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Optimization of 4 bars linkage time ratio

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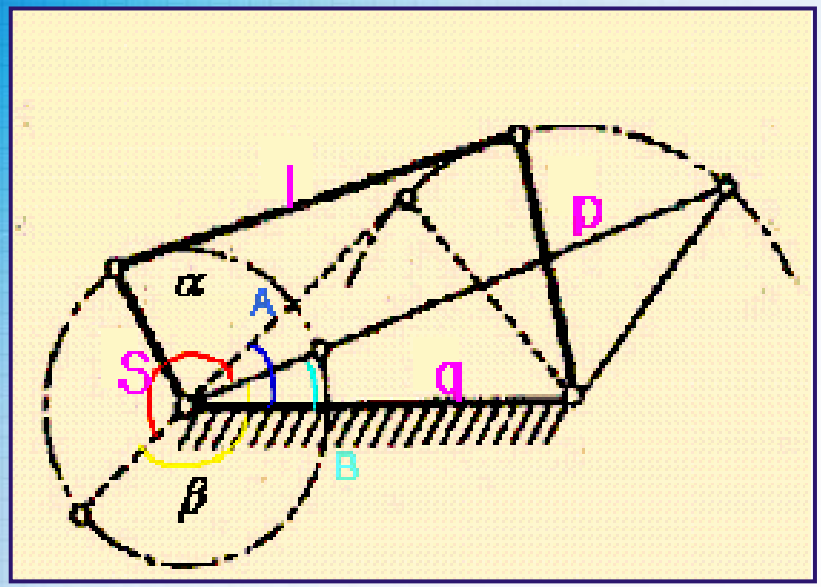
Contents

Theorem

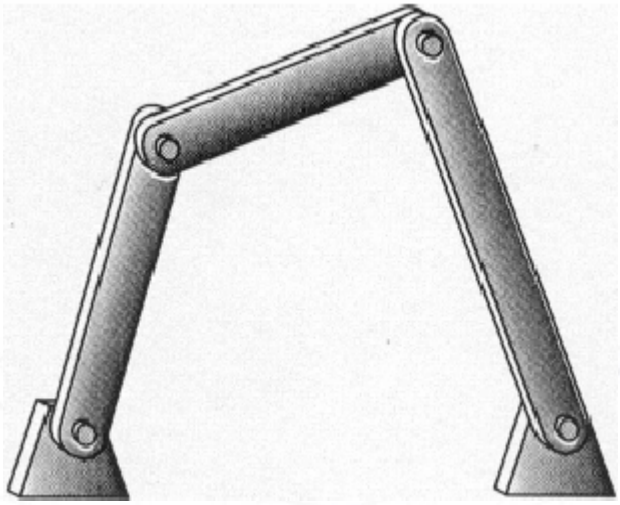


Modeling

$$A=\cos^{-1}\frac{Q^2+(L-S)^2-P^2}{2Q(L-S)}$$

$$B=\cos^{-1}\frac{Q^2+(L+S)^2-P^2}{2Q(L+S)}$$

$$Q=\frac{\pi+A-B}{\pi-A+B}$$



Formulation

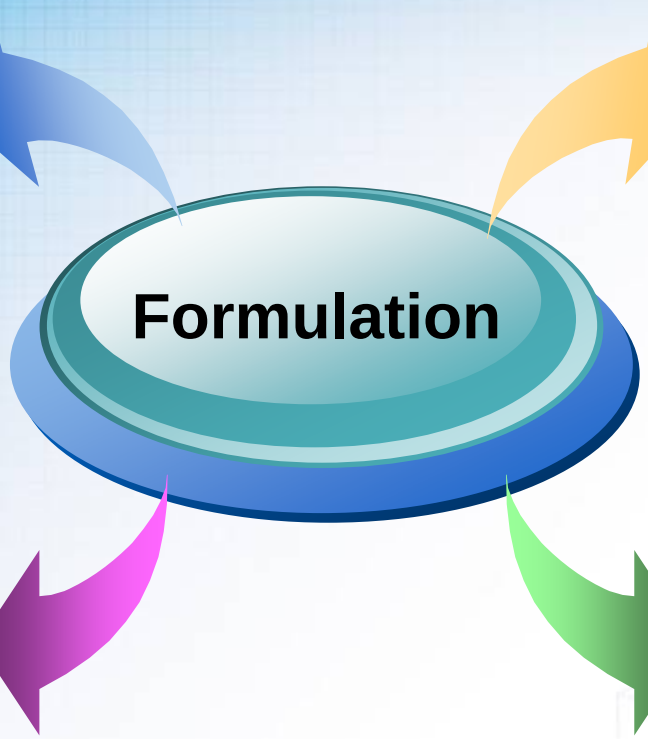
Variables

s (frame length) = c
p (crank length)
q (coupler length)
r (rocker length)

Data Collection

$$A=\cos^{-1}\frac{Q^2+(L-S)^2-P^2}{2Q(L-S)}$$

$$B=\cos^{-1}\frac{Q^2+(L+S)^2-P^2}{2Q(L+S)}$$



Obj. Function

maximize function

$$Q(p,q,r)=\frac{\pi+A-B}{\pi-A+B}$$

Constraint

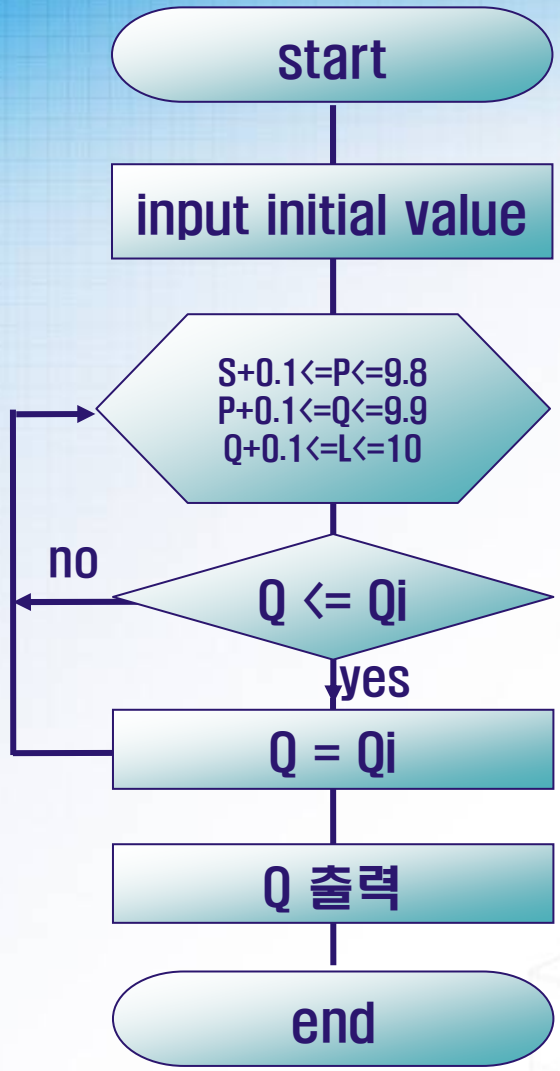
$$s=1$$

$$l\le 10$$

$$s<p<q<l$$

$$s+l<p+q$$

Flow Chart


start
input initial value
S+0.1<=P<=9.8
P+0.1<=Q<=9.9
Q+0.1<=L<=10
no
Q <= Qi
yes
Q = Qi
Q 출력
end

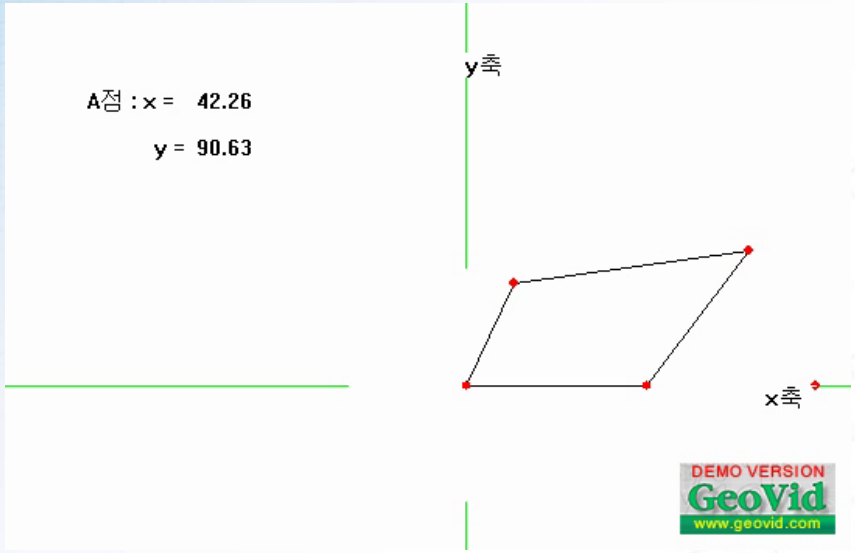
VC Cording

```
#include<stdio.h>
#include<math.h>
main()
{
float s=1, p, pa, q, qa, l, la, a, b, qf=0, qi=0, aa, bb, pp;
int i, j, k;
pp=3.141592654;
for(p=s+0.1;p<=9.8;p=p+0.1) // p>s인 조건
{ for(q=p+0.1;q<=9.9;q=q+0.1) // q>p인 조건
{ for(l=q+0.1;l<=10;l=l+0.1) // l >q인 조건
{ aa=s+l, bb=p+q;
 if(aa<bb)
 { a=acos((pow(q,2)+pow(l-s,2)-pow(p,2))/(2*q*(l-s)));
   b=acos((pow(q,2)+pow(l+s,2)-pow(p,2))/(2*q*(l+s)));
 qf=(pp+a-b)/(pp-a+b);
 if(qf>qi) //Time ratio가 높은 값을 대입
 { qi=qf, pa=p, qa=q, la=l; } } }}}
    printf("p의길이%f,q의길이%f,l의길이%f,효율%f\n",pa,qa,la,qi);
 }
```

Cording Solution

❖ Solution

- p=1.5, q=1.6, l=2.1, Time ratio=2.11423



Matlab Solution

- **pattern search**

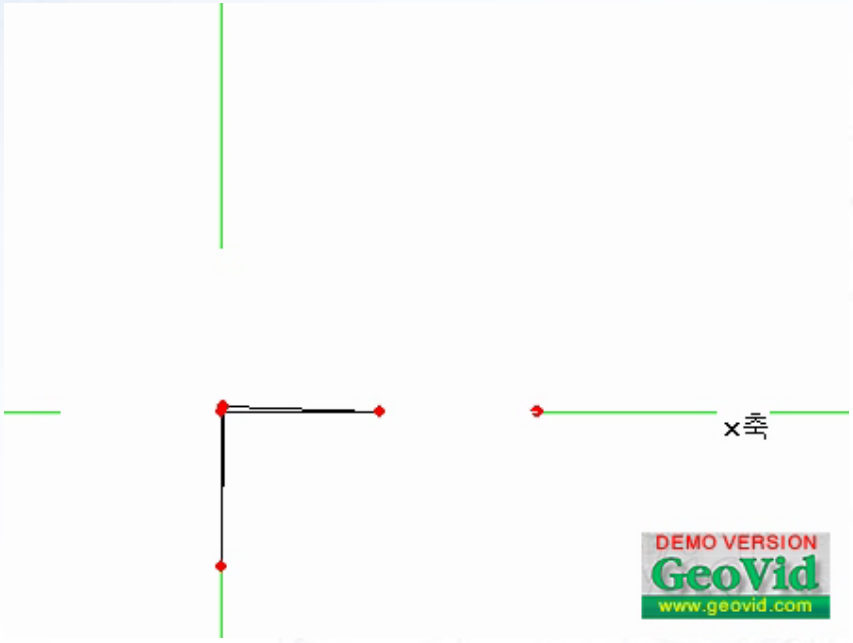
Initial condition: p=1.5, q=1.6, l=2.1

Iteration	100	300
p	1.00936	1.00219
q	1.00951	1.00221
l	1.00975	1.00224
Time ratio	2.9346	2.9584

Matlab Solution

- **pattern search**
  - Initial condition: p=1.5, q=1.3, l=1.1

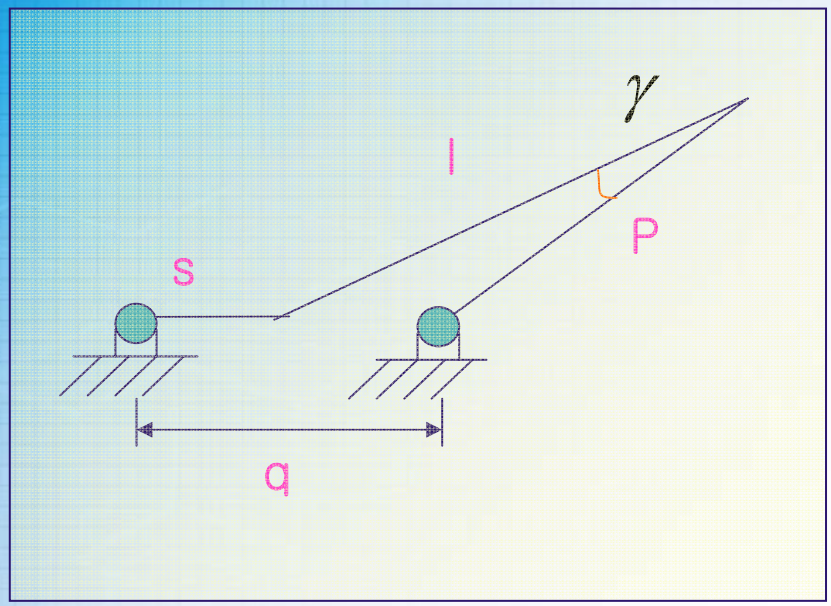
Iteration	32
p	1.00095
q	1.00096
l	1.00097
Time ratio	2.9594

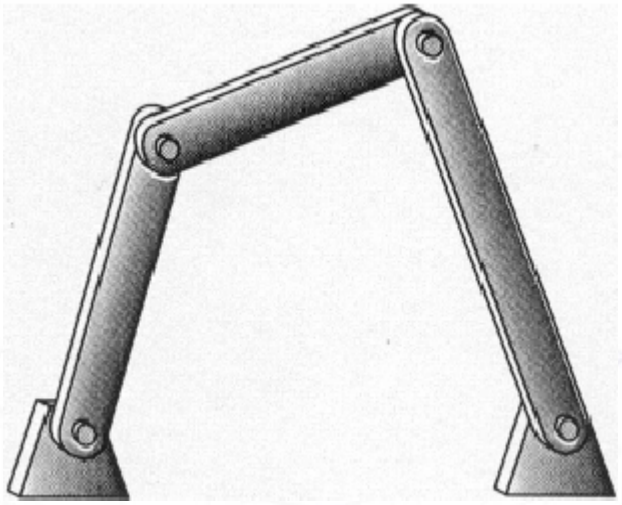


Theorem

Constrain

$$\gamma = \cos^{-1}\frac{l^2 + p^2 - (q-s)^2}{2lp} > 50^\circ$$



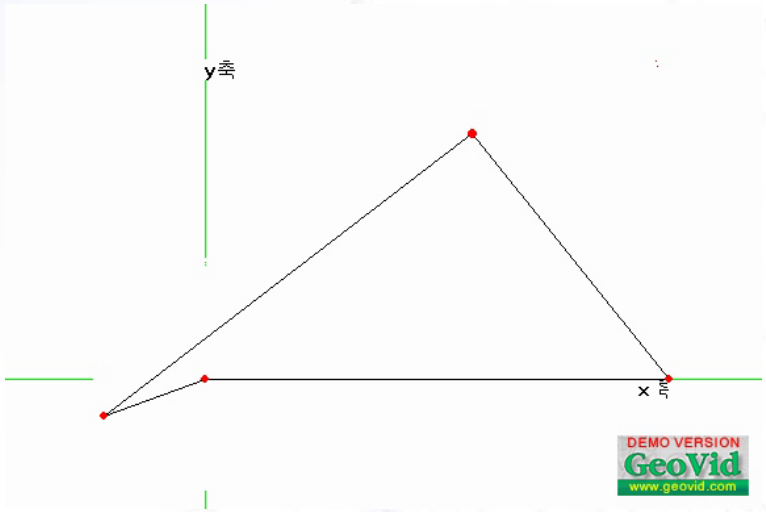


Matlab Solution

❖ pattern search

Initial condition: p=1.5, q=1.6, l=2.1

Iteration	3
p	2.90648
q	4.288
l	4.289
Time ratio	1.171948



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Thank You !