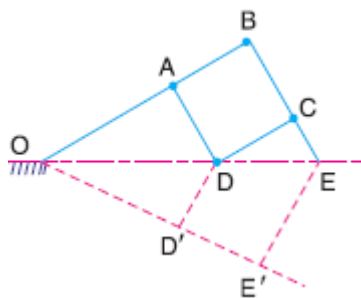


2. STRAIGHT LINE MOTION MECHANISMS

1. Sketch a pantograph, explain its working and show that it can be used to reproduce to an enlarged scale a given figure?

PANTOGRAPH:

1. It is a four bar linkage used to produce paths exactly similar to the ones traced out by a point on the linkage.
2. The paths so produced are usually on an enlarged or reduced scale and may be straight or curved ones.



1. It consists of a jointed parallelogram ABCD as shown in the figure.
2. It is made up of bars connected by turning pairs.
3. From similar triangles OAD and OBE,

$$OD/OE = AD/BE$$

4. Let O be fixed and the points D and E move to some new positions D' and E'. Then

$$OD/OE = OD'/OE'$$

5. Therefore the point E traces out the same path as described by point D.
 6. A pantograph is mostly used for the reproduction of plane areas and figures such as maps, plans ...etc.
 7. A modified form of pantograph is used to collect electricity at the top of electric trains.
2. What are straight line mechanisms? Explain about Exact straight motion mechanisms made up of turning pairs? (OR) Explain about Peaucellier mechanisms and Hart's mechanisms?

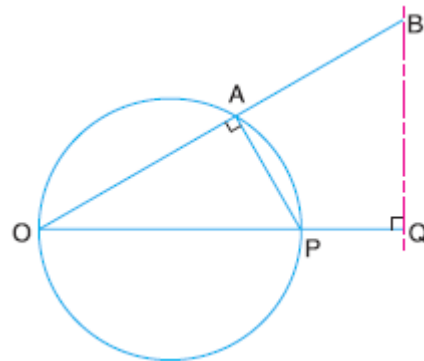
Straight line mechanisms: It is a constraint mechanism is that it permits only relative motion of an oscillatory nature along a straight line.

Exact straight line motion mechanisms made up of turning pairs:

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

Let B is a point on OA (chord), such that

$$OA \times OB = \text{constant}$$



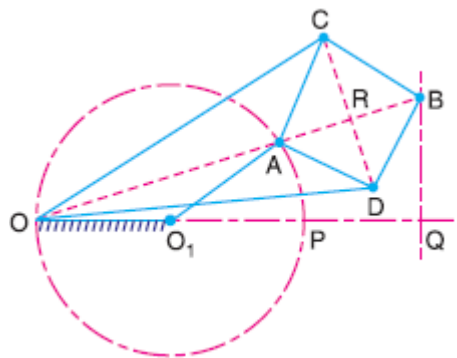
From similar triangles OAP and OBQ,

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

But OP and OQ are constant then $OA \times OB = \text{Constant}$.

Hence the point B moves along a straight path BQ which is perpendicular to OP.

1. Peaucellier mechanism:



1. It consists of 8 links i.e. a fixed link OO_1 and the straight links O_1A , OC , OD , AD , DB , BC and CA are connected by turning pairs.
2. The pin at A is constrained to move along the circumference of a circle.
3. $AC = CB = BD = DA$; $OC = OD$; and $OO_1 = O_1A$
4. From the triangles ORC and BRC ,

$$OC^2 = OR^2 + RC^2 \quad \dots(i)$$

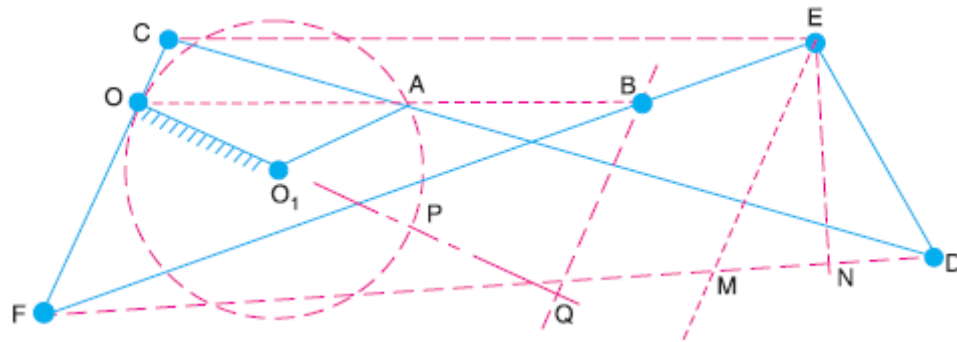
$$BC^2 = RB^2 + RC^2 \quad \dots(ii)$$

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

$$\begin{aligned} OC^2 - BC^2 &= OR^2 - RB^2 \\ &= (OR + RB)(OR - RB) \\ &= OB \times OA \end{aligned}$$

5. Therefore the product $OB \times OA$ remains constant. Hence the point B traces a straight path perpendicular to the diameter OP.

2. Hart’s mechanism:



1. It consists of six links i.e. a fixed link OO_1 and straight links O_1A , FC , CD , DE and EF are connected by turning pairs.
2. The pin at A is constrained to move along the circumference of a circle.
3. $FC = DE$; and $CD = EF$;
4. The points O , A and B divide the links FC , CD and EF in the same ratio.

From similar triangles CFE and OFB ,

$$\frac{CE}{FC} = \frac{OB}{OF} \quad \dots(i)$$

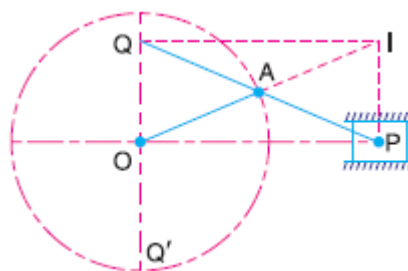
and from similar triangles FCD and OCA

$$\frac{FD}{FC} = \frac{OA}{OC} \quad \dots(ii)$$

5. Therefore the product $OB \times OA$ remains constant. Hence the point B traces a straight path perpendicular to the diameter OP .

3. Explain about Exact straight line motion consisting of one sliding pair?

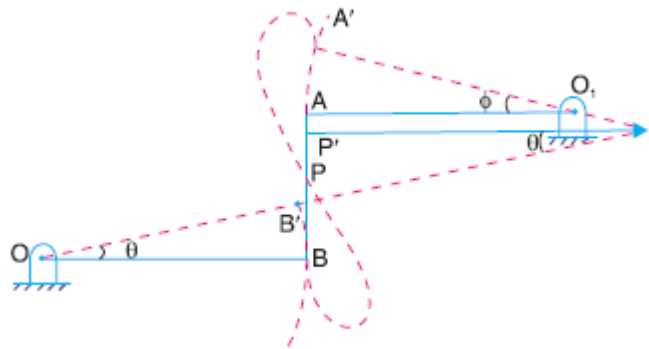
Scott-Russel’s mechnism:



1. It consists of a fixed member and moving member P of a sliding pair.
2. The straight link PAQ is connected by turning pairs to the link OA and the link P .
3. A is the middle point of PQ and $OA = AP = AQ$.
4. If OA makes one complete revolution, then P oscillate along the line OP through a distance of $2 OA$ on each side of O , and Q oscillate along QOQ' through the same distance $2 OA$ above and below O . Thus locus of Q is a copy of the locus of P .

4. Explain about approximate straight line motion mechanisms?

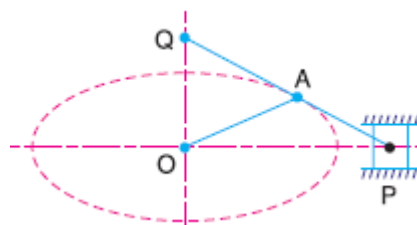
1. Watt’s mechanism:



1. It is a crossed four bar chain mechanism and in steam engines it guides the piston rod to have an approximate straight line motion.
2. In the mean position of the mechanism, links OB and O₁A are parallel and the coupling rod AB is perpendicular to O₁A and OB.
3. $\text{arc } B B' = \text{arc } A A' \quad \text{or} \quad OB \times \theta = O_1 A \times \phi \quad \dots(i)$
4. The tracing point P traces an approximate straight line over certain positions of its movement.

$$\therefore \frac{O_1 A}{OB} = \frac{PB}{PA}$$

2. Modified Scott-Russel mechanism:

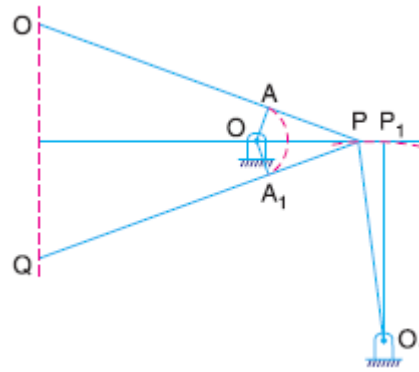


1. In this mechanism AP is not equal to AQ and points P & Q are constrained to move in the horizontal and vertical directions.
2. It forms an elliptical trammel, so that any point A on PQ traces an ellipse with semi major axis AQ and semi minor axis AP.
3. $OA = ((AP)^2) / (AQ)$.

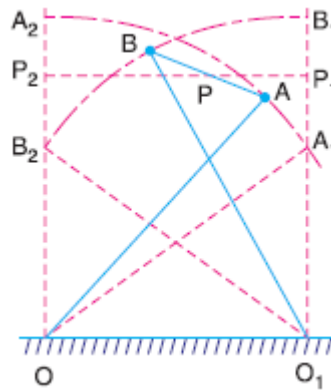
3. Grasshopper mechanism:

1. It is the modification of modified Scott-Russel’s mechanism with the difference that Point P does not slide along straight line.
2. It is a four bar mechanism and all the pairs are turning pairs.
3. In this, O and O₁ are fixed and link OA oscillates about O.

4. $OA = ((AP)^2) / (AQ)$.

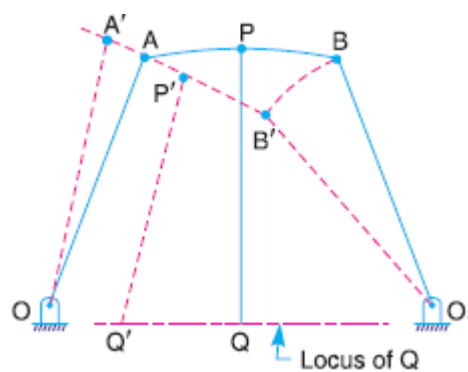


4. **Tchebicheff's mechanism:**



1. It is a four bar mechanism in which crossed links OA and O₁B are of equal length.
2. The point P, which is the mid-point of AB, traces out an approximately straight line parallel to OO₁.
3. $AB : OO_1 : OA = 1 : 2 : 2.5$

5. **Roberts mechanism:**



1. It is a four bar mechanism, which, in its mean position, has the form of a trapezium.
2. The link OA and O₁B are of equal length and OO₁ is fixed.
3. The point Q trace out an approximately straight line.