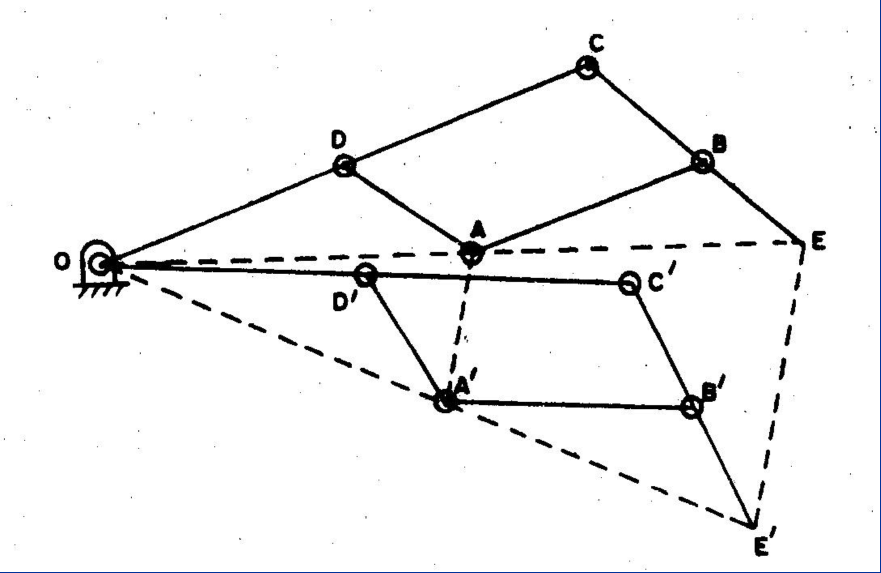
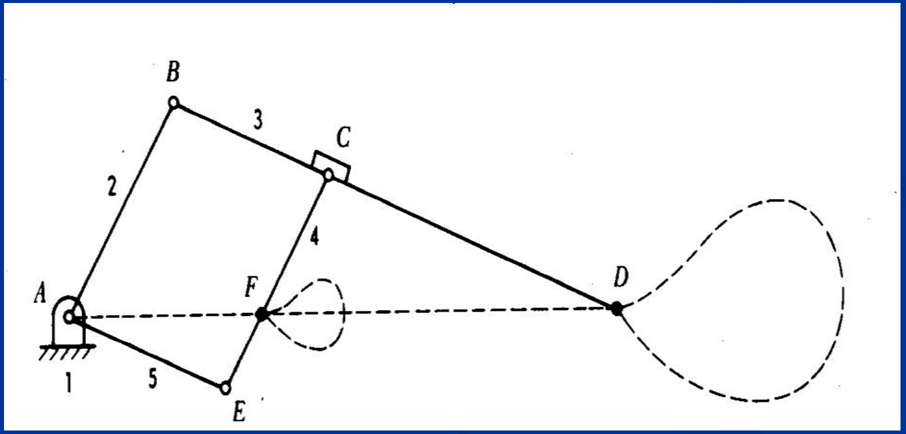
Kinematics of Machines (NME-502)

MECHANISM WITH LOWER PAIRS

Pantograph





Pantograph

- Pantographs are used for reducing or enlarging drawings and maps. They are also used for guiding cutting tools or torches to fabricate complicated shapes.
- In the mechanism shown in fig. path traced by point A will be magnified by point E to scale, as discussed below.
- In the mechanism shown, AB = CD; AD =BC and OAE lie on a straight line.
- When point A moves to A' , E moves to E' and OA'E' also lies on a straight line.

$\Delta ODA \equiv \Delta OCE$ and $\Delta OD'A' \equiv \Delta OC'E'$.

$$\therefore \frac{OD}{OC} = \frac{OA}{OE} = \frac{DA}{CE} \quad \text{And} \quad \frac{OD'}{OC'} = \frac{OA'}{OE'} = \frac{D'A'}{C'E'}$$

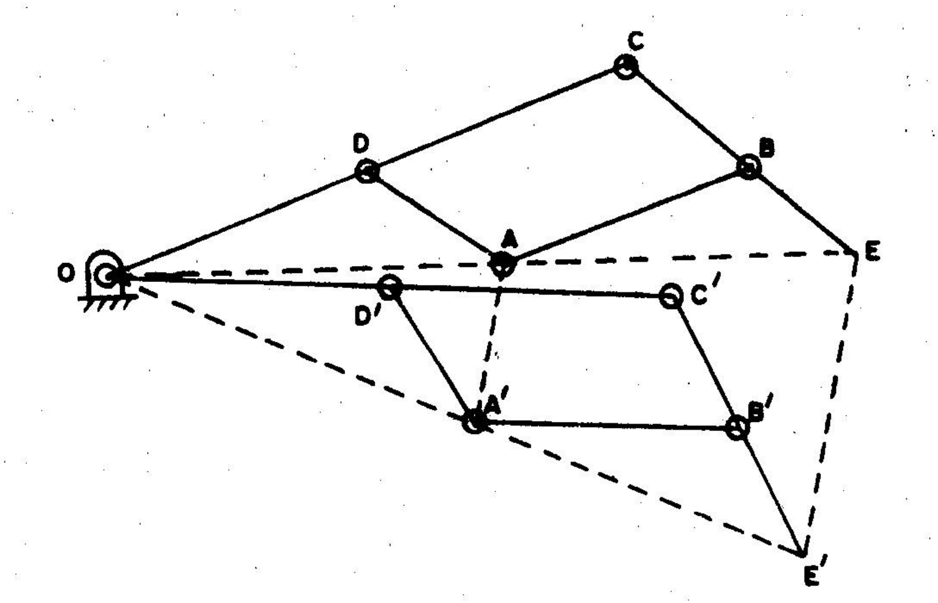
$$\text{But,} \quad \frac{OD}{OC} = \frac{OD'}{OC'}; \therefore \frac{OA}{OE} = \frac{OA'}{OE'}; \therefore \Delta OAA' \equiv \Delta OEE'$$

$$\therefore EE' \,//\, AA'$$

$$\text{And} \quad \frac{EE'}{AA'} = \frac{OE}{OA} = \frac{OC}{OD}$$

$$\therefore EE' = AA'\left(\frac{OC}{OD}\right)$$

Where $\left(\frac{OC}{OD}\right)$ is the magnification factor



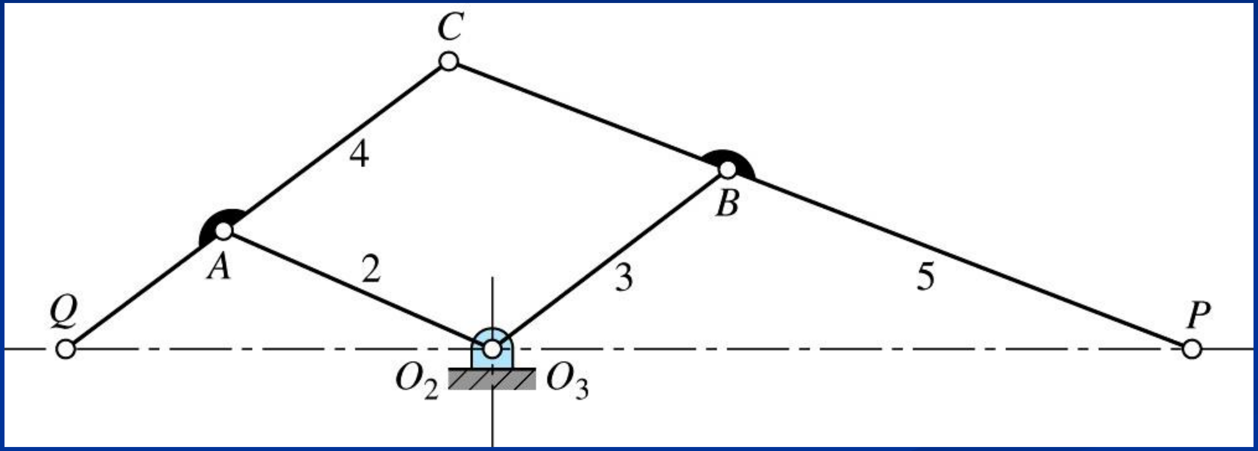


Figure The pantograph linkage.

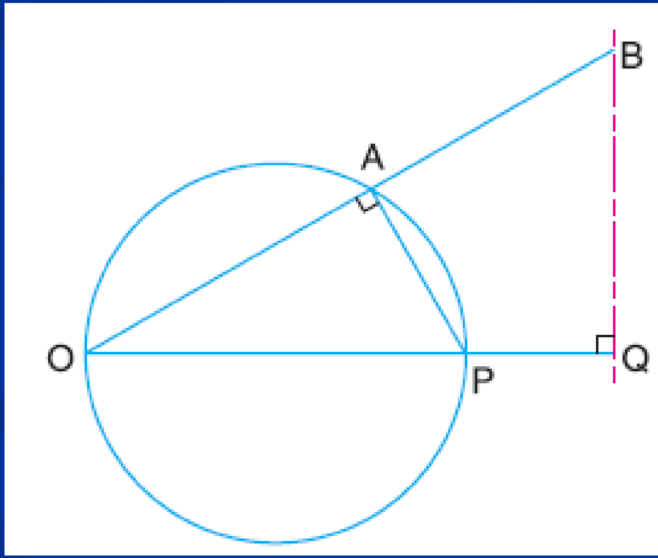
Condition for Exact Straight Line Motion Mechanisms

Let O be a point on the circumference of a circle of diameter OP.

Let OA *be any chord and B is a point on OA produced, such* that

$$OA \times OB = constant$$

- Then the locus of a point B *will be a*
- *straight line* perpendicular to the
- diameter OP.

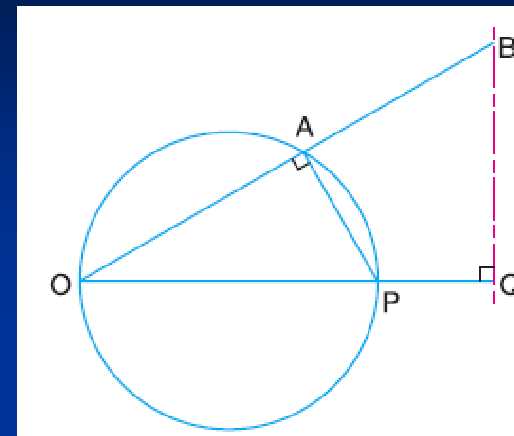


- Draw *BQ perpendicular to OP produced. Join AP*. The triangles *OAP and OBQ are similar.*

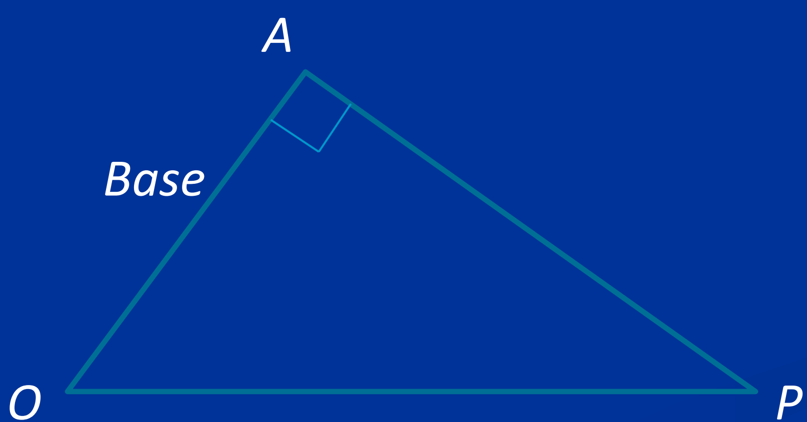
$$\therefore \qquad \frac{OA}{OP} = \frac{OQ}{OB}$$

or $$OP \times OQ = OA \times OB$$

or $$OQ = \frac{OA \times OB}{OP}$$



- But *OP is constant as it is the diameter of a circle, therefore,* if *OA* × *OB is constant, then OQ will be constant. Hence* the point *B moves along the straight path BQ which is perpendicular* to *OP*.



Peaucellier exact straight line motion mechanism:

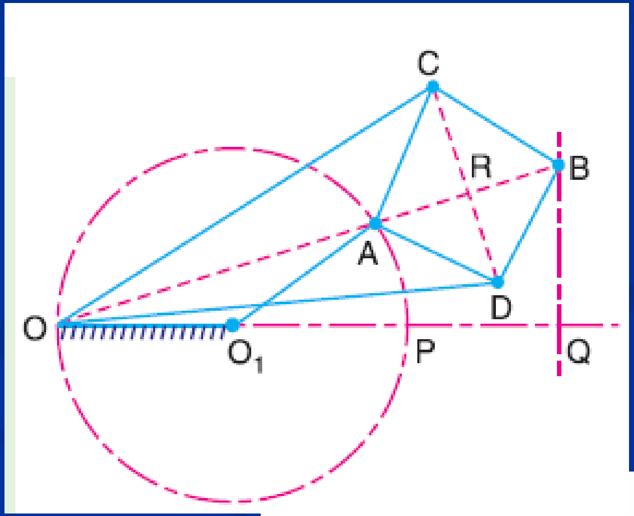
- The pin at *A is constrained to move along the circumference* of a circle with the fixed diameter *OP, by means of* the link O_1A.
- *In Fig., AC = CB = BD = DA ; OC = OD ; and* $OO_1 = O_1A$
- It may be proved that the product $OA \times OB$ *remains* constant, when the link O_1A *rotates. Join CD to bisect AB at R.* Now from right angled triangles *ORC and BRC, we have*

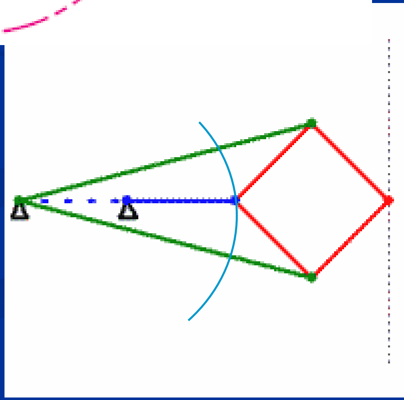
$$OC^2 = OR^2 + RC^2$$

and $$BC^2 = RB^2 + RC^2$$

Subtracting equation (*ii*) from (*i*), we have

$$OC^2 - BC^2 = OR^2 - RB^2$$
$$= (OR + RB)(OR - RB)$$
$$= OB \times OA$$





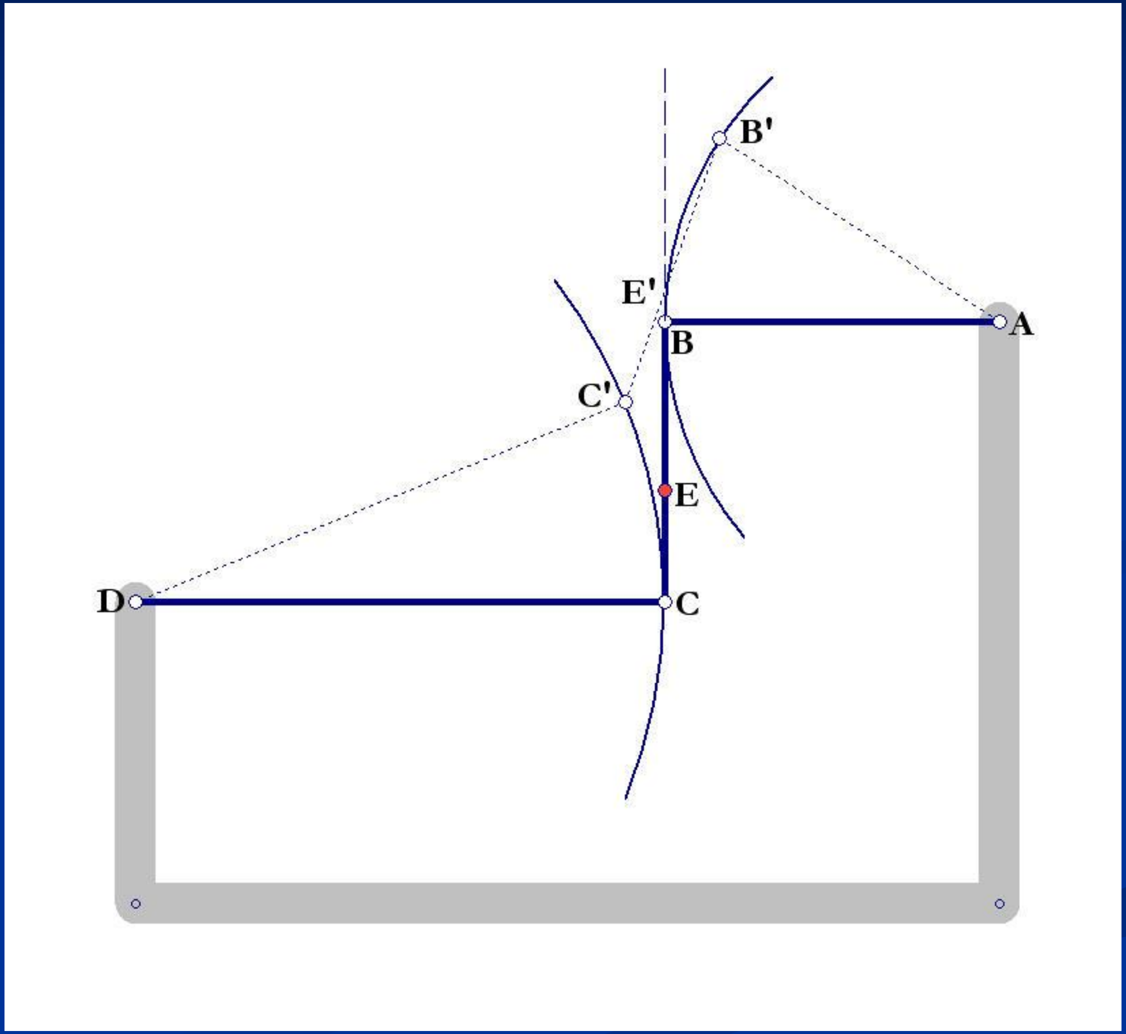
Since *OC and BC are of constant length, therefore* the product *OB × OA remains constant. Hence the point B* traces a straight path perpendicular to the diameter *OP.*

Watt's Parallel Motion

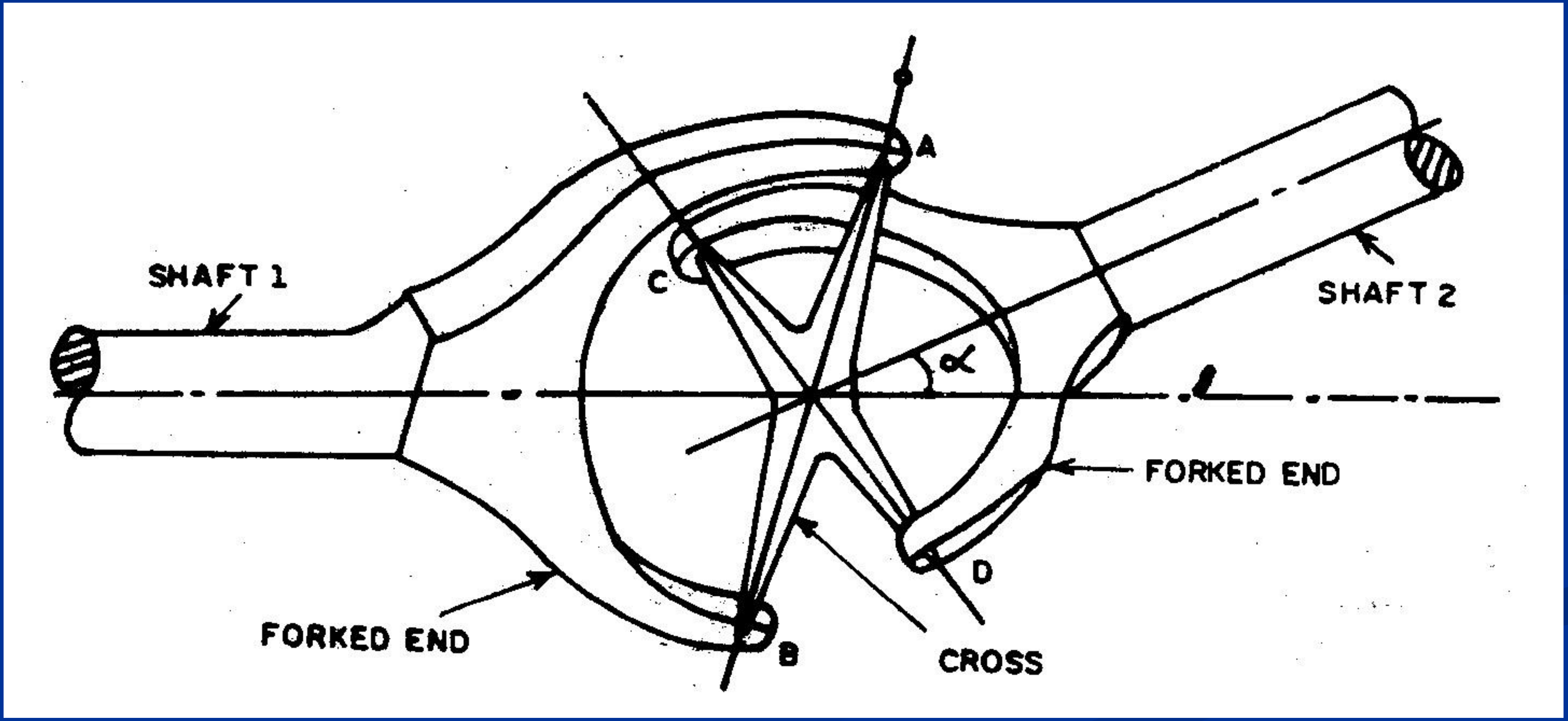
- The exact position of E′ is found by first assuming a small rotation of the bars so that B moves to B′ and C to C′.
- Let B′C′ cut BC or BC (produced) in E′. Then E′ will be the generating point for the straight line.
- To prove this we therefore need to show that the ratio

$$\frac{B'E'}{E'C'}$$

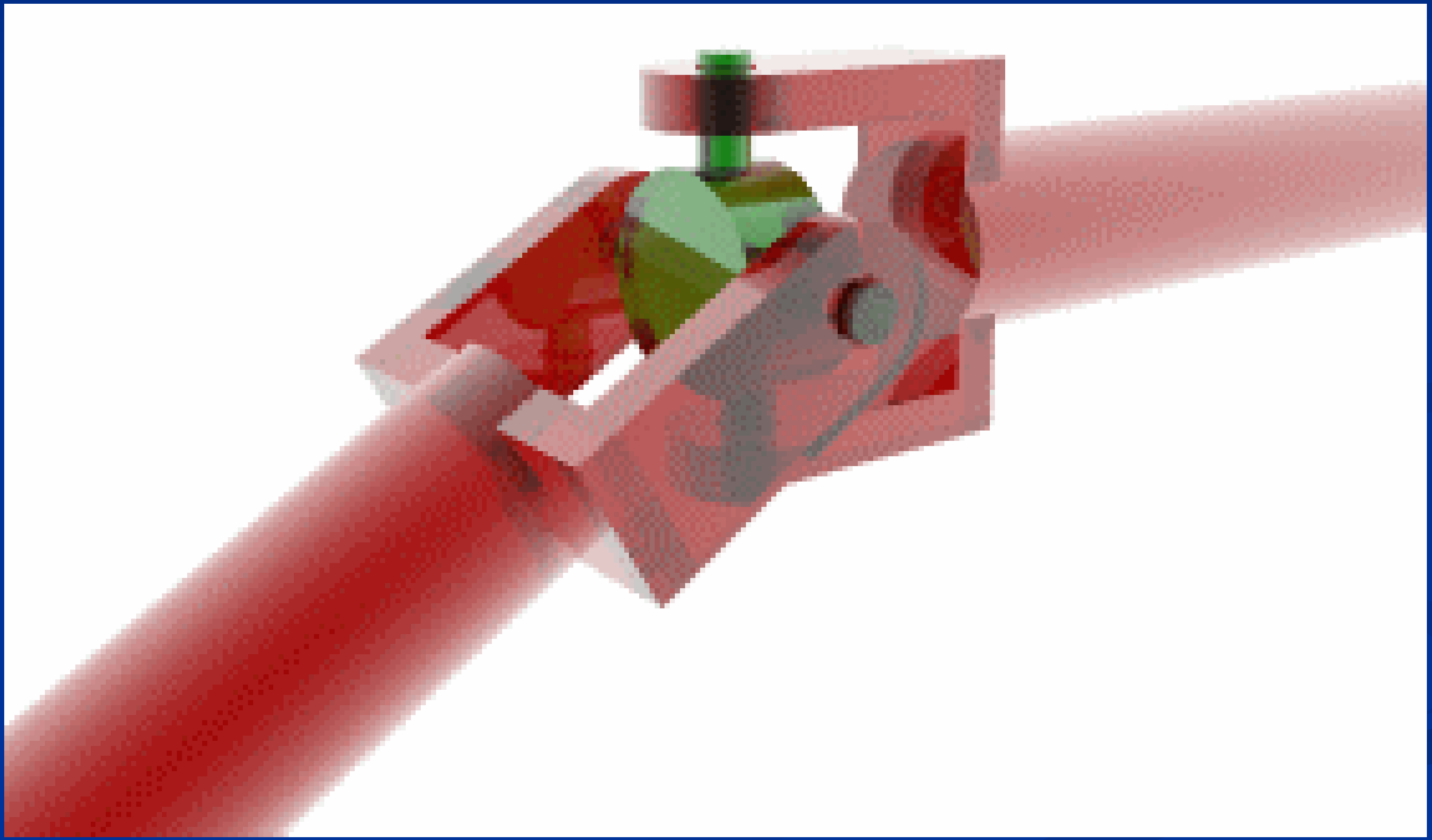
is constant for all small rotations of AB and CD about their mid-positions.



5.Hooke's joint

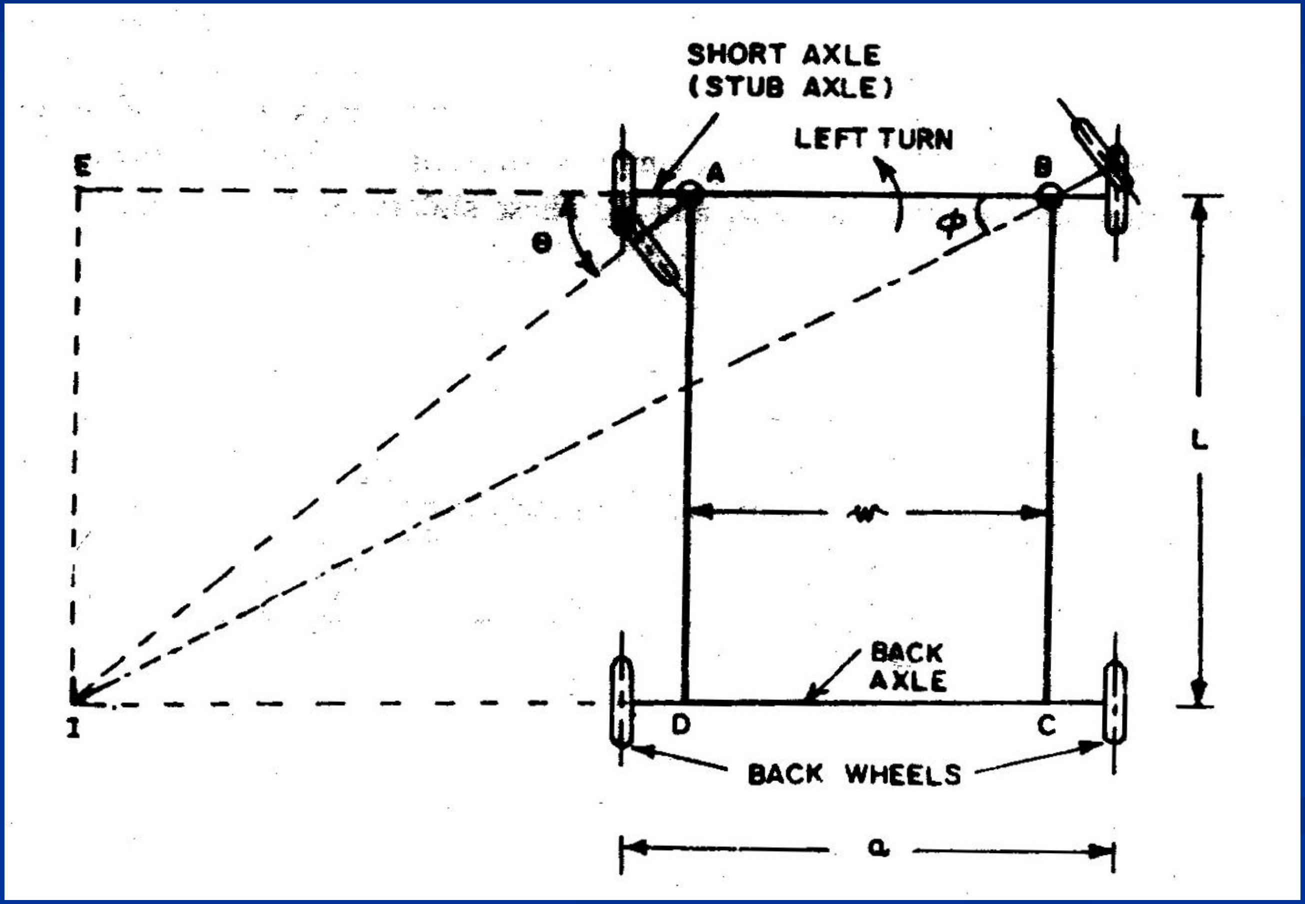


Hooke’s joint

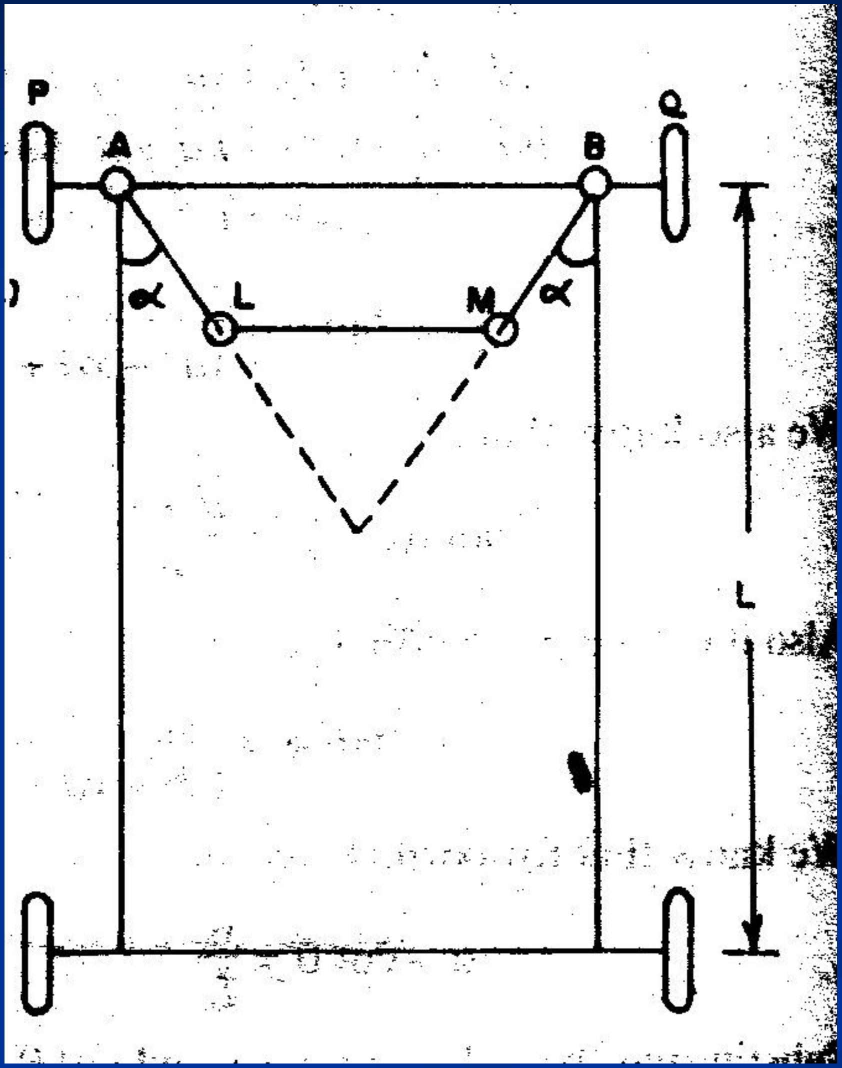


6.Steering gear mechanism

Condition for perfect steering



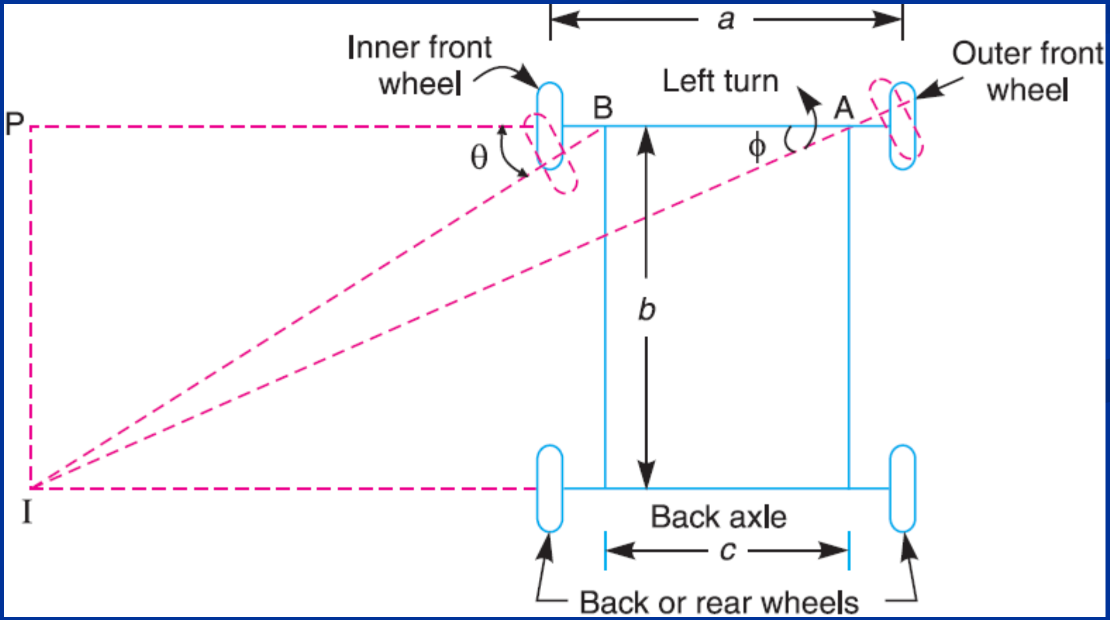
Ackermann steering gear mechanism



Steering Gear Mechanism

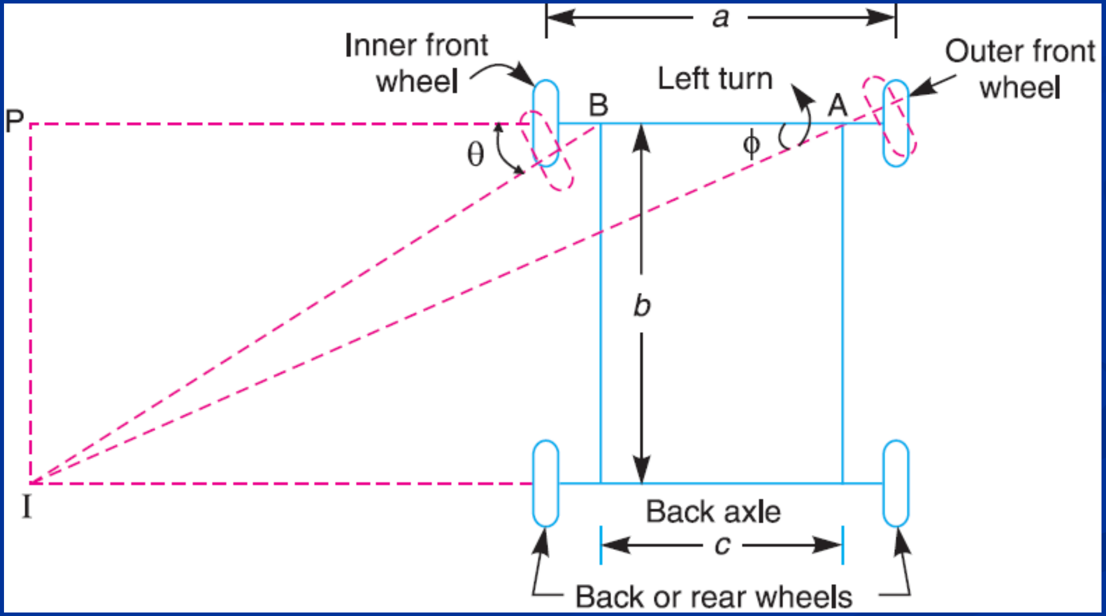
- The steering gear mechanism is used for changing the direction of two or more of the wheel axles with reference to the chassis, so as to move the automobile in any desired path.
- Usually the two back wheels have a common axis, which is fixed in direction with reference to the chassis and the steering is done by means of the front wheels.
- In automobiles, the front wheels are placed over the front axles, which are pivoted at the points *A and B, as shown in Fig. These points are fixed to the chassis.*
- *The back wheels are placed* over the back axle, at the two ends of the differential tube. When the vehicle takes a turn, the front wheels along with the respective axles turn about the respective pivoted points.

The back wheels remain straight and do not turn. Therefore, the steering is done by means of front wheels only.



Condition for perfect steering

- In order to avoid skidding (*i.e. slipping of the wheels sideways),* the two front wheels must turn about the same instantaneous centre *I which lies on the axis of* the back wheels.
- If the instantaneous centre of the two front wheels do not coincide with the instantaneous centre of the back wheels, the skidding on the front or back wheels will definitely take place, which will cause more wear and tear of the tyres.
- ***Thus, the condition for correct steering is that all the four wheels must turn about the same instantaneous centre.***
- The axis of the inner wheel makes a larger turning angle than the angle subtended by the axis of outer wheel.



Condition for perfect steering

Let a = Wheel track,

b = Wheel base, and

c = Distance between the pivots A and B of the front axle.

Now from triangle IBP,

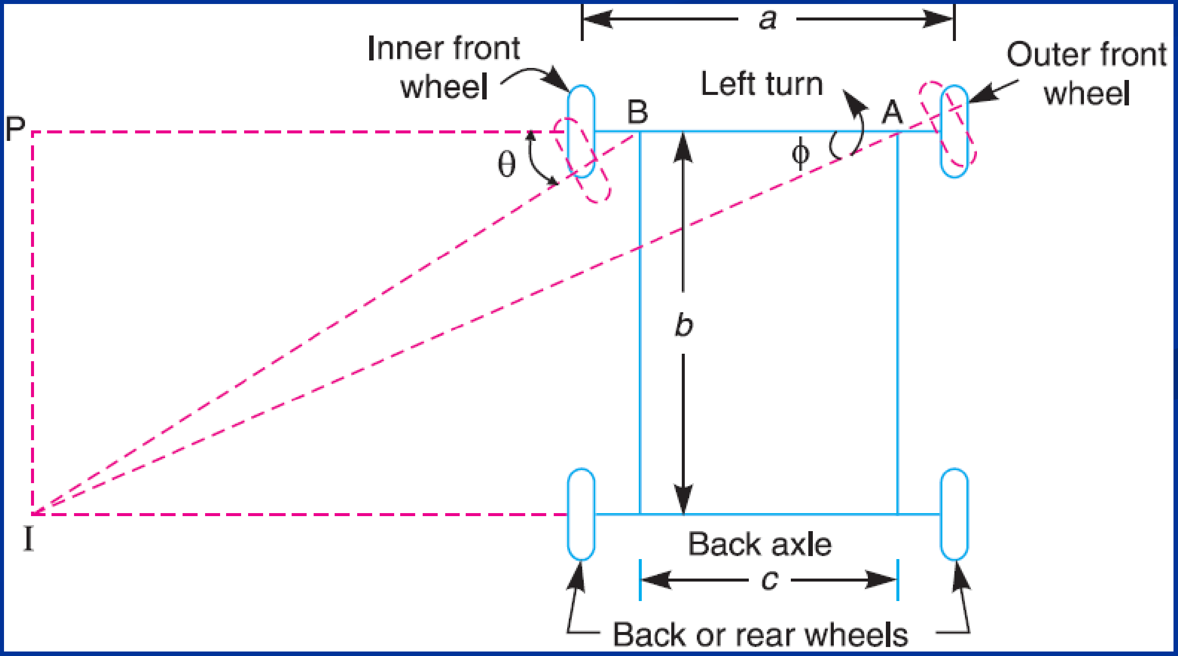
$$\cot\theta = \frac{BP}{IP}$$

and from triangle IAP,

$$\cot\phi = \frac{AP}{IP} = \frac{AB + BP}{IP} = \frac{AB}{IP} + \frac{BP}{IP} = \frac{c}{b} + \cot\theta \quad \ldots(\because IP = b)$$

$$\therefore \cot\phi - \cot\theta = c/b$$

This is the fundamental equation for correct steering. If this condition is satisfied, there will be no skidding of the wheels, when the vehicle takes a turn.



Ackermann steering gear mechanism

- In Ackerman steering gear, the mechanism *ABCD is a four bar crank chain, as shown in Fig.*
- The shorter links *BC and AD are of equal length and are connected by hinge joints with front* wheel axles. The longer links *AB and CD are of unequal length. The following are the only three* positions for correct steering.

1. **When the vehicle moves along a straight path, the longer links *AB and CD are parallel and*** the shorter links *BC and AD are equally inclined to the longitudinal axis of the vehicle, as shown by* firm lines in Fig..
2. **When the vehicle is steering to the left, the position of the gear is shown by dotted lines in** Fig. In this position, the lines of the front wheel axle intersect on the back wheel axle at *I, for* correct steering.
3. **When the vehicle is steering to the right, the similar position may be obtained.**