# 24AG401 THEORY OF MACHINES

# NOTES

**Double Slider Crank Chain:**

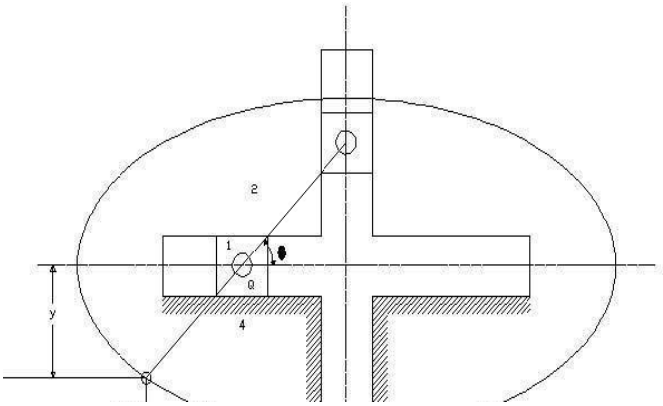
A four bar chain having two turning and two sliding pairs such that two pairs of the same kind are adjacent is known as double slider crank chain.

**Inversions of Double slider Crank chain:**

It consists of two sliding pairs and two turning pairs. They are three important inversions of double slider crank chain. 1) Elliptical trammel. 2) Scotch yoke mechanism. 3) Oldham‟s Coupling.

**Elliptical Trammel:**

This is an instrument for drawing ellipses. Here the slotted link is fixed. The sliding block P and Q in vertical and horizontal slots respectively. The end R generates an ellipse with the displacement of sliders P and Q.



The co-ordinates of the point R are x and y. From the

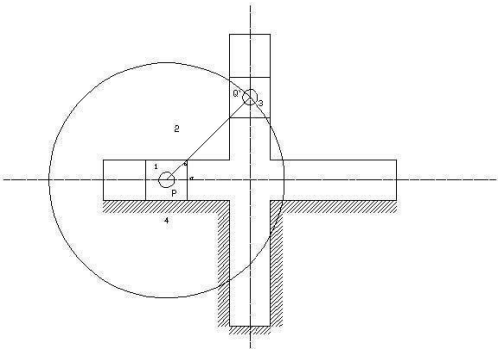
fig. cos θ = x.PR and Sin θ = y. QR

Squaring and adding (i) and (ii) we get

$x\ y^2 = \cos^2 \theta + \sin^2 \theta$

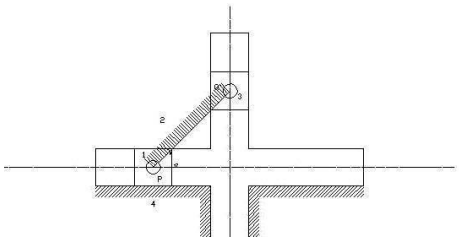
The equation is that of an ellipse, Hence the instrument traces an ellipse. Path traced by mid-point of It is an equation of circle with PR = QR = radius of a circle.

**Scotch yoke mechanism:** This mechanism, the slider P is fixed. When PQ rotates above




P, the slider Q reciprocates in the vertical slot. The mechanism is used to convert rotary to reciprocating mechanism.

**Oldham's coupling:** The third inversion of obtained by fixing the link connecting the 2 blocks P & Q. If one block is turning through an angle, the frame and the other block will also turn through the same angle. It is shown in the figure below.



- An application of the third inversion of the double slider crank mechanism is Oldham‟s coupling shown in the figure. This coupling is used for connecting two parallel shafts when the distance between the shafts is small.
- The two shafts to be connected have flanges at their ends, secured by forging. Slots are cut in the flanges. These flanges form 1 and 3.
- An intermediate disc having tongues at right angles and opposite sides is fitted in between the flanges. The intermediate piece forms the link 4 which slides or reciprocates in flanges 1 & 3.
- The link two is fixed as shown. When flange 1 turns, the intermediate disc 4 must turn through the same angle and whatever angle 4 turns, the flange 3 must turn through the same angle.
- Hence 1, 4 & 3 must have the same angular velocity at every instant. If the distance between the axis of the shaft is x, it will be the diameter if the circle traced by the centre of the intermediate piece. The maximum sliding speed of each tongue along its slot is given by
    - o v=xω where, ω = angular velocity of each shaft in rad/sec v = linear velocity in m/sec

**Mechanical Advantage**

The mechanical advantage (MA) is defined as the ratio of output torque to the input torque. (or) ratio of load to output.

**Transmission angle.**

The extreme values of the transmission angle occur when the crank lies along the line of frame.

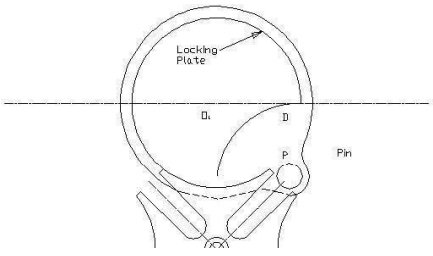
**Rocking Mechanisms: Intermittent motion mechanism:**

**Ratchet and Pawl mechanism:**

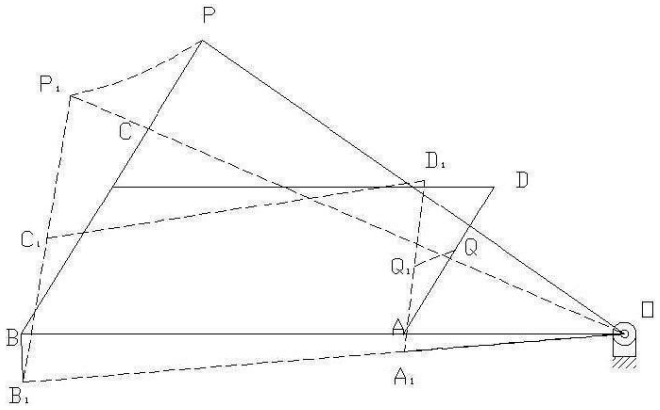
- This mechanism is used in producing intermittent rotary motion member. A ratchet and Pawl mechanism consist of a ratchet wheel 2 and a pawl 3 as shown in the figure.
- When the lever 4 carrying pawl is raised, the ratchet wheel rotates in the counter clock wise direction (driven by pawl). As the pawl lever is lowered the pawl slides over the ratchet teeth. One more pawl 5 is used to prevent the ratchet from reversing.
- Ratchets are used in feed mechanisms, lifting jacks, clocks, watches and counting devices.

**Geneva mechanism:** Geneva mechanism is an intermittent motion mechanism. It consists of a driving wheel D carrying a pin P which engages in a slot of follower F as shown in figure.

- During one quarter revolution of the driving plate, the Pin and follower remain in contact and hence the follower is turned by one quarter of a turn.
- During the remaining time of one revolution of the driver, the follower remains in rest locked in position by the circular arc.

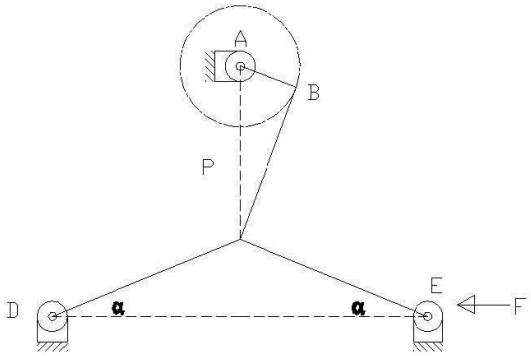


**Pantograph:** Pantograph is used to copy the curves in reduced or enlarged scales. Hence this mechanism finds its use in copying devices such as engraving or profiling machines.




- This is a simple figure of a Pantograph. The links are pin jointed at A, B, C and D. AB is parallel to DC and AD is parallel to BC. Link BA is extended to fixed pin O. Q is a point on the link AD.
- If the motion of Q is to be enlarged then the link BC is extended to P such that O, Q and P are in a straight line. Then it can be shown that the points P and Q always move parallel and similar to each other over any path straight or curved.
- Their motions will be proportional to their distance from the fixed point. Let ABCD be the initial position. Suppose if point Q moves to Q1, then all the links and the joints will move to the new positions (such as A moves to A1, B moves to Q1, C moves to Q1, D moves to D1 and P to P1) and the new configuration of the mechanism is shown by dotted lines. The movement of Q (Q Q1) will be enlarged

to PP1 in a definite ratio.




**Toggle Mechanism:**

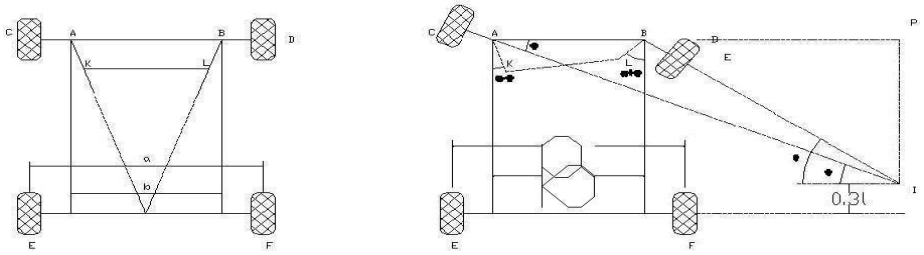
- In slider crank mechanism as the crank approaches one of its dead centre position, the slider approaches zero. The ratio of the crank movement to the slider movement approaching infinity is proportional to the mechanical advantage. This is the principle used in toggle mechanism.
- A toggle mechanism is used when large forces act through a short distance is required. The figure below shows a toggle mechanism. Links CD and CE are of same length. Resolving the forces at C vertically **F Sin α =P Cos α 2**
- Therefore, F = P . (because Sin α/Cos α = Tan α) 2 tan α Thus for the given value of P, as the links CD and CE approaches collinear position (αO), the force F rises rapidly.

**Hooke's joint:**

- Hooke‟s joint used to connect two parallel intersecting shafts as shown in figure. This can also be used for shaft with angular misalignment where flexible coupling does not serve the purpose.

- Hence Hooke‟s joint is a means of connecting two rotating shafts whose axes lie in the same plane and their directions making a small angle with each other.
- It is commonly known as Universal joint. In Europe it is called as Cardan joint.

**Ackermann steering gear mechanism:**




- This mechanism is made of only turning pairs and is made of only turning pairs wear and tear of the parts is less and cheaper in manufacturing.
- The cross-link KL connects two short axles AC and BD of the front wheels through the short links AK and BL which forms bell crank levers CAK and DBL respectively as shown in fig, the longer links AB and KL are parallel and the shorter links AK and BL are inclined at an angle α.
- When the vehicles steer to the right as shown in the figure, the short link BL is turned so as to increase α, whereas the link LK causes the other short link AK to turn so as to reduce α. The fundamental equation for correct steering is,

$$\mathbf{Cot\Phi - Cos\theta = \frac{b}{l}}$$

- In the above arrangement it is clear that the angle Φ through which AK turns is less than the angle θ through which the BL turns and therefore the left front axle turns through a smaller angle than the right front axle. For different angle of turn θ, the

corresponding value of Φ and (Cot Φ – Cos θ) are noted.

- This is done by actually drawing the mechanism to a scale or by calculations. Therefore, for different value of the corresponding value of and are tabulated.

**Three correct steering positions will be:**

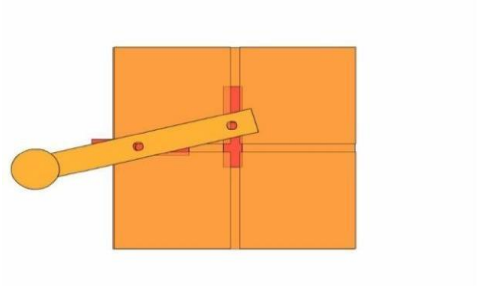
1) When moving straight.

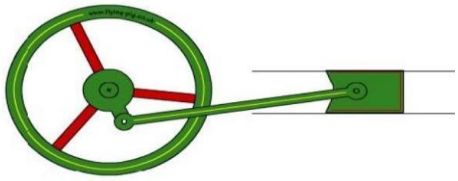
2) When moving one correct angle to the right corresponding to the link ratio AK/AB and angle α.

**3)** Similar position when moving to the left.

**In all other positions pure rolling is not obtainable.**

**ELLIPTICAL TRAMMEL PISTON ARRANGEMENT**





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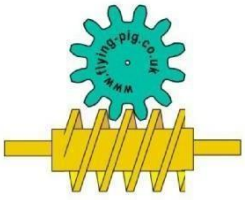
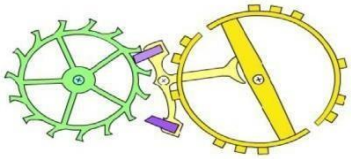
**ELLIPTICAL TRAMMEL:** This fascinating mechanism converts rotary motion to reciprocating motion in two axis. Notice that the handle traces out an ellipse rather than a circle. A similar mechanism is used in ellipse drawing tools



**PISTON ARRANGEMENT:** This mechanism is used to convert between rotary motion and reciprocating motion, it works either way. Notice how the speed of the piston changes. The piston starts from one end, and increases its speed. It reaches maximum speed in the

middle of its travel then gradually slows down until it reaches the end of its travel.RACK AND PINION RATCHET

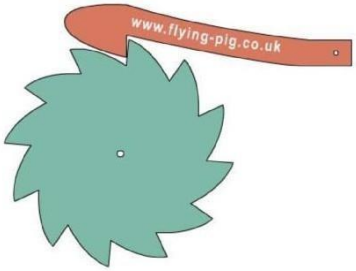
**RACK AND PINION:** The rack and pinion is used to convert between rotary and linear motion. The rack is the flat, toothed part, the pinion is the gear.

- Rack and pinion can convert from rotary to linear of from linear to rotary. The diameter of the gear determines the speed that the rack moves as the pinion turns.
- Rack and pinions are commonly used in the steering system of cars to convert the rotary motion of the steering wheel to the side to side motion in the wheels. Rack and pinion gears give a positive motion especially compared to the friction drive of a wheel in tarmac.
- In the rack and pinion railway a central rack between the two rails engages with a pinion on the engine allowing the train to be pulled up very steep slopes.

**RATCHET:** The ratchet can be used to move a toothed wheel one tooth at a time. The part used to move the ratchet is known as the pawl.

- The ratchet can be used as a way of gearing down motion. By its nature motion created by a ratchet is intermittent. By using two pawls simultaneously this intermittent effect can be almost, but not quite, removed.
- Ratchets are also used to ensure that motion only occurs in only one direction, useful for winding gear which must not be allowed to drop. Ratchets are also used in the freewheel mechanism of a bicycle.

**WORM GEAR** **WATCH ESCAPEMENT**


## Straight line generators

The easiest way to generate a straight-line motion is by using a sliding pair but in precision machines sliding pairs are not preferred because of wear and tear. Hence in such cases different methods are used to generate straight line motion mechanisms:

**Exact straight-line motion mechanism.**

a. Peaucellier mechanism, b. Hart mechanism, c. Scott Russell mechanism

**Approximate straight-line motion mechanisms**

a. Watt mechanism, b. Grasshopper‟s mechanism, c. Robert‟s mechanism, d. Tchebicheff‟s mechanism

### a. Peaucillier mechanism:

The pin Q is constrained to move long the circumference of a circle by means of the link OQ. The link OQ and the fixed link are equal in length. The pins P and Q are on opposite corners of a four-bar chain which has all four links QC, CP, PB and BQ of equal length to the fixed pin A. i.e., link AB = link AC. The product AQ x AP

remain constant as the link OQ rotates may be proved as follows: Join BC to bisect PQ at F; then, from the right angled triangles AFB, BFP, we have AB=AF+FB and BP=BF+FP. Subtracting,

AB-BP= AF-FP=(AF–FP) (AF+FP) = AQ x AP .

Since AB and BP are links of a constant length, the product AQ x AP is constant. Therefore, the point P traces out a straight path normal to AR.

**b. Robert's mechanism:**

This is also a four bar chain. The link PQ and RS are of equal length and the tracing pint „O" is rigidly attached to the link QR on a line which bisects QR at right angles. The best position for O may be found by making use of the instantaneous centre of QR. The path of O is clearly approximately horizontal in the Robert"s mechanism.