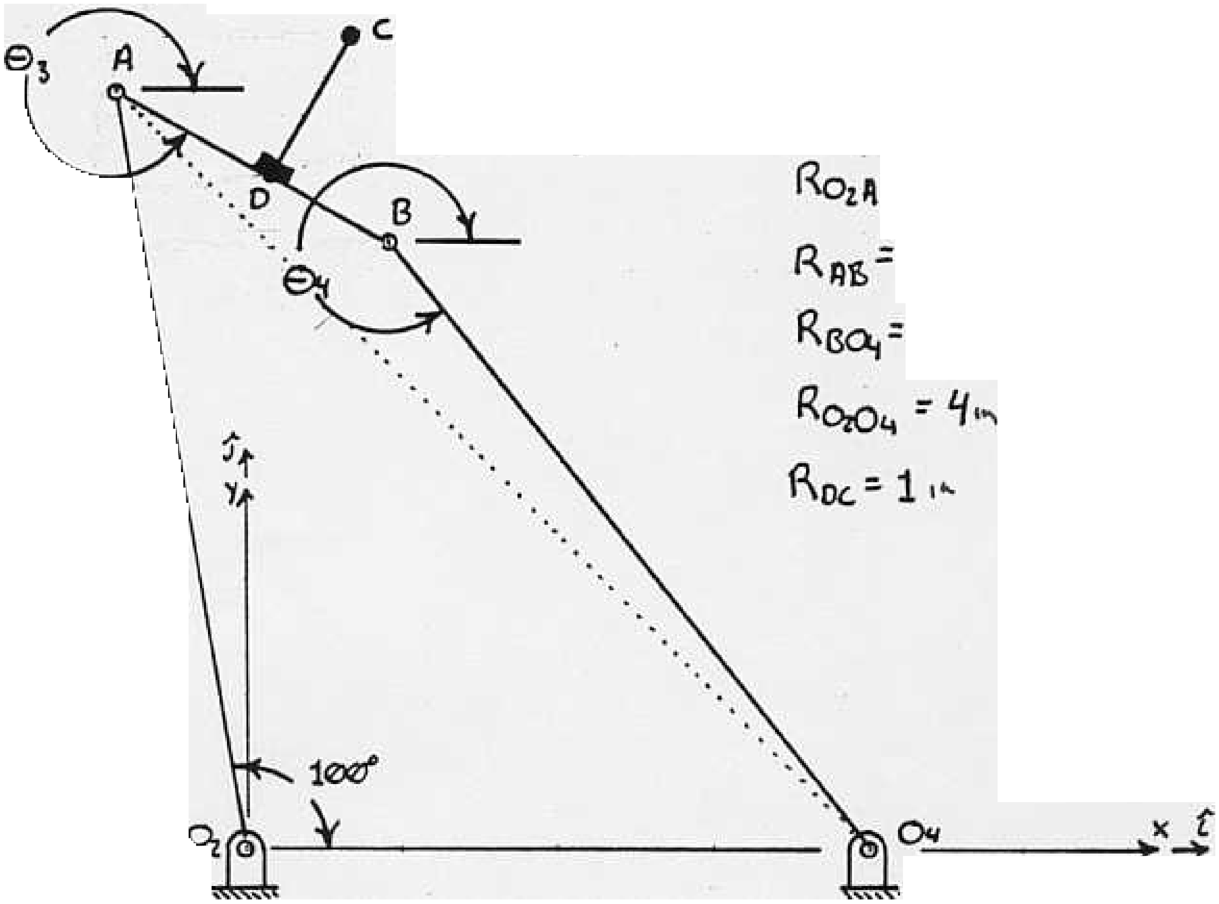
NAME: Solution

PROBLEM #1: Given the configuration shown below, answer the following questions.



6 **1a)** Given Gruebler's Equation (DOF = 3(L-1) - 2J), determine the overall number of Degrees-Of-Freedom for this mechanism.

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

$L = 4$

$J = 4$

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

$\boxed{DOF = 1}$

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1b) Is this a Grashof Linkage?

$s+l \leq p+q$

$2+5 \leq 5+4$

$\boxed{7 \leq 9}$ This is a Grashof linkage

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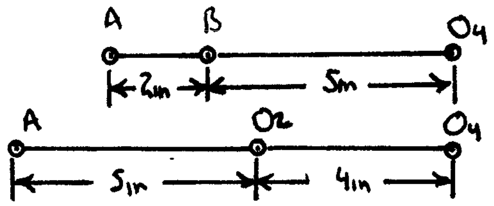
1c) Can a DC motor be attached at O_2 to drive link R_{O_2A}? Explain your answer.

No. If R_{O_2A} rotated to the 180° position, the distance from O_4 to A along the x axis would be 9 in, at this position links O_4B and BA only add up to 7in, therefore the linkage could never achieve this position.



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1d) Graphically determine angles θ_3 and θ_4.

$\theta_3 = 330°$

$\theta_4 = 309°$

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1d) Analytically determine angles θ_3 and θ_4.

$R_{AO_4} = \sqrt{(5in)^2 + (4in)^2 - 2(5)(4)\cos 100°} = 6.924$

$(5in)^2 = (6.924in)^2 + (4in)^2 - 2(6.924in)(4in)\cos\theta_{AO_4O_2} \Rightarrow \theta_{AO_4O_2} = 45.33°$

$(4in)^2 = (6.924in)^2 + (5in)^2 - 2(5in)(6.924in)\cos\theta_{O_2AO_4} \Rightarrow \theta_{O_2AO_4} = 34.68°$

$(6.924in)^2 = (2in)^2 + (5in)^2 - 2(2in)(5in)\cos\theta_{ABO_4} \Rightarrow \theta_{ABO_4} = 161.3$

$(2)^2 = (6.924in)^2 + (5in)^2 - 2(5in)(6.924in)\cos\theta_{AO_4B} \Rightarrow \theta_{AO_4B} = 5.320°$

$(5in)^2 = (2in)^2 + (6.924in)^2 - 2(2in)(6.924in)^2\cos\theta_{O_4AB} \Rightarrow \theta_{O_4AB} = 13.46°$

$\theta_3 = 270° + 10° + \theta_{O_2AO_4} + \theta_{O_4AB} = \boxed{328.1°}$

$\theta_4 = 180° + \theta_{ABO_4} - (360° - \theta_3) = \boxed{309.4°}$

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1e) Write the loop closure equation for this linkage. Write each of the components of this equation in magnitude unit vector format or polar form.

$$R_{O_2A}\hat{e}_{O_2A} + R_{AB}\hat{e}_{AB} + R_{BO_4}\hat{e}_{BO_4} = R_{O_2O_4}\hat{e}_{O_2O_4}$$

where

$$R_{O_2A}\hat{e}_{O_2A} = 5in(-0.1736\hat{i} + 0.9848\hat{j}) = 5in\, e^{j100°}$$

$$R_{AB}\hat{e}_{AB} = 2in(0.8490\hat{i} - 0.5284\hat{j}) = 2in\, e^{j328.1°}$$

$$R_{BO_4}\hat{e}_{BO_4} = 5in(0.6347\hat{i} - 0.7727\hat{j}) = 5in\, e^{\hat{j}309.4}$$

$$R_{O_2O_4}\hat{e}_{O_2O_4} = 4in\,\hat{i} = 4in\, e^{j0}$$

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1f) Given that DC is rigidly attached to link AB, write an expression for the position of point C given the linkage shown.

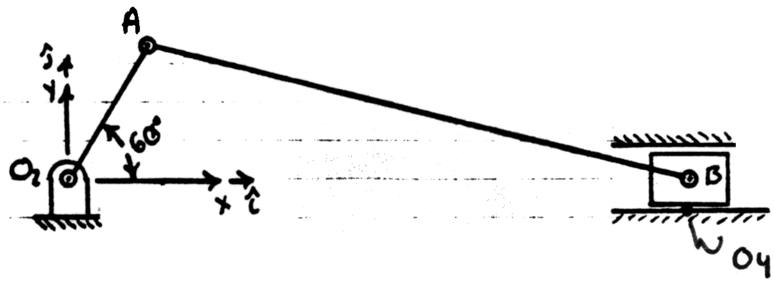
$$R_{O_2C}\,\hat{e}_{O_2C} = R_{O_2A}\,\hat{e}_{O_2A} + R_{AD}\,\hat{e}_{AD} + R_{DC}\,\hat{e}_{DC}$$

$$5\text{in}(-0.1736\hat{i} + 0.9848\hat{j}) + 1\text{in}(0.8490\hat{i} - 0.5284\hat{j})$$
$$+ 1\text{in}(0.5284\hat{i} + 0.8490\hat{j})$$

$$= 0.5094\text{ in }\hat{i} + 5.2446\text{ in }\hat{j} =$$

$$= \underline{\underline{5.269\text{in}(0.0967\hat{i} + 0.9954\hat{j}) = 5.269\text{in}\, e^{j84.45^\circ}}}$$

PROBLEM #2: Answer the following questions for the linkage shown.



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2a) Identify the number of degrees of freedom associated with each joint in this linkage.

O_2 has 1 DOF

A has 1 DOF

B has 1 DOF

O_4 has 1 DOF

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2b) What is the overall number of degrees of freedom associated with this linkage?

$$DOF = 3(L-1) - 2J = 3(4-1) - 2(4) = \boxed{1}$$