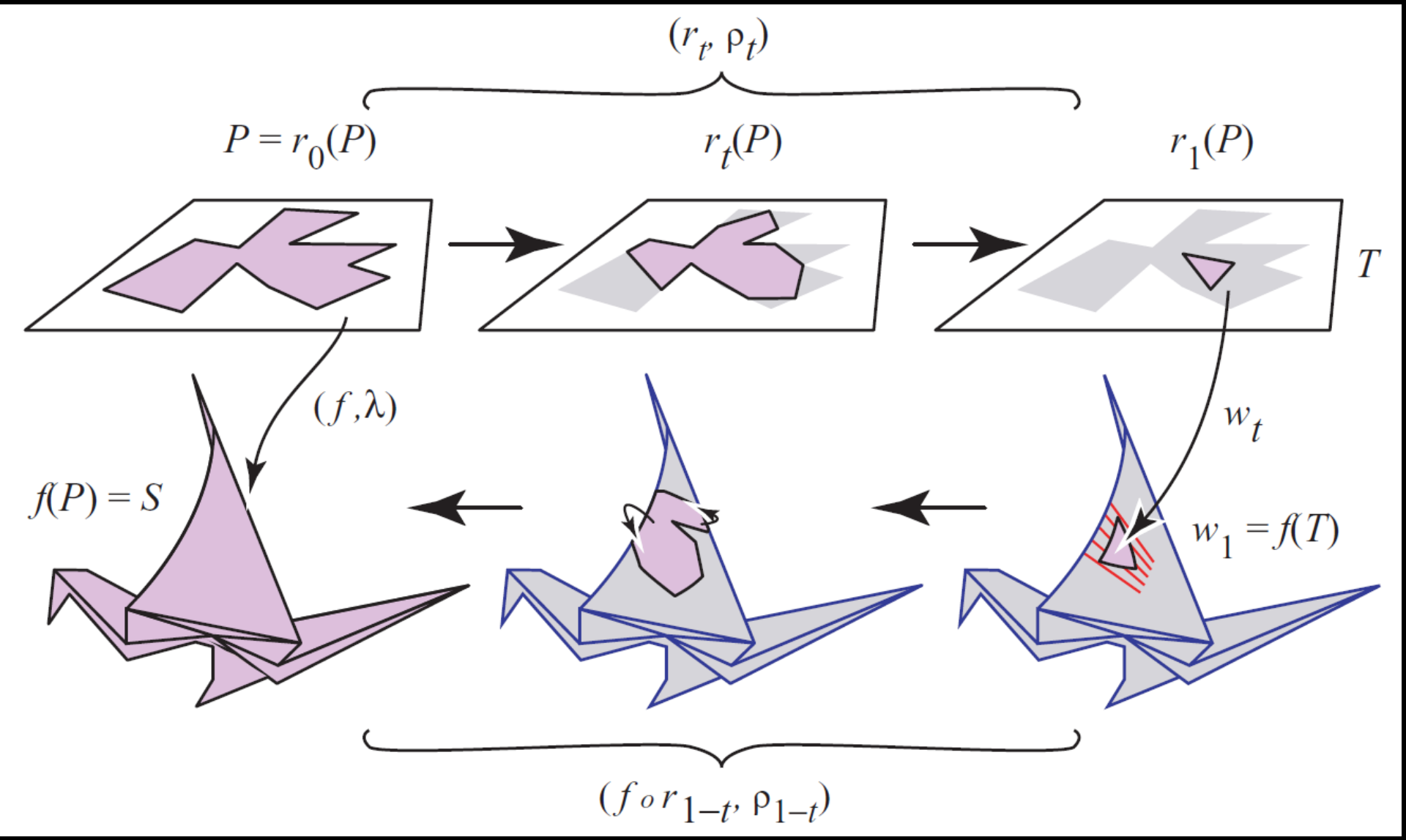
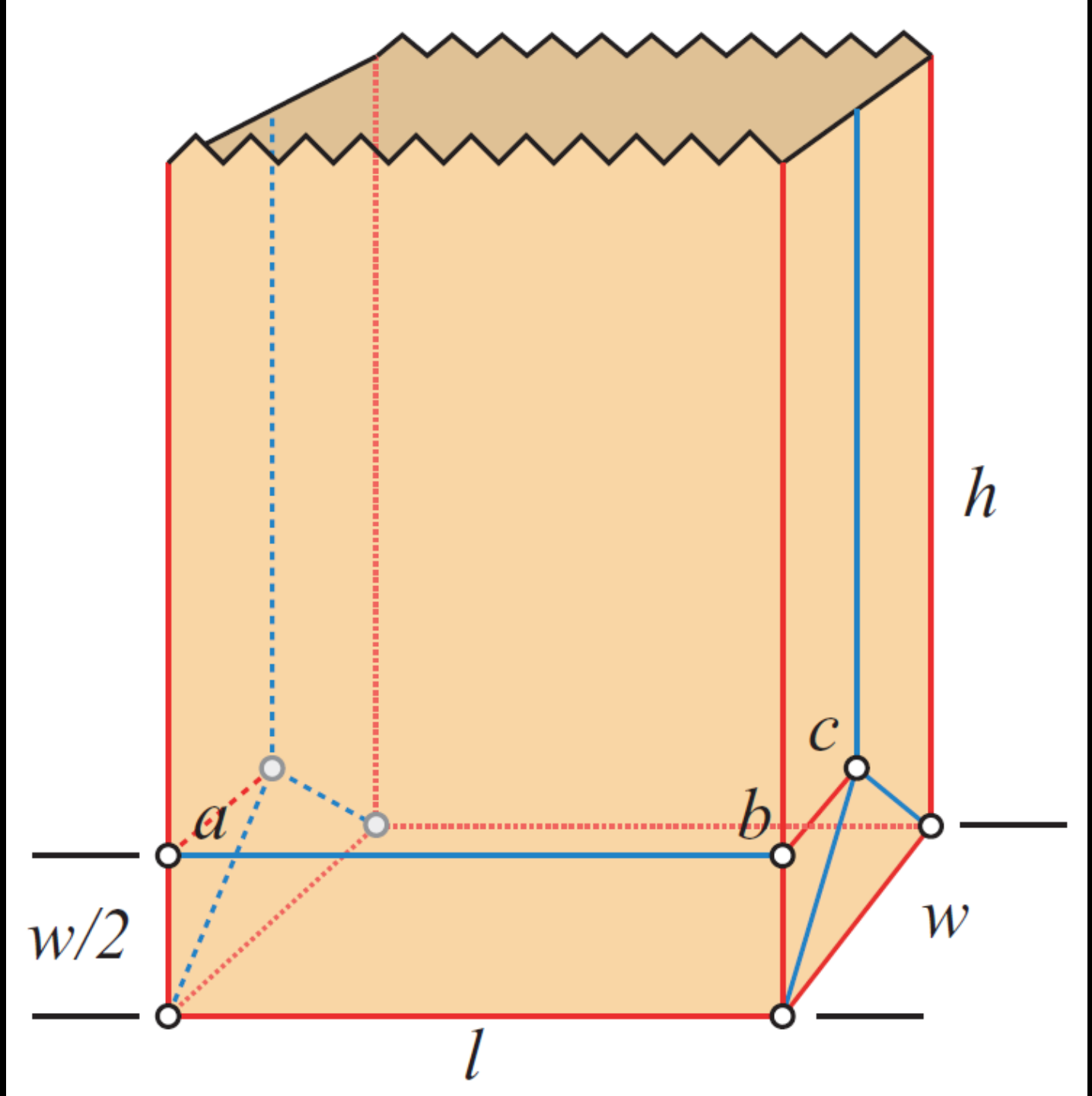

(r_t, ρ_t)
$P = r_0(P)$
$r_t(P)$
$r_1(P)$
T
(f, λ)
w_t
$f(P) = S$
$w_1 = f(T)$
$(f \circ r_{1-t}, \rho_{1-t})$


h
c
a
b
w/2
w
l

NATURE SERIES.

HOW TO DRAW A STRAIGHT LINE;

A

LECTURE ON LINKAGES.

BY

A. B. KEMPE, B.A.,

OF THE INNER TEMPLE, ESQ.;
MEMBER OF THE COUNCIL OF THE LONDON MATHEMATICAL SOCIETY;
AND LATE SCHOLAR OF TRINITY COLLEGE, CAMBRIDGE.

WITH NUMEROUS ILLUSTRATIONS.

London :
1877.

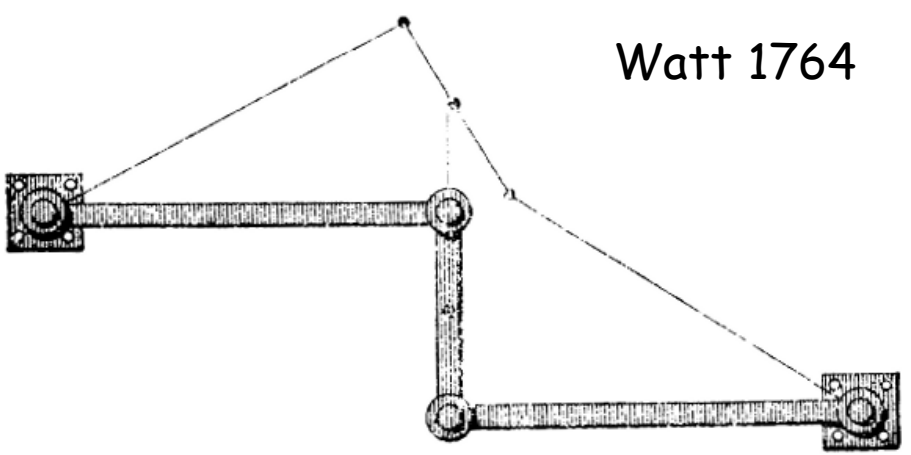
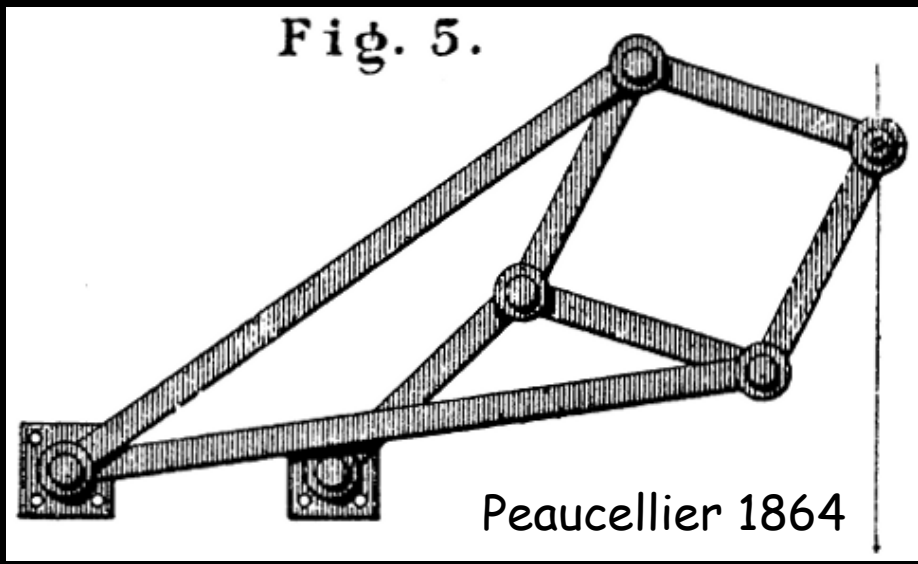


Fig. 2.



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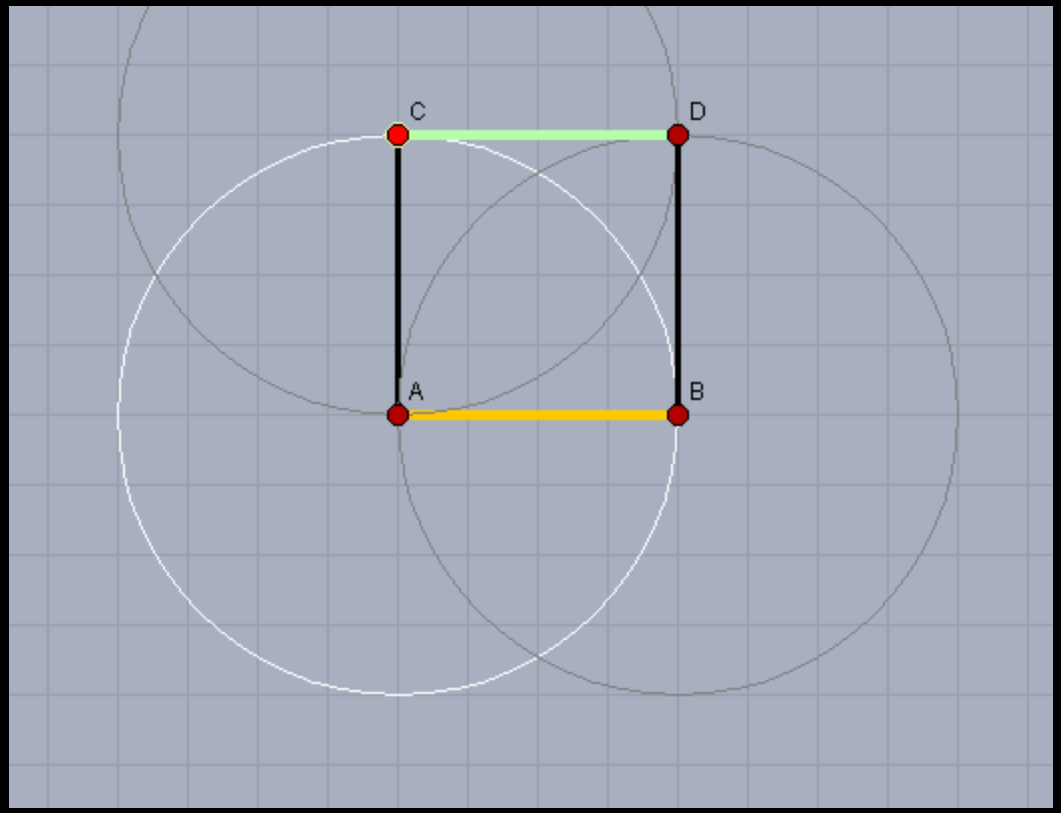
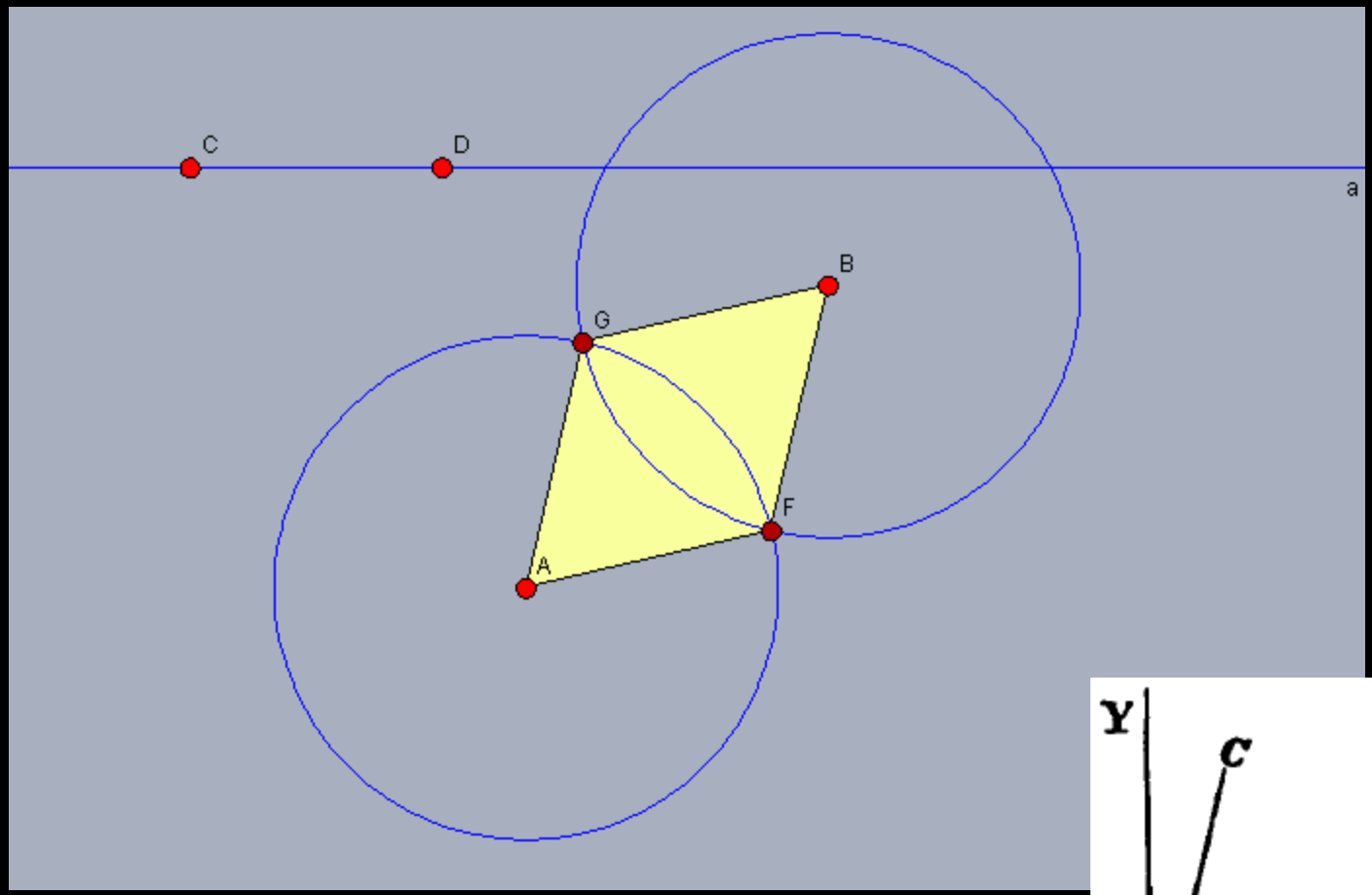

C
D
A
B



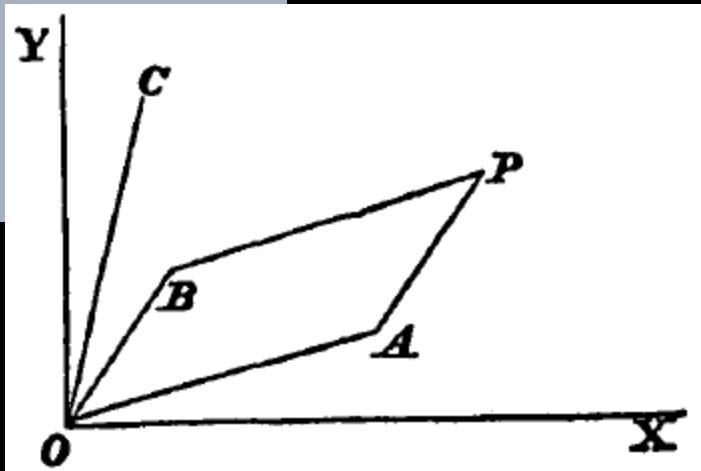


Fig. 6.

```
> subs({x=r/2*cos(alpha)+r/2*cos(beta),
        y=r/2*sin(alpha)+r/2*sin(beta)},
       x^3*y-5*x*y^2);
```

$$\left(\frac{1}{2}r\cos(\alpha)+\frac{1}{2}r\cos(\beta)\right)^3\left(\frac{1}{2}r\sin(\alpha)+\frac{1}{2}r\sin(\beta)\right)-5\left(\frac{1}{2}r\cos(\alpha)+\frac{1}{2}r\cos(\beta)\right)\left(\frac{1}{2}r\sin(\alpha)+\frac{1}{2}r\sin(\beta)\right)^2 \tag{1}$$

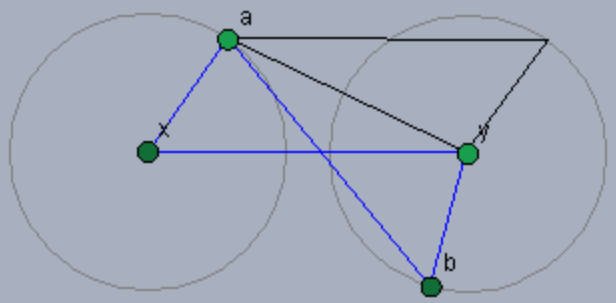
```
> expand(%);
```

$$\frac{1}{16}r^4\cos(\alpha)^3\sin(\alpha)+\frac{1}{16}r^4\cos(\alpha)^3\sin(\beta)+\frac{3}{16}r^4\cos(\alpha)^2\cos(\beta)\sin(\alpha) \tag{2}$$
$$+\frac{3}{16}r^4\cos(\alpha)^2\cos(\beta)\sin(\beta)+\frac{3}{16}r^4\cos(\alpha)\cos(\beta)^2\sin(\alpha)+\frac{3}{16}r^4\cos(\alpha)\cos(\beta)^2\sin(\beta)$$
$$+\frac{1}{16}r^4\cos(\beta)^3\sin(\alpha)+\frac{1}{16}r^4\cos(\beta)^3\sin(\beta)-\frac{5}{8}r^3\cos(\alpha)\sin(\alpha)^2-\frac{5}{4}r^3\cos(\alpha)\sin(\alpha)\sin(\beta)$$
$$-\frac{5}{8}r^3\cos(\alpha)\sin(\beta)^2-\frac{5}{8}r^3\cos(\beta)\sin(\alpha)^2-\frac{5}{4}r^3\cos(\beta)\sin(\alpha)\sin(\beta)-\frac{5}{8}r^3\cos(\beta)\sin(\beta)^2$$

```
> combine(%,trig);
```

$$\frac{1}{128}r^4\sin(4\beta)+\frac{1}{128}r^4\sin(4\alpha)+\frac{1}{16}r^4\sin(2\alpha)+\frac{1}{32}r^4\sin(\beta+3\alpha)+\frac{1}{64}r^4\sin(-\beta+3\alpha) \tag{3}$$
$$+\frac{3}{32}r^4\sin(\beta+\alpha)+\frac{3}{64}r^4\sin(2\beta+2\alpha)+\frac{1}{16}r^4\sin(2\beta)+\frac{1}{32}r^4\sin(3\beta+\alpha)-\frac{1}{64}r^4\sin(-3\beta$$
$$+\alpha)-\frac{15}{32}r^3\cos(\alpha)+\frac{5}{32}r^3\cos(3\alpha)-\frac{5}{32}r^3\cos(2\alpha-\beta)+\frac{15}{32}r^3\cos(2\alpha+\beta)-\frac{5}{32}r^3\cos(\alpha$$
$$-2\beta)+\frac{15}{32}r^3\cos(\alpha+2\beta)-\frac{15}{32}r^3\cos(\beta)+\frac{5}{32}r^3\cos(3\beta)$$

```
>
```



Drag the red slider to adjust the side lengths of the contraparallelogram

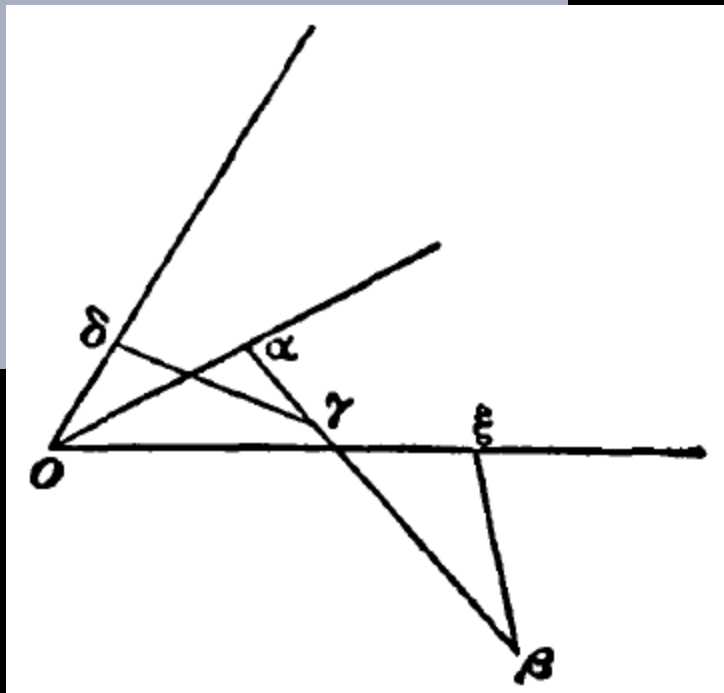
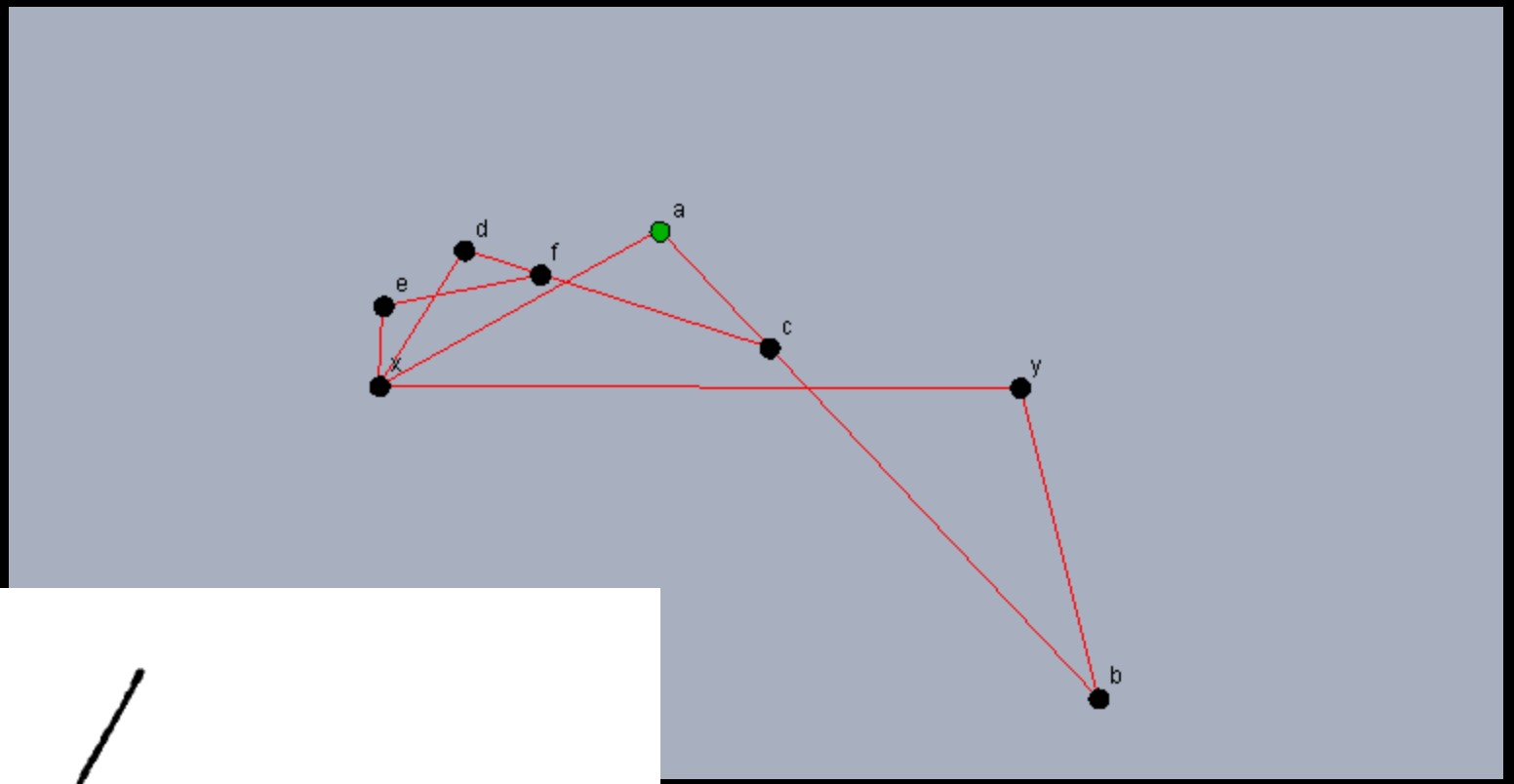


Fig. 1.



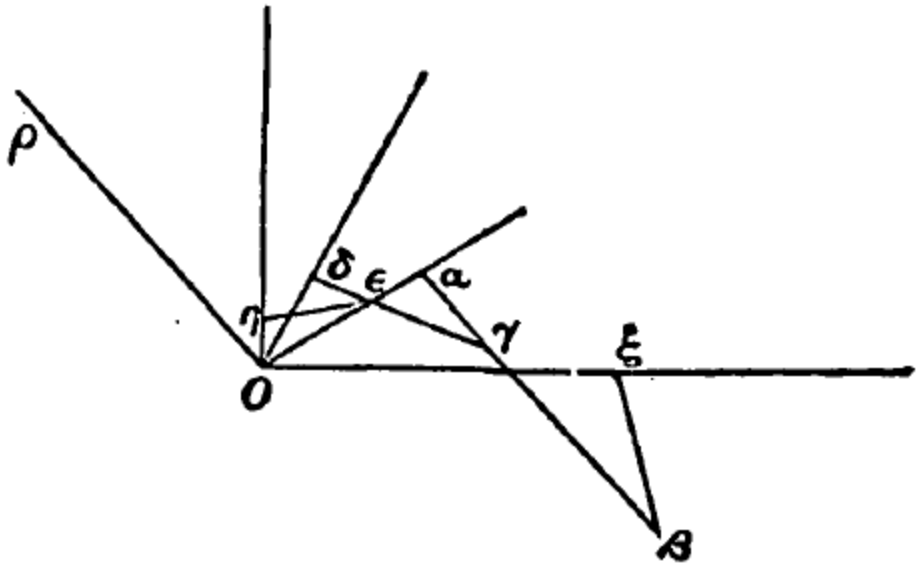
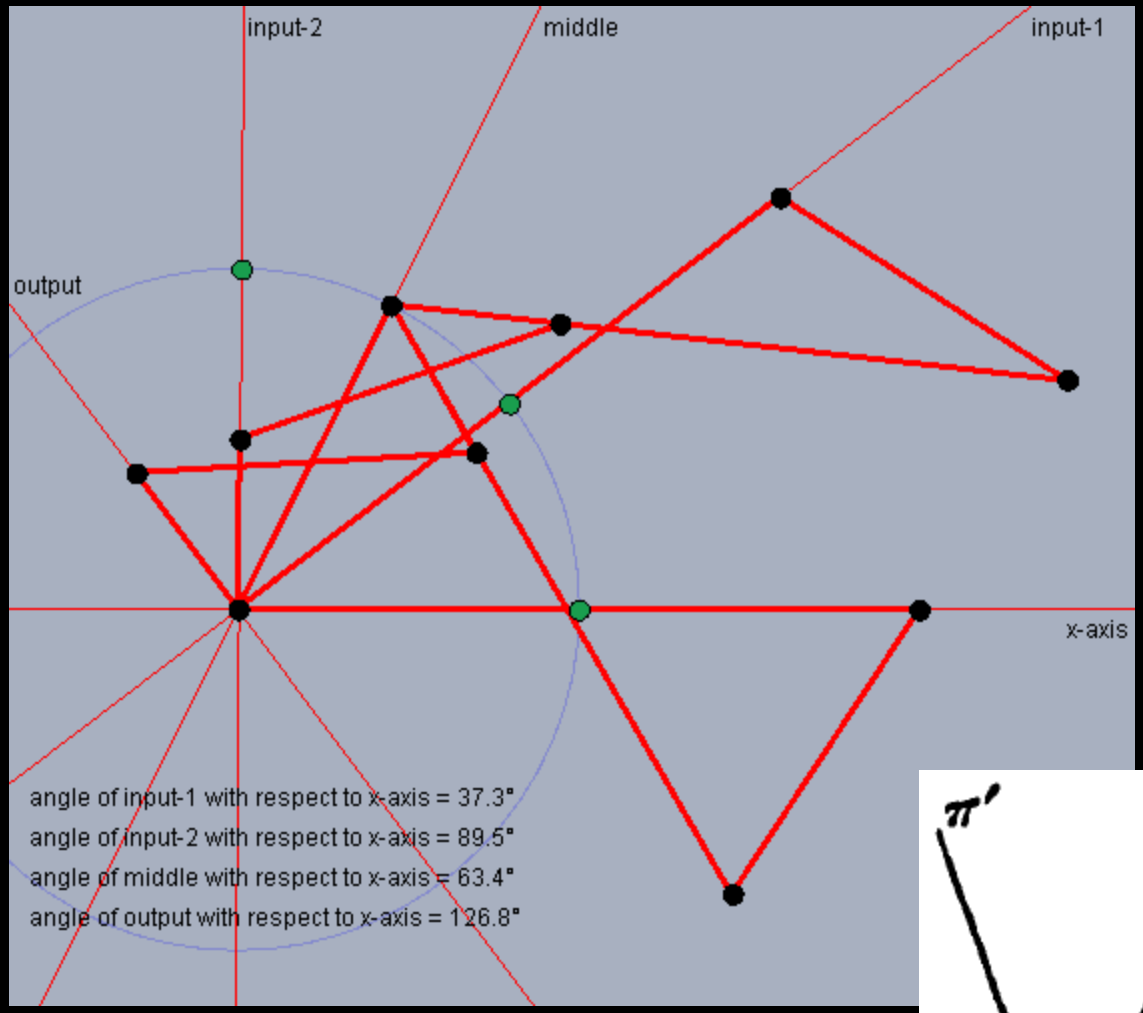


Fig. 2.


input-2
middle
input-1
output
x-axis
angle of input-1 with respect to x-axis = 37.3°
angle of input-2 with respect to x-axis = 89.5°
angle of middle with respect to x-axis = 63.4°
angle of output with respect to x-axis = 126.8°

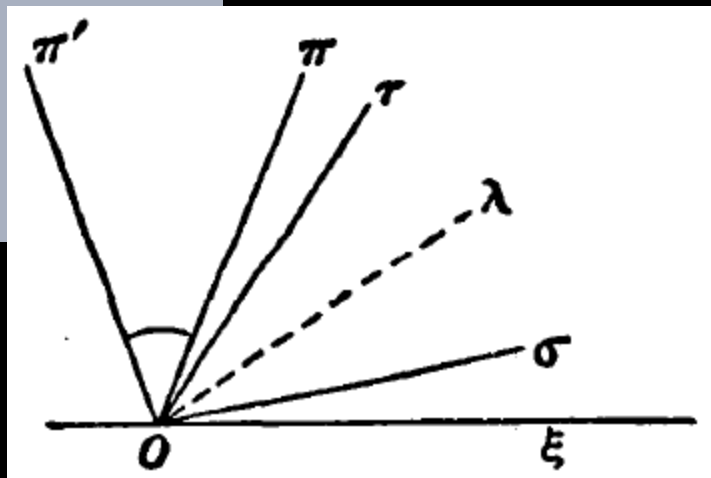
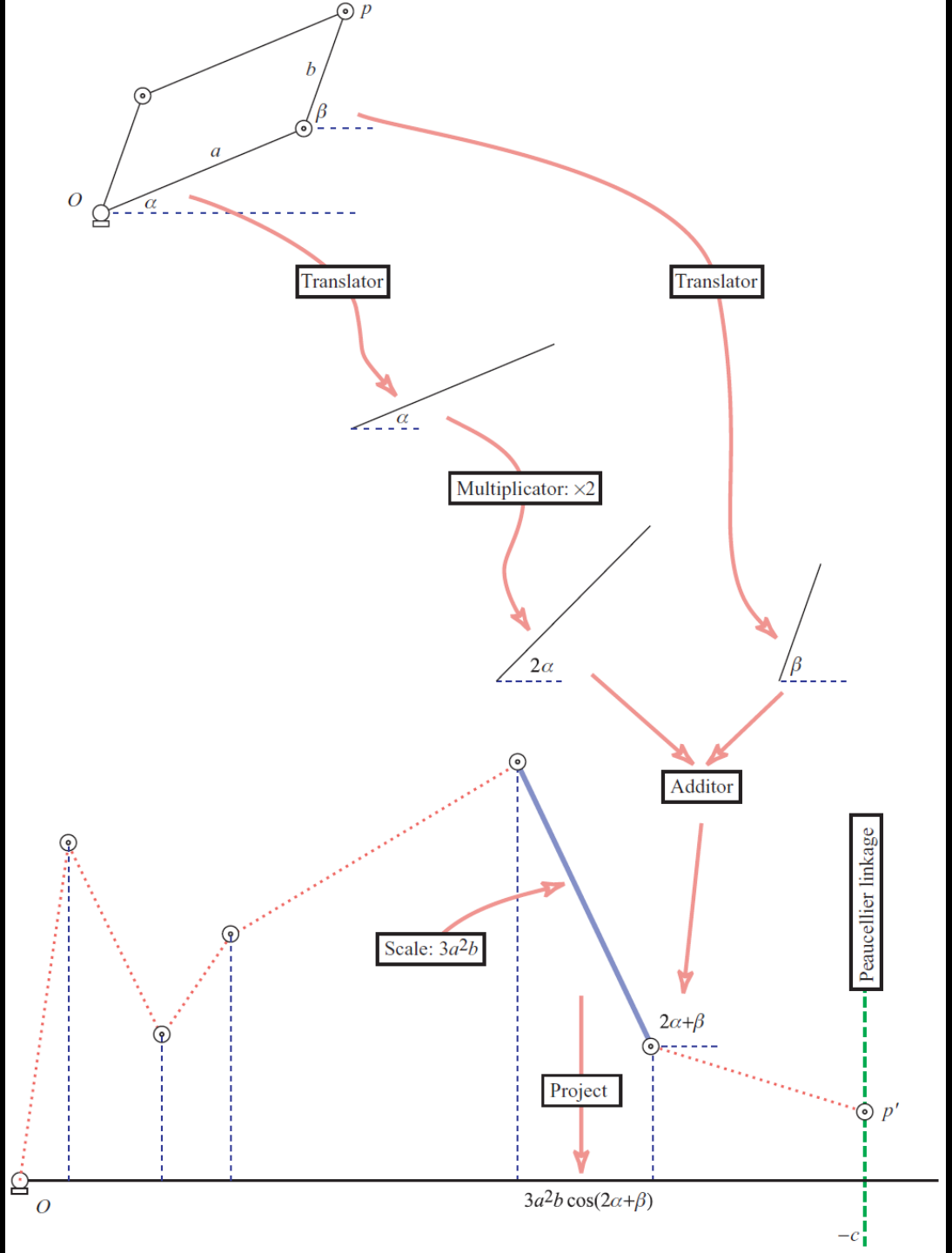
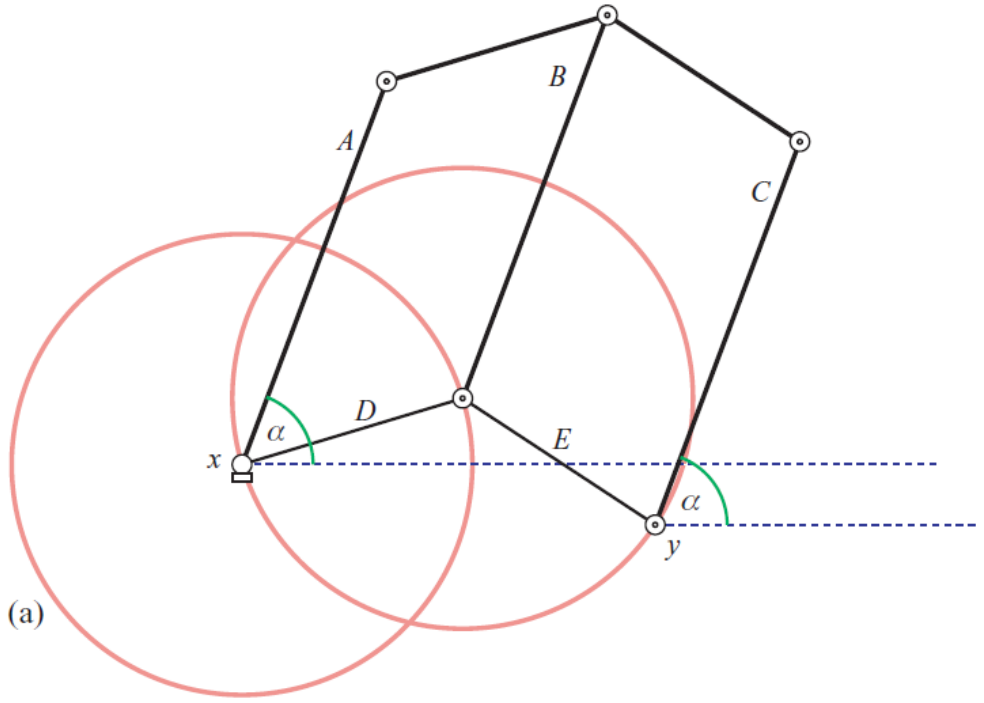
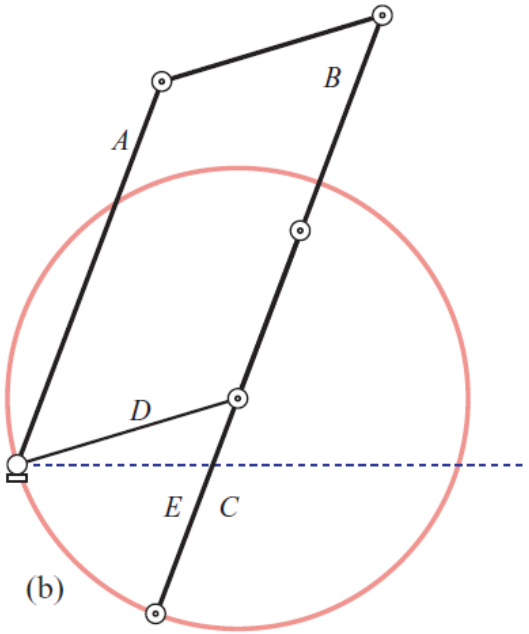

π′
π
τ
λ
σ
O
ξ

Fig. 3.

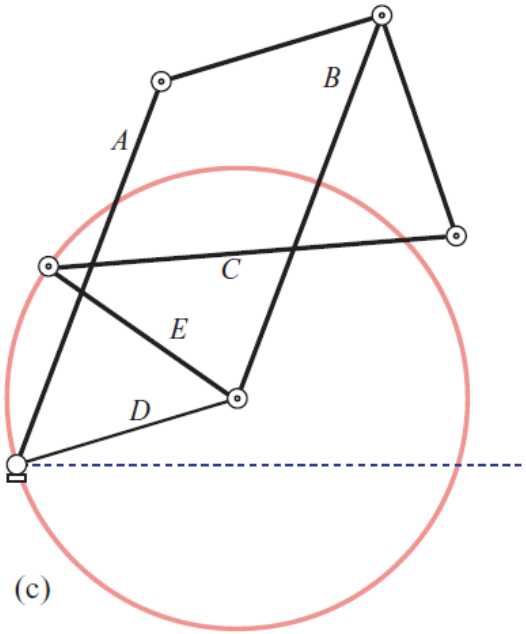

p
b
β
a
O
α
Translator
Translator
α
Multiplicator: ×2
2α
β
Additor
Peaucellier linkage
Scale: 3a²b
2α+β
Project
p′
O
3a²b cos(2α+β)
−c



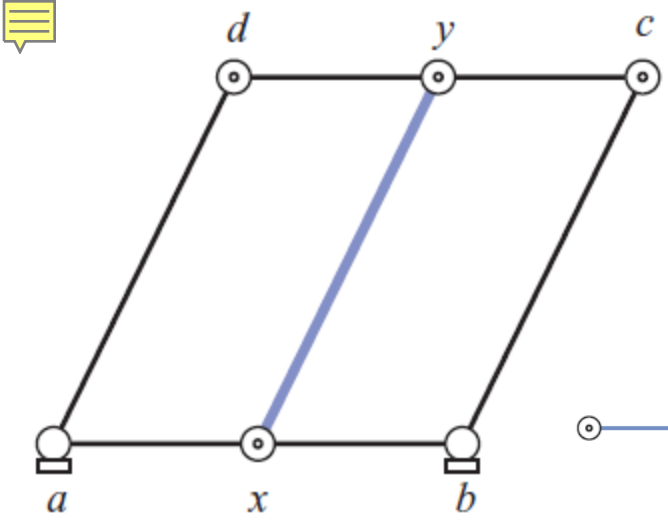
(a)

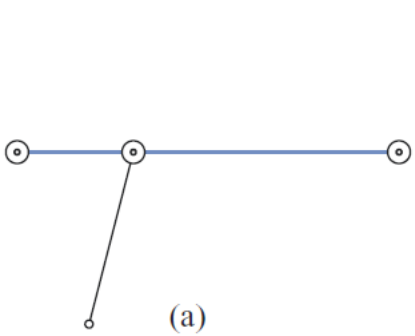


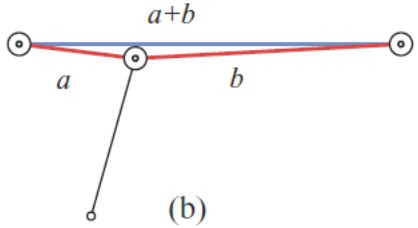
(b)

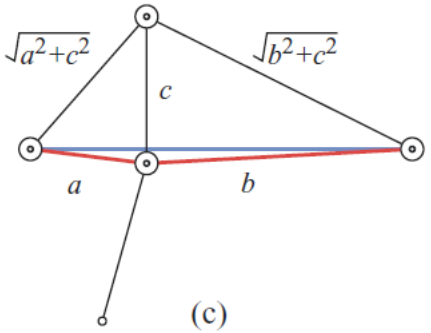


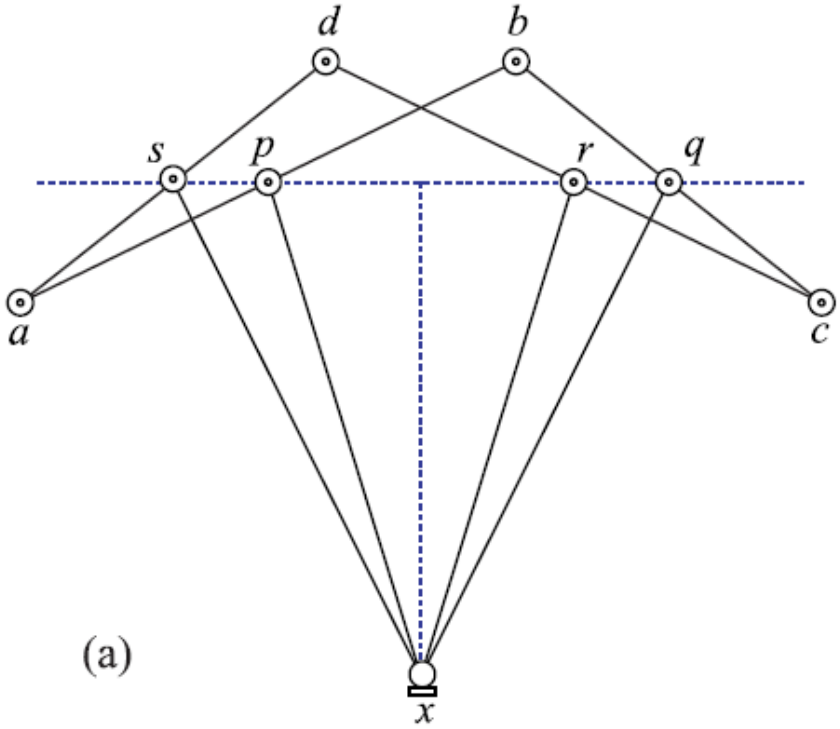
(c)

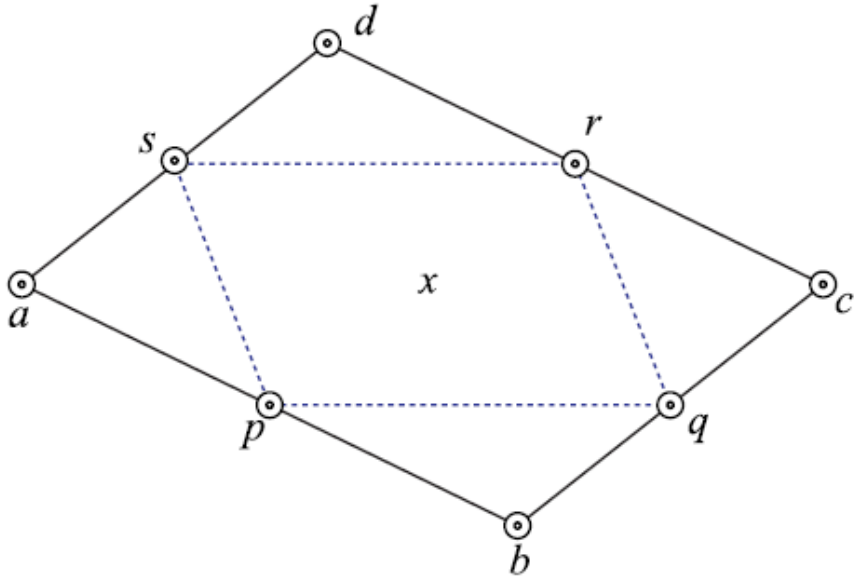

d
y
c
a
x
b

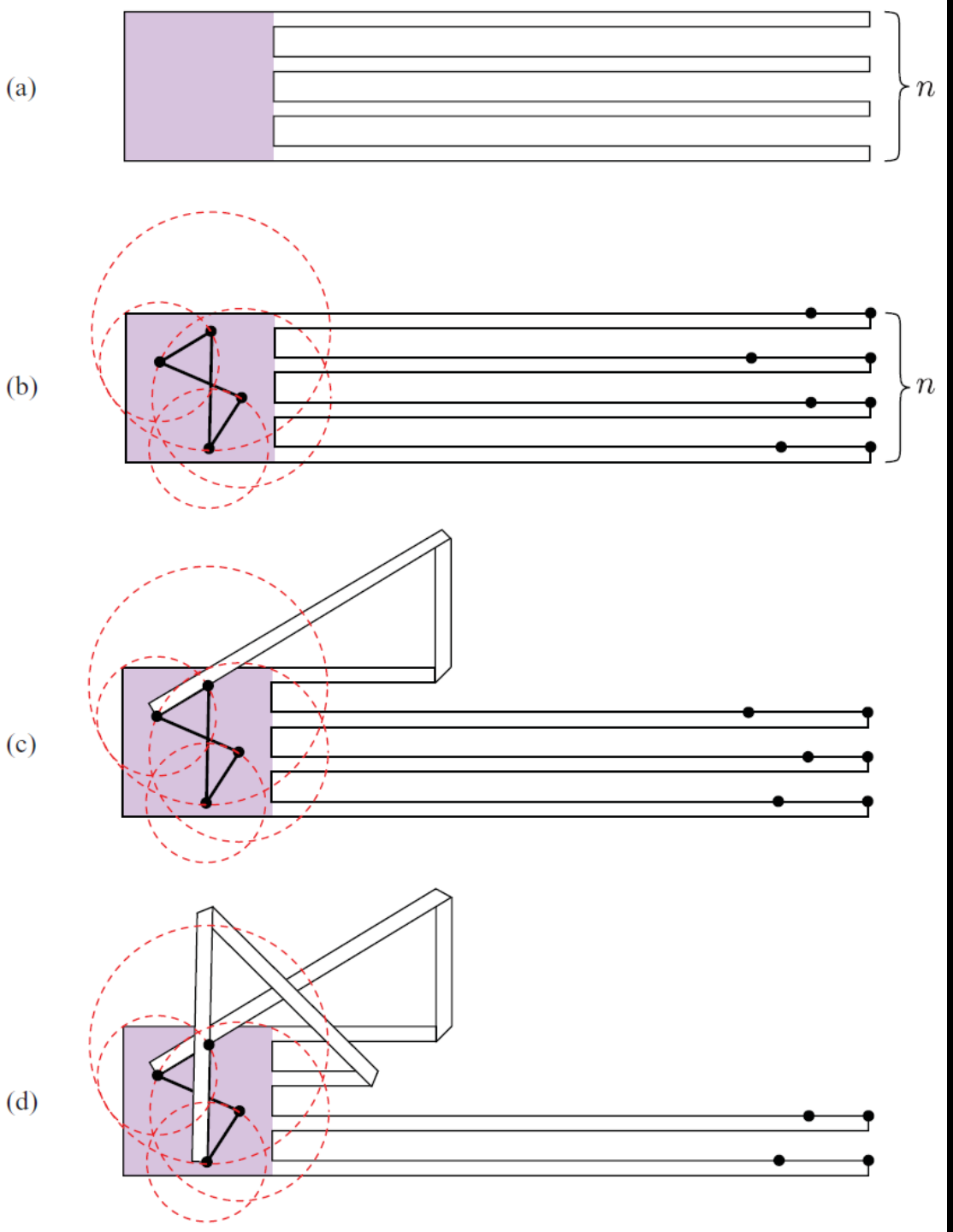

(a)


a+b
a
b
(b)


√a²+c²
√b²+c²
c
a
b
(c)


d
b
s
p
r
q
a
c
x
(a)


d
s
r
x
a
c
p
q
b
(b)


(a)
n
(b)
n
(c)
(d)