3) - 2 = 9 - 6 - 2 = \boxed{1}$$

(d) ALL JOINTS IN THIS PART OF THE PROBLEM ARE FULL, BUT SOME OF THE JOINTS ARE COMPLEX

$$M = 3(L-1) - 2\cdot J$$

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

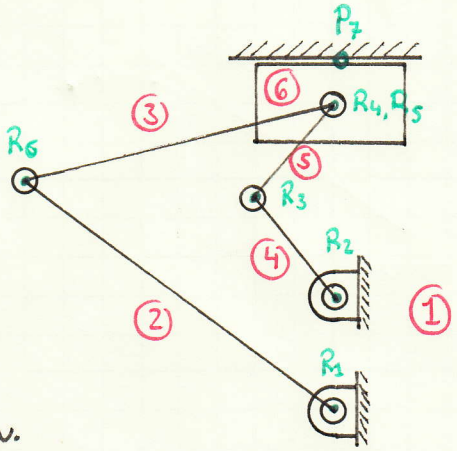


ONE WAY TO TURN THIS STRUCTURE INTO A MECHANISM WITH $M=1$ IS TO REMOVE LINK ③

FOR THE MECHANISM WITH THE ABOVE MODIFICATION

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

$$= 3(6-1) - 2(7) = 15 - 14 = \boxed{1}$$



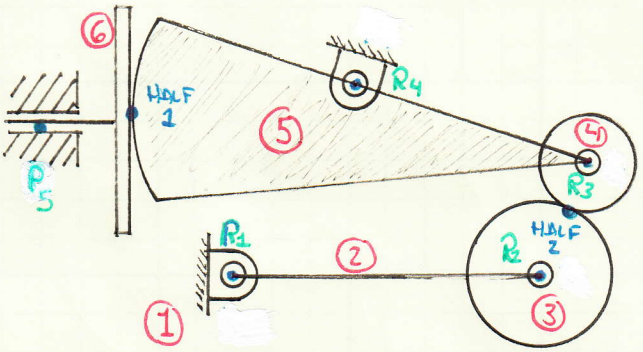
(e) LINK ⑤ HAS BEEN SLIGHTLY MODIFIED FROM THE PROBLEM DESCRIPTION TO BETTER SHOW ITS FUNCTION.

$$M = 3(L-1) - 2J_1 - J_2$$

$$= 3(6-1) - 2(5) - 2$$

$$= 15 - 10 - 2 = \boxed{3}$$

THIS IS CONSIDERED A PARADOX RESULT



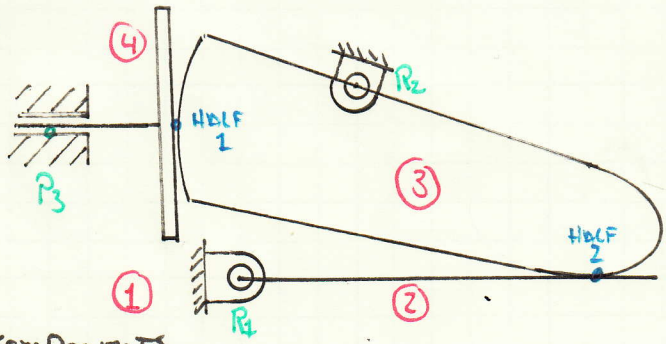
BOTH ROLLER/LINK ③ AND ④ CAN BE ROTATED WITHOUT MOVING THE OTHER PARTS OF THE MECHANISM SO THEY ARE CONSIDERED REDUNDANT.

THE MOBILITY OF THE RECONFIGURED SYSTEM CAN NOW BE COMPUTED

$$M = 3(L-1) - 2J_1 - J_2$$

$$= 3(4-1) - 2(3) - 2$$

$$= 9 - 6 - 2 = \boxed{1}$$



<u>SUMMARY</u>: IN (c) AND (e) REDUNDANT COMPONENTS ARE FOUND TO GIVE MISLEADING RESULTS. THESE REDUNDANT COMPONENTS ARE IDENTIFIED BY CONCEPTUALLY MOVING THE COMPONENTS IN THE MECHANISM AND IF THE MOVEMENT DOES NOT CAUSE A CHANGE IN THE OTHER MECHANISM COMPONENTS, THE COMPONENT IS NOT NEEDED.