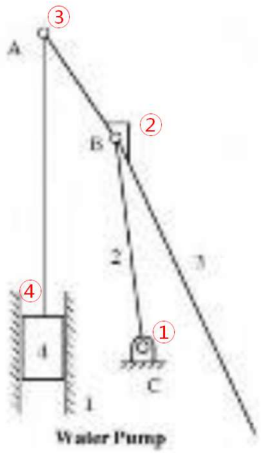
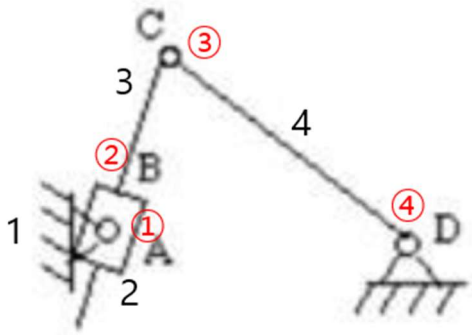
1. (각 2 점) 용어 정확히 사용해야 (FDM, SLA, SLS 등은 업체 기술명)

(1)	material extrusion	(2)	vat polymerization
(3)	material jetting	(4)	binder jetting
(5)	powder bed fusion	(6)	direct energy deposition
(7)	sheet lamination	(8)	FDM
(9)	SLA	(10)	SLS

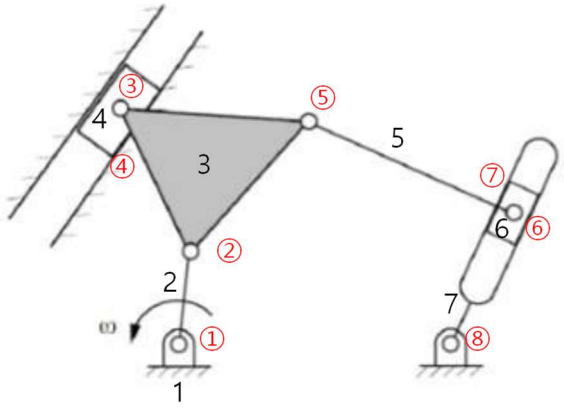
2. Gruebler equation (pin-in-slot: half joint)



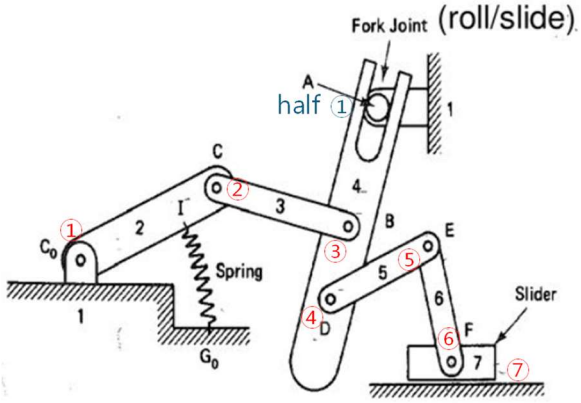
(1)



(2)



(3)



(4)

	L (2점)	J (full/half) (2/1점)	DOF=3(L-1)-2J
(1)	4	4/0	9 – 8 = 1
(2)	4	4/0	9 – 8 = 1
(3)	7	8/0	18 – 16 = 2
(4)	7	7/1	18 – 15 = 3

3. (각 2 점)

(1) double-crank (2) double-rocker (3) parallelogram (4) crank-rocker (5) kite (deltoid)

4. (각 5 점) Bezier curve 아님

$\mathbf{P}(t)=(1-t)^3\mathbf{P}_0+2t(1-t)\mathbf{P}_1+t(1-t)\mathbf{P}_2+t^3\mathbf{P}_3$

(1) Yes, $\mathbf{P}(0)=\mathbf{P}_0$ and $\mathbf{P}(1)=\mathbf{P}_3$

(2) No, blending fucntion is not symmetric, e.g., $B_1(1-t)\neq B_2(t)$

(3) Yes, blending functions sum to one

5. control point, weight 각 3 점, rational form 2 점

$$x=\frac{2t^2}{t^2+1}=\frac{(1-t)^2w_0V_{0x}+2(1-t)tw_1V_{1x}+t^2w_2V_{2x}}{(1-t)^2w_0+2(1-t)tw_1+t^2w_2}=\frac{(w_0V_{0x}-2w_1V_{1x}+w_2V_{2x})t^2+(-2w_0V_{0x}+2w_1V_{1x})t+w_0V_{0x}}{(w_0-2w_1+w_2)t^2+(-2w_0+2w_1)t+w_0}$$

$$\left.\begin{matrix}w_0-2w_1+w_2=1\\-2w_0+2w_1=0\\w_0=1\end{matrix}\right\}\rightarrow\begin{cases}w_0=1\\w_1=1\\w_2=2\end{cases},\begin{cases}V_{0x}-2V_{1x}+2V_{2x}=2\\-V_{0x}+2V_{1x}=0\\V_{0x}=0\end{cases}\rightarrow\begin{cases}V_{0x}=0\\V_{1x}=0\\V_{2x}=1\end{cases}$$

$$y=\frac{(t+1)^2}{t^2+1}=\frac{(w_0V_{0y}-2w_1V_{1y}+w_2V_{2y})t^2+(-2w_0V_{0y}+2w_1V_{1y})t+w_0V_{0y}}{(1-t)^2w_0+2(1-t)tw_1+t^2w_2}\rightarrow\begin{cases}V_{0y}-2V_{1y}+2V_{2y}=1\\-2V_{0y}+2V_{1y}=2\\V_{0y}=1\end{cases}\rightarrow\begin{cases}V_{0y}=1\\V_{1y}=2\\V_{2y}=2\end{cases}$$

$$\begin{cases}\mathbf{V}_0=(0,1),\mathbf{V}_1=(0,2),\mathbf{V}_2=(1,2)\\w_0=1,w_1=1,w_2=2\end{cases}$$

6. 10 점, (5 점+5 점), 5 점

(1) $\begin{bmatrix}x\\y\end{bmatrix}=(1-t)^3\begin{bmatrix}1\\0\end{bmatrix}+3(1-t)^2t\begin{bmatrix}1\\\alpha\end{bmatrix}+3(1-t)t^2\begin{bmatrix}\beta\\1\end{bmatrix}+t^3\begin{bmatrix}0\\1\end{bmatrix}$

$x=1+(3\beta-3)t^2+(2-3\beta)t^3\rightarrow x'=2(3\beta-3)t+3(2-3\beta)t^2=0$

$t\left[2(\beta-1)+(2-3\beta)t\right]=0\rightarrow t_x=\frac{2-2\beta}{2-3\beta}$ or 0

$y=3\alpha t+(3-6\alpha)t^2+(3\alpha-2)t^3\rightarrow y'=3\alpha+2(3-6\alpha)t+3(3\alpha-2)t^2=0$

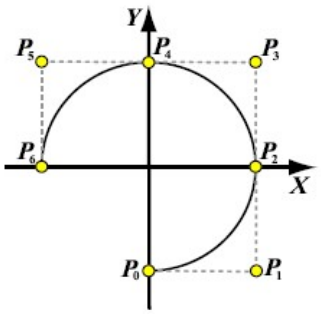
$(3\alpha-2)t^2+2(1-2\alpha)t+\alpha=0\rightarrow((3\alpha-2)t-\alpha)(t-1)=0\rightarrow t_y=\frac{\alpha}{3\alpha-2}$ or 1

(2) simple symmetry argument is by reversing the curve and concluding that $(1-t)$ is the smae function of α that t is of β

$t_y=1-t_x=1-\frac{2-2\alpha}{2-3\alpha}=\frac{-\alpha}{2-3\alpha}\Rightarrow\frac{2-2\beta}{2-3\beta}=\frac{\alpha}{3\alpha-2}\rightarrow\beta=\frac{4-4\alpha}{4-3\alpha}$

(3) $\alpha=2\rightarrow\beta=2$

7. (10 점: 조정점 2, 매듭값 3, 가중치 2, 곡선식: 3)



$(\text{오더})\ k=3$

$(\text{조정점 } 7\text{개})\ n=6$

$\mathbf{P}_0=(0,-1),\mathbf{P}_1=(1,-1),\mathbf{P}_2=(1,0),\mathbf{P}_3=(1,1),\mathbf{P}_4=(0,1),\mathbf{P}_5=(-1,1),\mathbf{P}_6=(-1,0)$

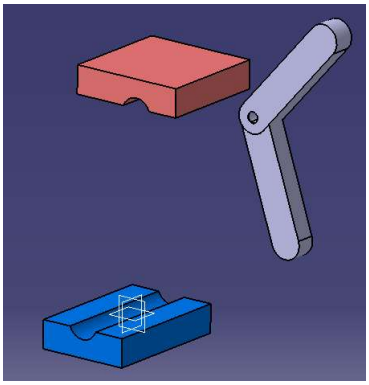
$(\text{매듭값 } 10\text{개})\ \underbrace{0,0,0}_{\mathbf{P}_0},\underbrace{\frac{1}{3},\frac{1}{3}}_{\mathbf{P}_2},\underbrace{\frac{2}{3},\frac{2}{3}}_{\mathbf{P}_4},\underbrace{1,1,1}_{\mathbf{P}_6}$

$(\text{호모지니어스 좌표/가중치})\ w_1=w_3=w_5=\frac{1}{\sqrt{2}},\ w_0=w_2=w_4=w_6=1$

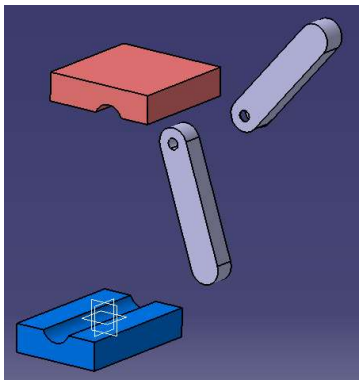
$$\mathbf{P}(u)=\frac{\sum_{i=0}^{6}w_i\mathbf{P}_iN_{i,3}(u)}{\sum_{i=0}^{6}w_iN_{i,3}(u)}=\frac{w_0\mathbf{P}_0N_{0,3}(u)+w_1\mathbf{P}_1N_{1,3}(u)+w_2\mathbf{P}_2N_{2,3}(u)}{w_0N_{0,3}(u)+w_1N_{1,3}(u)+w_2N_{2,3}(u)}$$

8. (각 5 점)

(1) SubProduct 와 내부 파트 간의 상하 관계를 없애고 내부 두 개 parts 를 독립적으로 이동시키기 위한 기능



사용하지 않은 경우



사용한 경우

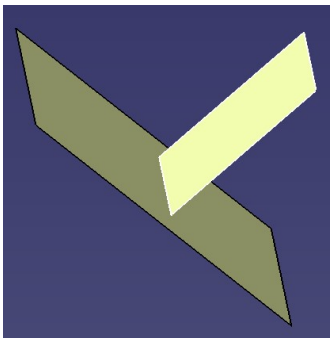
(2) Explode: 조립체를 분해하는 기능, 분해 후 update 기능을 이용해 원상 복구되는 것을 확인

Clash: 조립체의 간섭을 확인하는 기능, 부품 간 간섭 체크를 통해 조립 완성도 확인

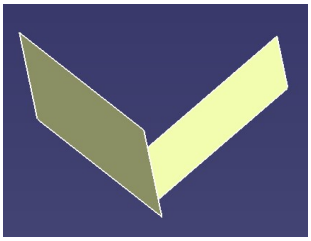
9. (각 5 점)

Split: Surface/Curve 형상을 임의의 요소를 기준으로 절단

Trim: 임의의 요소를 기준으로 절단과 동시에 두 형상을 하나의 요소로 결합



Split

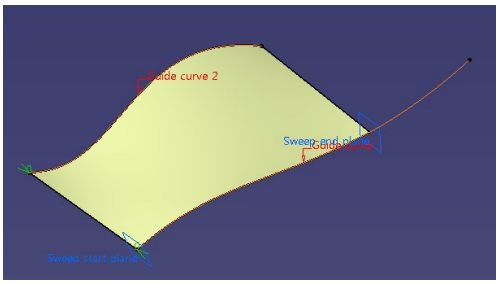


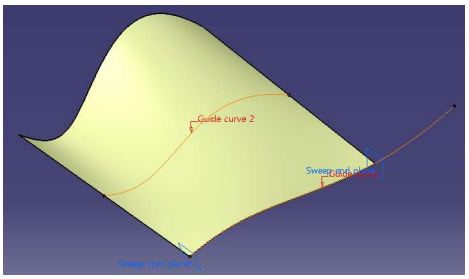
Trim

10, (각 5 점)

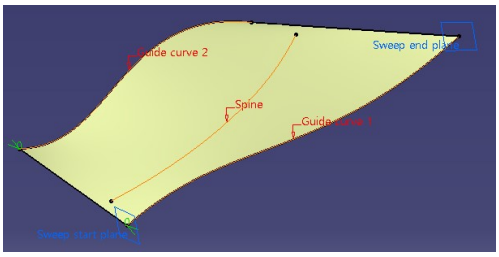
(1) Two limits: 두 개의 Curves 를 기준으로 Surface 생성

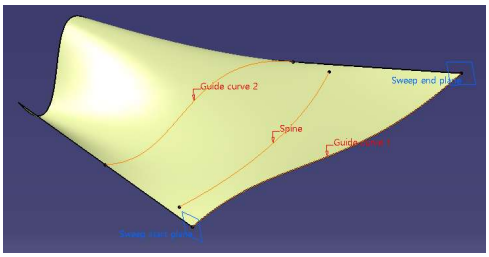
Limit and middle: 두 번째 선택된 Curve 를 Surface 의 중앙에 위치하도록 두 배의 Surface 생성





(2) 두 Guide curves 의 길이가 다를 경우 끝 점까지 이어진 Surface 가 생성되지 않음. 해결책으로 Spine 기능을 이용하여 보간 Curve 를 만들어 준 뒤 Surface 재생성.





11.

1. (1) fix

2. (1)과 (3), (6), (8) Rigid joint 연결 (2 pts)

3. (1), (2) Revolute joint 연결 + 동력 angle driven (2 pts)

4. (3), (4) Prismatic joint 연결 또는 Cylindrical joint 연결 (1 pts)

5. (5), (6) Revolute joint 연결 (1 pts)

6. (7), (8) Prismatic joint 연결 또는 Cylindrical joint 연결 (1 pts)

7. (2), (4) Point-surface joint 또는 Point-curve joint 연결 또는 Slide-curve 연결 (1 pts)

8. (4), (5) Slide-curve joint 연결 (1 pts)

9. (5), (7) Slide-curve joint 연결 (1 pts)