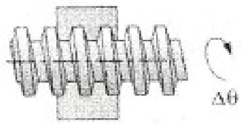
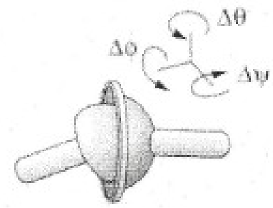
期中考

1. (15%)

請回答以下兩種接頭的名稱、自由度、運動方式、接觸方式。

Please describe the name, DOF, motion type, and contact type of joints

(1) 

(2) 

2. (10%)

定義獨立輸入自由度為 m，機構自由度為 n，請回答下列問題。

m symbol the independent input, and *n* symbol the DOF of mechanism. Please answer following question.

(1)假如 m=n，此機構屬於____________

If m=n, the mechanism belong to__________________.

(2) 假如 n>m，此機構屬於______________

If n>m, the mechanism belong to __________________.

(3) 假如 n<1，此機構的稱為______________

If n<1, the mechanism is called__________________.

(4) 假如 n=0，此機構的稱為______________

If n=0, the mechanism is called__________________.

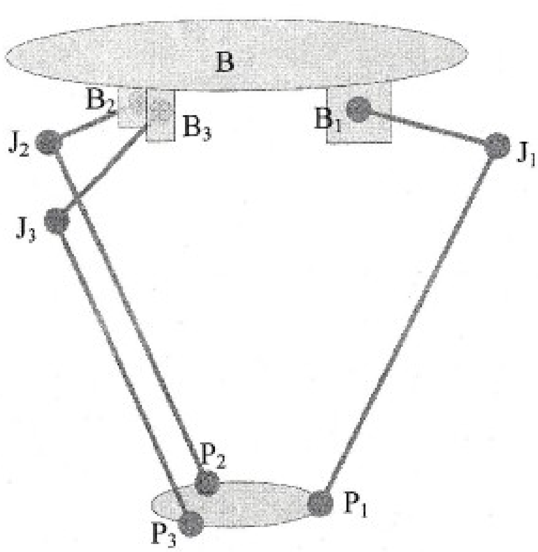
(5) 假如 n<0，此機構的稱為______________

If n<0, the mechanism is called__________________.

3. (5%)

請定義此空間機構之自由度(請詳細列出計算過程)

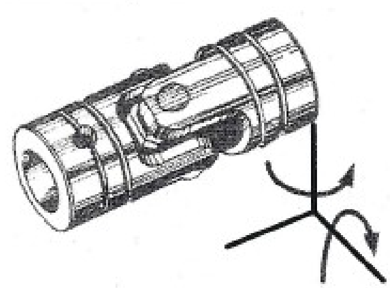
Please define the DOF of the space mechanism (show the detail of calculation process)



B_1, B_2, B_3: revolute joint

J_1, J_2, J_3, P_1, P_2, P_3: universal joint

Universal joint



4. (10%)

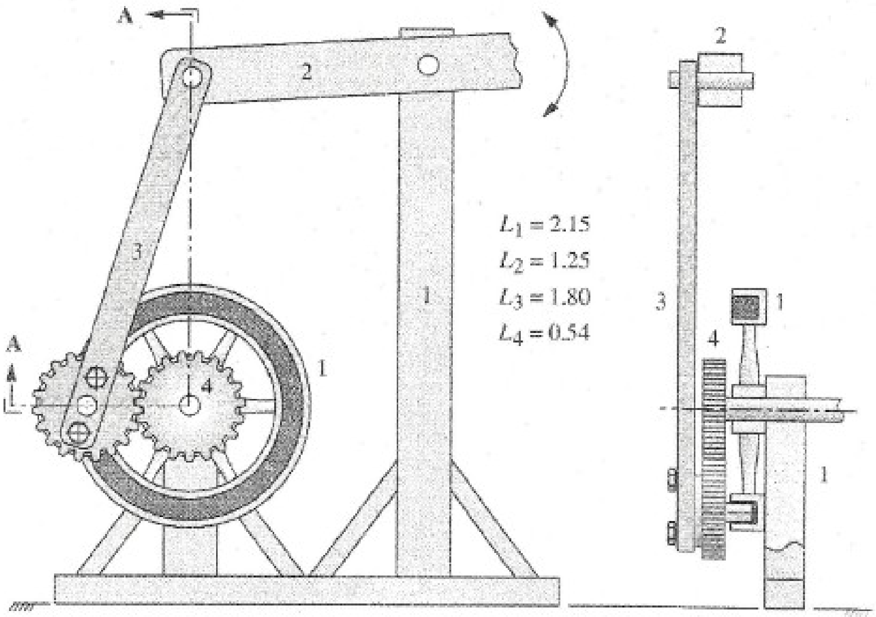
請合成一自由度為 1 之平面四連桿機構，且其中一個接頭為滑行對。

Please synthesize a four-link mechanism with 1-DOF planar motion, and one joint is sliding joint.

5. (20%)

請定義此機構之(1)機構簡圖; (2)運動鍊; (3)自由度

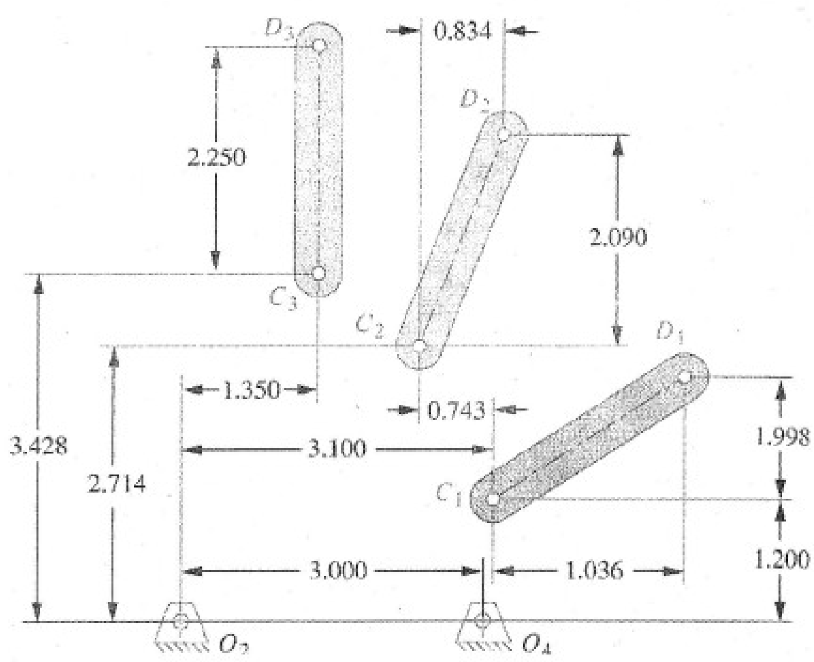
Please define the (1) mechanism skeleton, (2) kinematic chain; (3) DOF of this mechanism.



6. (15%)

設計一四連桿機構能具有此三個位置變化，且令其固定於點 O_2、 O_4。

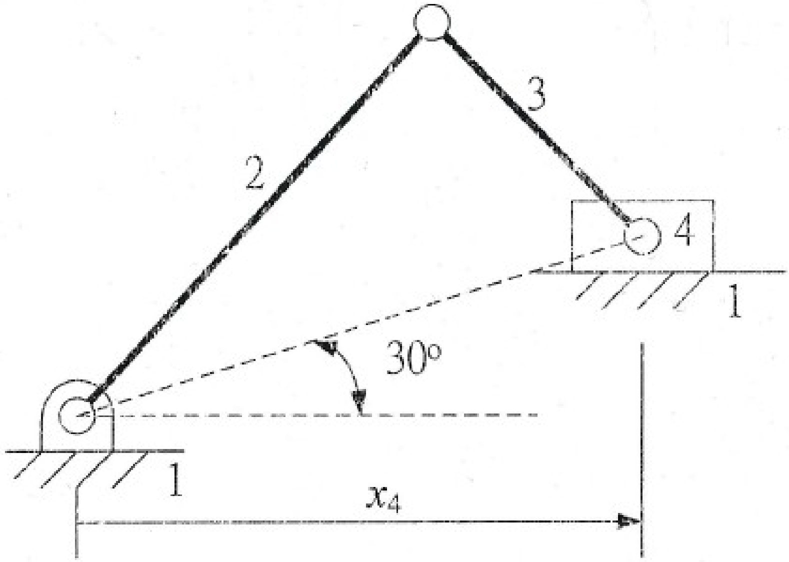
Design a four-bar mechanism to given the three position using the fixed pivots O_2 and O_4.



7. (25%)

針對此四連桿機構，連桿 2、3 長度分別為 0.2 及 0.1m。假如輸入角度 θ_2 為 60 度，請計算連桿 3 之角度 θ_3 與連桿 4 位移 x_4

For the 4-link mechanism, lengths of link 2 and link 3 are 0.2 and 0.1m. If input angular position θ_2 is 60 deg, please find the angular position of link 3 (θ_3) and displacement of link 4 (x_4)



(1)利用向量迴路法求閉合解 Applying Vector loop method find the closed-form solution.

(2) 利用牛頓法求得數值解，起使估測值為 θ_3=65°, x_4=0.15m，進行一次疊代即可。
Applying Newton's method find the Numerical solution. Initial estimates are θ_3=65°, x_4=0.15m. Show one time the calculation.

4004?????

1.

(1) 螺旋對，自由度為1，曲線運動與面接觸

(2) 球面對，自由度為3，球面運動與面接觸

2.
(1) 拘束運動機構
(2) 無拘束機構
(3) 過度拘束機構 or 結構
(4) 靜定結構
(5) 靜不定結構

3.

5

Kutzbach's Criteria

$F = 6(N-1) - \Sigma p_i c_i$

N: 桿件數　P_i: 接頭類型數量　C_i: 該種接頭自由度

$N = 8$

$C_1 = 5 \quad P_1 = 3$

$C_2 = 4 \quad P_2 = 6$

$F = 6(8-1) - (5\times3 + 4\times6)$

$= 3$

$DoF = 3_{\#}$

4. 10

自由度為1，且為平面四連桿機構.

∴ DoF = 1.

N = 4.

$3(N-1) - 2J = 1 \Rightarrow J = 4$

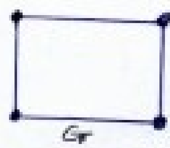
~~$J = \frac{N}{2} = 2$~~

~~...= 4~~

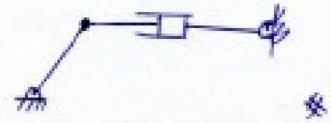
∴ ~~有四個旋轉對~~

運動鏈

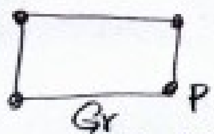
(1)



(4,4).



(2)

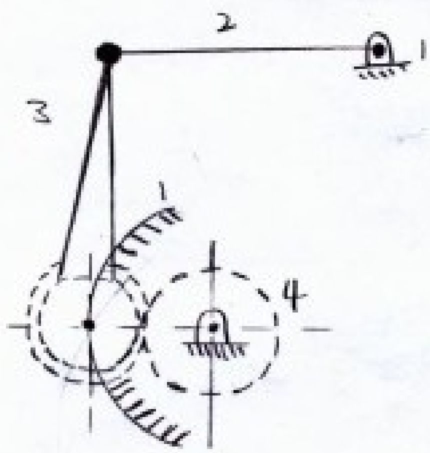


5. 20

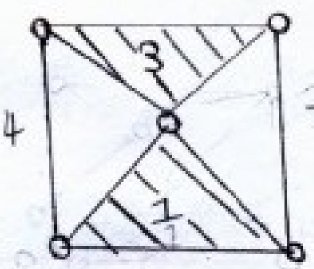
(1) mechanism skeleton

(2) kinematic chain

7



7



(3) DOF

6 kutzbach's mobility equation

$$F = 3(N-1) - 2J_1 - J_2$$

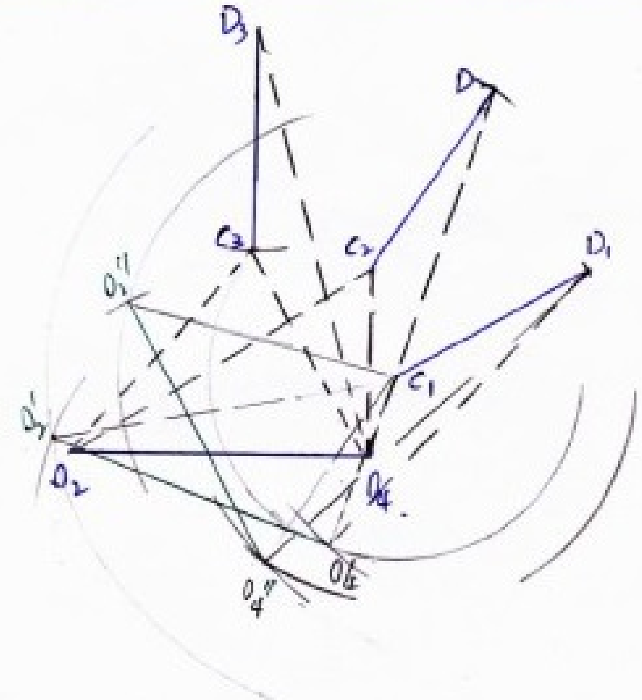
$N = 4$

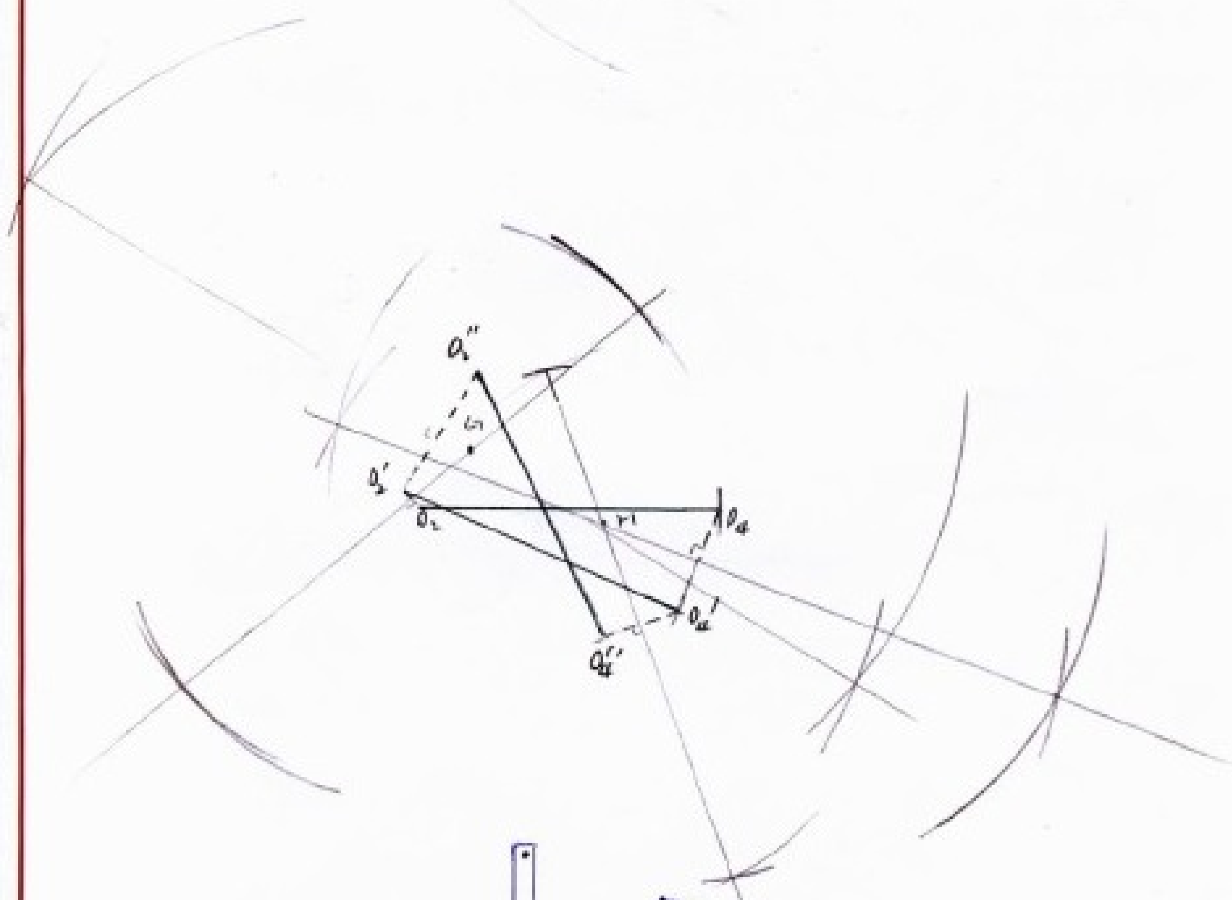
$J_1 = 3$

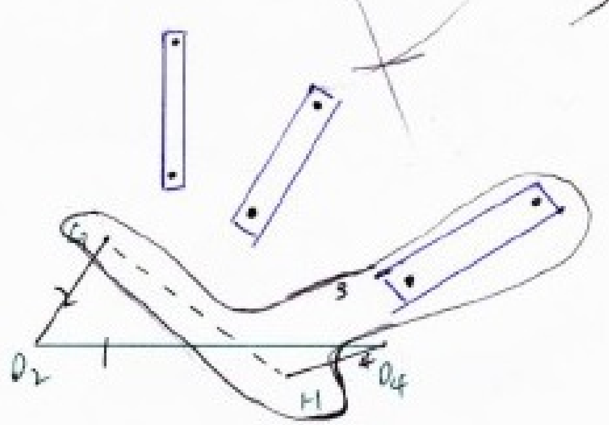
$J_2 = 2$

$F = 1$ #

(6)







∴ 7.

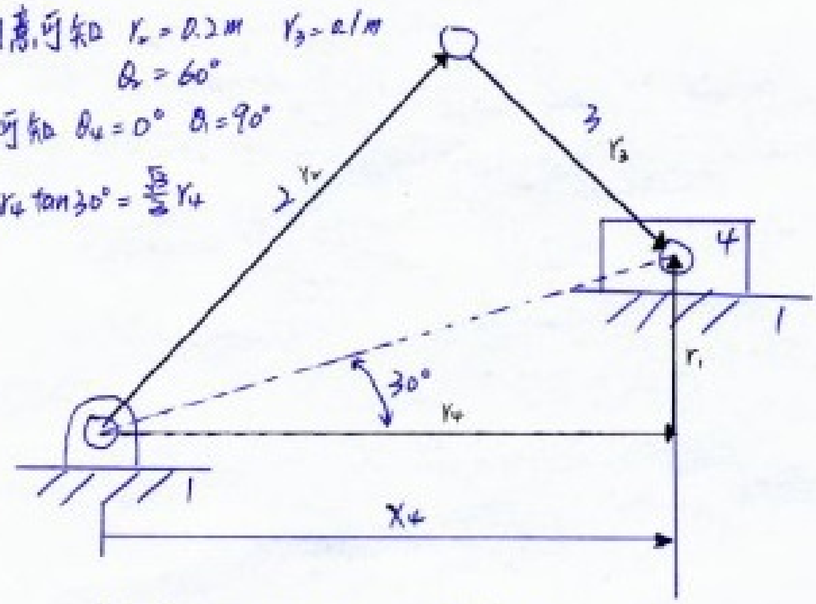
(1)

依題意可知 $r_2 = 0.2m$ $r_3 = 0.1m$

$\theta_2 = 60^\circ$

由圖可知 $\theta_4 = 0^\circ$ $\theta_1 = 90^\circ$

$r_1 = r_4 \tan 30^\circ = \frac{\sqrt{3}}{3} r_4$



$r_2 + r_3 - r_4 - r_1 = 0 \Rightarrow r_3 = r_4 + r_1 - r_2$

$(r_3 \cdot r_3) = (r_4 + r_1 - r_2) \cdot (r_4 + r_1 - r_2)$

$\Rightarrow r_3^2 = r_1^2 + r_2^2 + r_4^2 + 2 r_1 r_4 \cos(\theta_1 - \theta_4) - 2 r_1 r_2 \cos(\theta_1 - \theta_2) - 2 r_2 r_4 \cos(\theta_2 - \theta_4)$

$\Rightarrow 0.1^2 = \frac{1}{3} r_4^2 + 0.2^2 + r_4^2 + 0 - 2 \cdot \frac{\sqrt{3}}{3} r_4 \cdot 0.2 \cos 30^\circ - 2 \times 0.2 \cdot r_4 \cos 60^\circ$

$\Rightarrow \frac{4}{3} r_4^2 - 0.4 r_4 + 0.03 = 0$

$\Rightarrow r_4 = 0.15\,m$

x方向： $r_4 - r_2 \cos 60^\circ = r_3 \cos\theta_3$

$0.15 - 0.2 \times 0.5 = 0.1 \cos\theta_3$

$\cos\theta_3 = \frac{0.05}{0.1} = 0.5$

$\therefore \theta_3 = \pm 60^\circ$， ∵ $+60^\circ$ 不連續 ∴ $\theta_3 = -60^\circ$

Ans： $r_4 = x_4 = 0.15\,m$ ， $\theta_3 = -60^\circ$ #

(2)

$\theta_3 = 65^\circ$, $r_4 = 0.15m$, $r_2 = 0.3m$, $r_3 = 0.1m$, $\theta_2 = 60^\circ$, $r_1 = 0.577 r_4$

x: $f(r_4, \theta_3) = r_2\cos\theta_2 + r_3\cos\theta_3 - r_4 = -7.74\times10^{-3}$

y: $g(r_4, \theta_3) = r_2\sin\theta_2 + r_3\sin\theta_3 - 0.577 r_4 = 0.177$

$\dfrac{\partial f(r_4,\theta_3)}{\partial r_4} = -1$, $\dfrac{\partial g(r_4,\theta_3)}{\partial r_4} = -0.577$

$\dfrac{\partial f(r_4,\theta_3)}{\partial \theta_3} = -r_3\sin\theta_3 = -0.09$, $\dfrac{\partial g(r_4,\theta_3)}{\partial \theta_3} = r_3\cos\theta_3 = 0.042$

$$\begin{cases} f(r_4,\theta_3) + \dfrac{\partial f(r_4,\theta_3)}{\partial r_4}\Delta r_4 + \dfrac{\partial f(r_4,\theta_3)}{\partial \theta_3}\Delta\theta_3 = 0 \\ g(r_4,\theta_3) + \dfrac{\partial g(r_4,\theta_3)}{\partial r_4}\Delta r_4 + \dfrac{\partial g(r_4,\theta_3)}{\partial \theta_3}\Delta\theta_3 = 0 \end{cases}$$

$$\Rightarrow \begin{cases} -\Delta r_4 - 0.09\Delta\theta_3 = 7.74\times10^{-3} \\ -0.577\Delta r_4 + 0.042\Delta\theta_3 = -0.177 \end{cases}$$

用克拉瑪法則

$$\Delta = \begin{vmatrix} -1 & -0.09 \\ -0.577 & 0.042 \end{vmatrix} = -0.09393$$

$$\Delta r_4 = \frac{\begin{vmatrix} 7.74\times10^{-3} & -0.09 \\ -0.177 & 0.042 \end{vmatrix}}{-0.09393} = 0.166$$

$$\Delta\theta_3 = \frac{\begin{vmatrix} -1 & 7.74\times10^{-3} \\ -0.577 & -0.177 \end{vmatrix}}{-0.09393} = -1.932 \text{ rad} = -110.7$$

$\theta_3 = \theta_3 + \Delta\theta_3 = 65 - 110.7 = -45.7^\circ$

$r_4 = r_4 + \Delta r_4 = 0.15 + 0.166 = 0.316$