UNIT -1

Mechanisms and Machines

Day-1

Introduction:

It is the branch of engineering which deals with the relative motion and forces be tween various machine elements. This subject is divided into two parts i.e. Kinematics of machines and dynamics of machines.

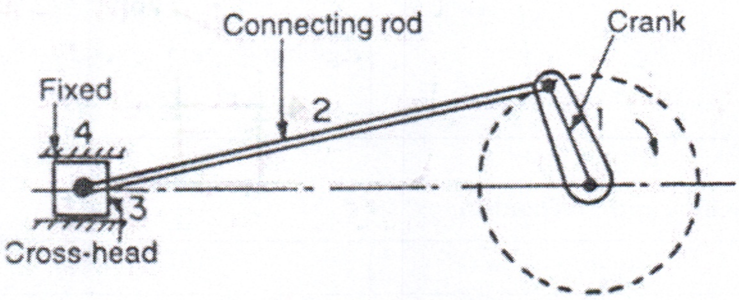
Kinematics of machines: It is the branch of theory of machines which deals with the study of relative motion of various machine elements without the consideration of forces.

Dynamics of Machines : It is the theory of machines which deals with the study of forces acting on various machine elements.

1) Define Link with an example?

Link or Element: Each part of machine which moves relative to some other part is known as kinematic link.

Eg: Piston, piston rod and crosshead, Connecting rod with small and big end bearing Crank, crank shaft and flywheel, Cylinder, engine frame and main bearings



Reciprocating Steam Engine

A link or elements need not to be rigid body, but it must be a resistant body. A body is said to be resistant body if it is capable of transmitting the required forces with negligible deformation.

The link should have the following two characteristics

(i) It should have relative motion .

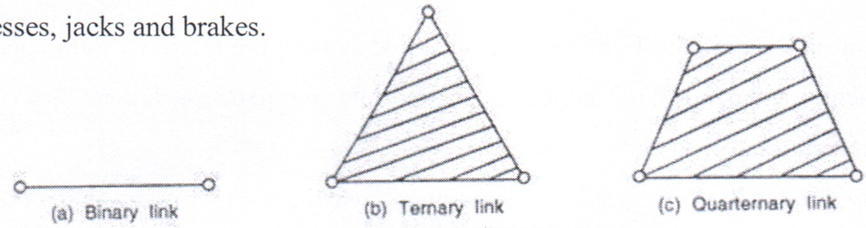
(ii) It must be resistant body.

2) Explain about different Types of links.

Rigid link: It does not undergo any deformation while transmitting motion. e.g. Crank, connecting rod and piston

Flexible link: It will partly deforms while transmitting forces. e.g. springs, belts ,ropes , etc.

Fluid link: motion is transmitted through the fluid by pressure or compression only. e.g: hydraulic presses, jacks and brakes.



Types of kinematic links.

3) Differentiate Machine and Structure:

Machine	*Structure*
1.There is a relative motion between its members .	1.There is no relative motion
2.It transforms energy into u seful work	2. It does not convert the available energy into work.
3. Tembers of it transmit motion and Forces	3.Members of it transmit forces only
e.g. car lathe etc	e.g. bridge, frame, building etc

4) Differentiate Machine and Mechanism:

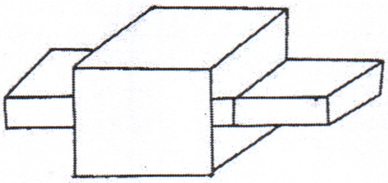
Machine	*Mechanism*
1. It is like a human body used for transmitting energy into useful work.	1. It is like skeleton and has definite motion between various links.
2. It is the practical development of the machine.	2. It is the modal of a machine
3. It is related to energy.	3. It is related to motion only.
4. It has many links.	4. It has also many links.
e.g: Lathe , Shaper etc.	e.g. Engine indicator , type writer etc .

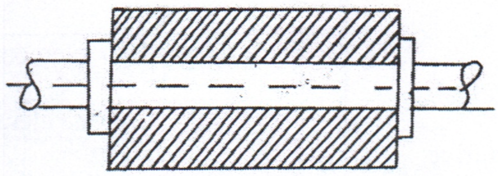
5) Explain different types of constraint Motions with proper diagrams?

Constraint means the limitation on motion or action. Constrained motion is of three types.

1. Completely constrained motion:

The motion is in a definite direction. e.g. Square bar moving in a square hole Shaft with collars at its ends moving round hole.

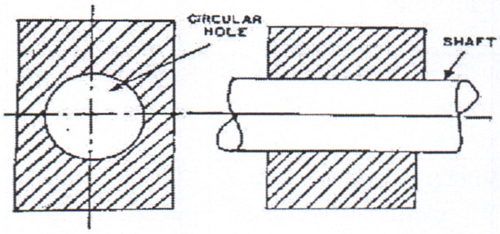




2. Incompletely constrained motion:

This type of motion takes place in more than in one direction

e.g. Circular bar moving in a circular hole may have two types of motions i.e.. Rotary and reciprocating **FIG: A**



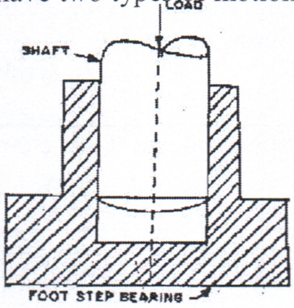


FIG: A **FIG: B**

3. Successfully constrained motion:

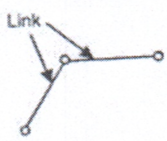
This motion is not competed by itself but by some other means.

e.g.. Motion of piston inside the cylinder is not completed by itself but due to rotation of crank.

Engine valves are not having their own motion but they are operated by rocker arms. Rotation of vertical shaft in footstep bearing. **FIG : B**

6) What is meant by a kinematic pair and how are they classified?

Kinematic Pair: Two links or elements of machine, when in contact with each other, are said to form a pair. The motion between the links is completely or successfully constrained.



(a) Kinematic pair

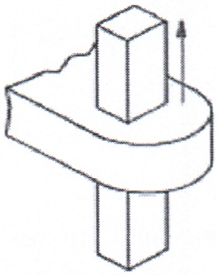
Classification of Kinematic Pairs: Kinematic Pairs can be classified on the basis of

(a)Type of relative motion

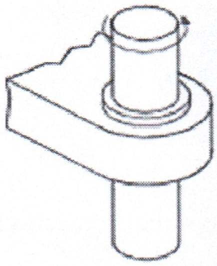
(b)Type of contact

(c)Type of constraint

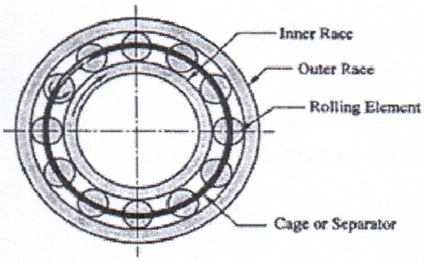
	Name of Pair	***Definition***	***Examples***
Type of Relative Motion	Sliding pair	Two elements have a slidingmotion relative to each other	Piston and Cylinder, Rectangular rod in rectangular hole
	Turning pair	Two elements are connected such that one element can turn around the Other	Shaft rotating in bearing, rotation of crank
	Rolling pair	One element is free to roll on the Other	Motion of a rolling wheel on flat surface.
	Screw pair	One element turns about the other by means of threads only	Bolt and nut, screw jack
	Spherical pair	One element is in the form of a sphere and turns about the fixed element.	Ball and socket joint
Type of Contact	Lower pair	Pair in motion has a surface contact Between its elements. contact surfaces of the two elements are alike	Shaft rotating in bearing, piston reciprocating ina cylinder
	Higher pair	There is a line or point contact between the elements of a pair	Cam and follower Ball and roller bearings
Type of Constraint	Closed pair	Elements of the pair are held together mechanically.	All lower pair
	Unclosed pair	The two elements are not held together mechanically. Two elements are connected together by gravity or spring force.	Cam and follower



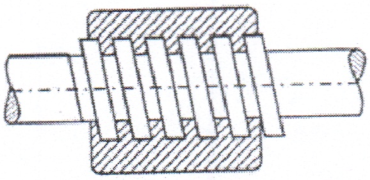
Prismatic (Sliding) Pair...1-DOF



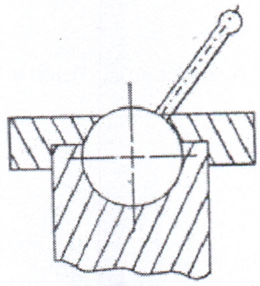
Turning Pair...1-DOF



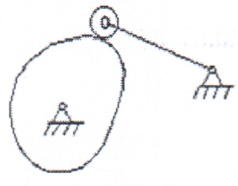
Rolling Pair



(e) Screw pair



Spherical pair



Cam Follower

<u>Previous Questions</u>

1) Define the terms Machine and Mechanism. How do they differ? (2013-April Set-1)

2) Differentiate between Mechanism and Kinematic chain (2013-April Set-3)

3) Sketch and explain how the kinematic pairs are classified based on type closure. (2013-April Set-3)

4) Sketch and explain different constrained motions. (2013-April Set-4)

Day 2:

What is meant by a kinematic chain?

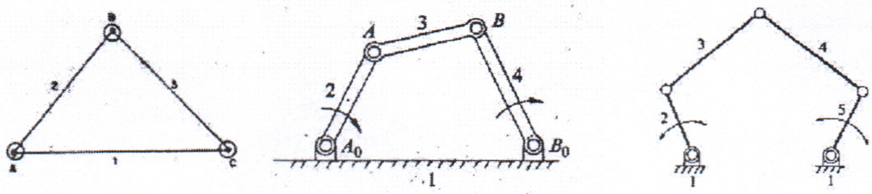
<u>Kinematic Chain:</u> When the kinematic pairs are coupled in such a way that the last link is joined to the first link to transmit definite motion, it is called kinematic chain. Two equations for lower pairs are available to determine whether the assemblage of links and pairs forms kinematic chain or not. The equations are given as

If L= no of links $L=2P-4$

P= no of pairs

J= no of joints $J=(3/2)L-2$

If	LHS > RHS	Locked chain
	LHS = RHS	Kinematic chain
	LHS < RHS	unconstrained chain



What are different types of joints?

1. Binary joint: When **TWO** links are joined at the same connection, the joint is known a s binary joint.

2. Ternary joint: When **THREE** links are joined at the same connection, the joint is known as binary joint.

3. Quaternary joint: When **FOUR** links are joined at the same connection, the joint is known as binary joint.

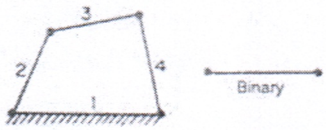


FIG: A

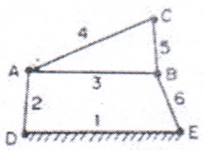


FIG: B

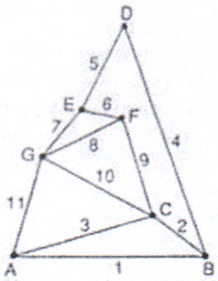
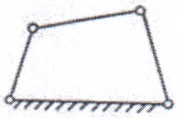


FIG: C

Define Mechanism and how do you determine degrees of freedom or movability of a mechanism?

When one of the links of a kinematic chain is fixed, the chain is known as mechanism. It may be used for transmitting or transforming motion .

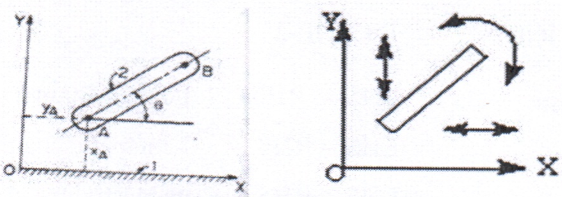
e.g. engine indicators, type writers etc.



(c) Mechanism

Degrees of freedom or Mobility of a mechanism is defined as the number of independent input parameters which are required to specify the relative position of all the links.

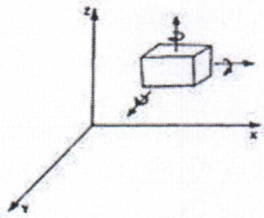
Plane Mechanism: A two dimensional planar link can be specified by three independent parameters namely co-ordinates of a point **(x,y)** on the link and its orientation angle. Therefore, one unconstrained planar link has three degree of freedom.



DOF-Plane Mechanism

Space Mechanism: Consider a rigid body as shown in **Fig.**, and then the body is described to have the follo wing independent motions.

1. Translation motion along x,y, and Z axes.
2. Rotational motion about x,y, and Z axes.



3-Rotary motions
3-Linear motions

Therefore the body is having six independent motions. Thus we can say that the body is having six degrees of freedom. The number of degrees of freedom for a body in space is given by

D.O.F=6 - number of constraints.

<u>Kutzbach Criterion for Plane Mechanisms:</u>

F=3(n-1)-2j-h

Where

F = Total degrees of freedom in the mechanism

n = Number of links (including the frame)

j = Number of lower pairs (one degree of freedom)

h = Number of higher pairs (two degrees of freedom)

This equation is called **Kutzbach Criterion** for the movability of mechanism having plane motion. If there are no two degree of freedom pairs, then **h=0**

F=3(n-1)-2j

<u>Grubler's Criterion for Plane Mechanism:</u> The Grubler's criterion applies to mechanism with only single degree of freedom joints where the overall movability of the mechanism is unity. Substituting F=1 and h=0 in Kutchbatch equation, we have

1=3(n-1)-2j

3n-2J-4=0

This equation is known as the Grubler's criterion for plane mechanisms with constrained motion.

Previous questions

1) How do you say the given chain is a kinematic chain? Explain with examples. (2013-April Set-1)

2) What is the significance of degrees of freedom of a kinematic chain when it functions as a mechanism? Give examples. (2013-April Set-1)

3) How the joints are classified? Explain with examples. (2013-April Set-2)

4) Which criterion is preferred to find the movability? Derive the condition. (2013-April Set-2)

5) Name the criterion which is applicable to plane mechanisms with single degree of freedom joints and derive the condition. (2013-April Set-3)

Day-3

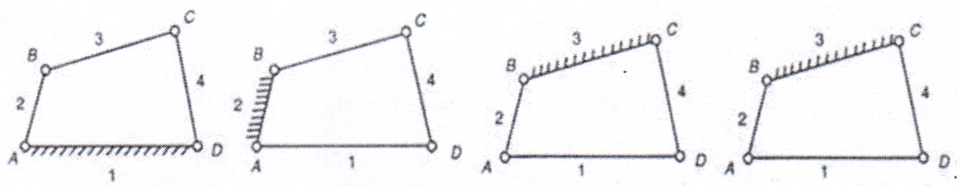
Inversions of mechanisms:

When one of the links is fixed in a Kinematic Chain, it is called mechanism. So we can obtain as many mechanisms as the number of links in a kinematic chain by fixing, in turn, different links in a kinematic chain. The method of obtaining different mechanisms by fixing different links in a kinematic chain is known as **Inversion of the Mechanism.**

The relative motion between the various links is not changed in any manner through the process of inversion, but the absolute motions may be changed drastically.

If Number of links in a mechanism = **n**

The number of inversions = **n**



Inversions of Four Bar mechanisms

Grashof's Law:

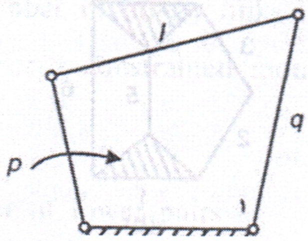
For a planar four bar linkage, the sum of the shortest and longest links cannot be greater than the sum of the remaining links if there is to be continuous relative rotation between two members.

If

s=length of shortest link

l = length of longest link

p, q=lengths of remaining links



Then

$l + s <= p + q$

Classification of Four Bar Mechanisms

Grashof's Law

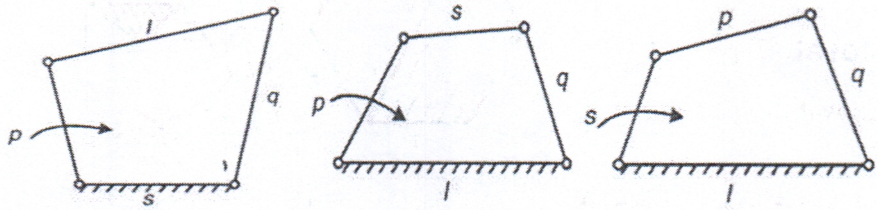
Type I : s+l<= p+q

Case	l+s versus p+q	Shortest Bar	Type
1	<	Frame	Double Crank
2	<	Slider	Crank Rocker
3	<	Coupler	Double Rocker
4	=	Any	Change point
5	>	Any	Double Rocker

Shortest bar is the frame - Double crank.

Shortest bar is the slider - Crank Rocker

Shortest bar is the coupler – Double Rocker



C-C R-R C-R

Type 2: s+l> p+q

All the four inversions are Double crank mechanisms.

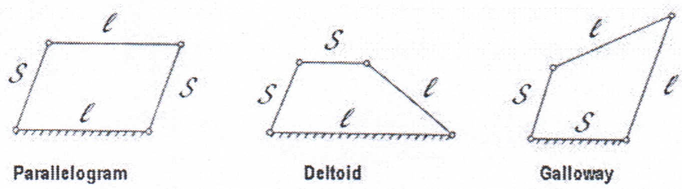
Type 3: s+l= p+q

l=p, s=q

Case1: Parallelogram Mechanism: Two equal lengths are not adjacent. All the four inversions of this mechanism are Double crank mechanisms .

Case2: Deltoid Mechanism: Two equal length links are placed adjacent and the longer link is fixed. All the inversions are Crank – Rocker mechanisms.

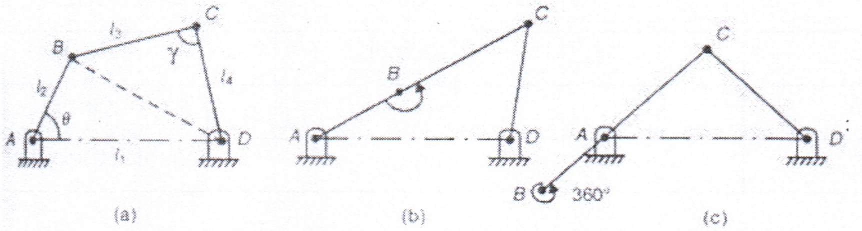
Case3: Galloway Mechanism : Two equal length links are placed adjacent and the shorter link is fixed. . All the inversions are Crank – Rocker mechanisms.



Limit positions, Dead Centre and Transmission Angle:

Limit Positions:

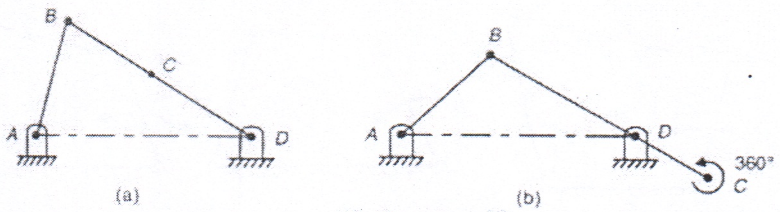
It is the position of the mechanism in which interior angle between coupler and crank is either 180^0 or 360^0 .



Limit positions of a four bar mechanism.

Dead Centre:

It is the position of the mechanism in which interior angle between cou pler and follower is either 180^0 or 360^0 .



Dead centre positions.

Transmission Angle:

An interior angle between the coupler and the follower links at any position other than the deadcentre. γ –is called transmission angle. It is an important from the point view of transmission efficiency. For a high speed mechanism, the value transmission angle less than 20 is not acceptable.

Day-4

Types of Kinematic chains and their inversions:

Kinematic chains have four lower pairs, each pair being either sliding pair or turning pair. There are three important kinematic chains.

1. Four bar chain- All four turning pairs.
2. Slider crank chain - One sliding and one turning pair.
3. Double slider crank chain - Two sliding and two turning pairs.

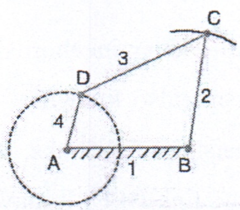
Q) Explain about Four Bar Chain or Quadric Cycle Chain

We know that the kinematic chain is a combination of four or more kinematic pairs, such that the relative motion between the links or elements is completely constrained.

The simplest and the basic kinematic chain is a four bar chain or quadric cycle chain, as shown in Fig. It consists of four links, each of them forms a turning pair at A, B, C and D. The four links may be of different lengths. According to Grashof 's law for a four bar mechanism, the sum of the shortest and longest link lengths should not be greater than the sum of the remaining two link lengths if there is to be continuous relative motion between the two links.

In a four bar chain, one of the links, in particular the shortest link, will make a complete revolution relative to the other three links, if it satisfies the Grashof 's law. Such a link is known as crank or driver. In Fig., AD (link 4) is a crank. The BC (link 2) which makes a partial rotation or oscillates is known as lever or rocker or follower and the CD (link 3) which connects the crank and lever is called connecting rod or coupler. The fixed link AB (link 1) is known as frame of the mechanism.

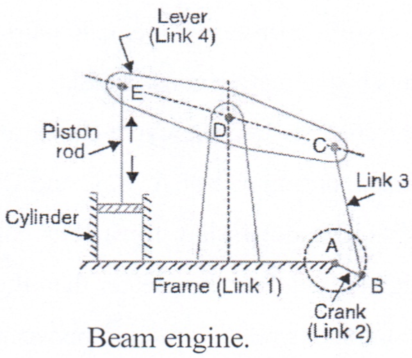
When the crank (link 4) is the driver, the mechanism is transforming rotary motion into oscillating motion.



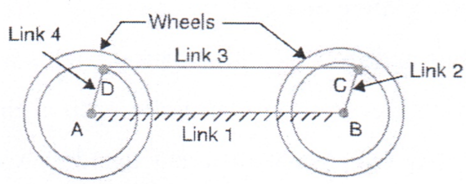
Q) Explain various Inversions of Four Bar Chain

Beam engine or crank and lever mechanism:

A part of the mechanism of a beam engine (also known as crank and lever mechanism) which consists of four links, is shown in Fig. In this mechanism, when the crank rotates about the fixed centre A , the lever oscillates about a fixed centre D. The end E of the lever CDE is connected to a piston rod which reciprocates due to the rotation of the crank. In other words, the purpose of this mechanism is to convert rotary motion into reciprocating motion.



Beam engine.



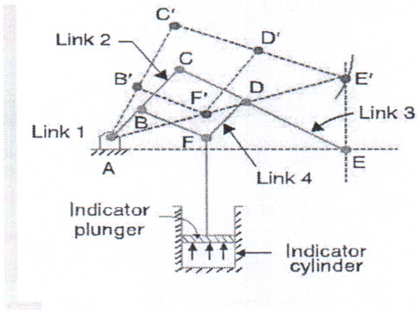
Coupling rod of a locomotive.

Coupling rod of a locomotive or Double crank mechanism:

The mechanism of a coupling rod of a locomotive (also known as double crank mechanism) which consists of four links, is shown in Fig above. In this mechanism, the links AD and BC (having equal length) act as cranks and are connected to the respective wheels. The link CD acts as a coupling rod and the link AB is fixed in order to maintain a constant centre to centre distance between them. This mechanism is meant for transmitting rotary motion from one wheel to the other wheel.

Watt's indicator mechanism (Double lever mechanism):

A Watt's indicator mechanism (also known as Watt's straight line mechanism or double lever mechanism) which consists of four links, is shown in Fig. The four links are : fixed link at A , link A C, link CE and link BFD. It may be noted that BF and FD form one link because these two parts have no relative motion between them. The links CE and BFD act as levers. The displacement of the link BFD is directly proportional to the pressure of gas or steam which acts on the indicator plunger. On any small displacement of the mechanism, the tracing point E at the end of the link CE traces out approximately a straight line. The initial position of the mechanism is shown in Fig. by full lines whereas the dotted lines show the position of the mechanism when the gas or steam pressure acts on the indicator plunger.



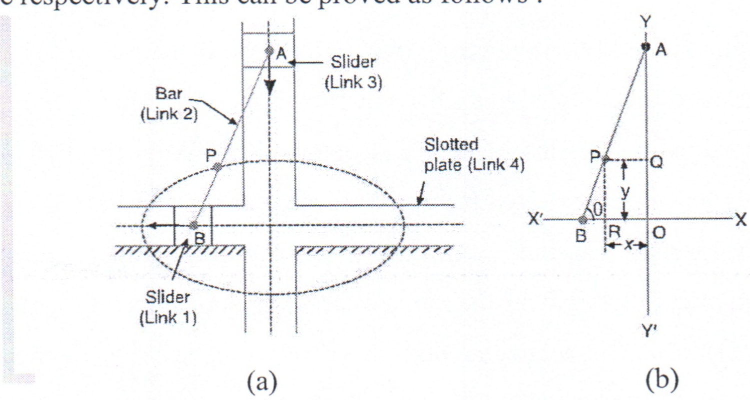
Watt's indicator mechanism.

Explain various Inversions of Double Slider Crank Chain:

Elliptical trammels.

It is an instrument used for drawing ellipses. This inversion is obtained by fixing the slotted plate (link 4), as shown in Fig. The fixed plate or link 4 has two straight grooves cut in it, at right angles to each other. The link 1 and link 3, are known as sliders and form sliding pairs with link 4. The link AB (link 2) is a bar which forms turning pair with links 1 and 3.

When the links 1 and 3 slide along their respective grooves, any point on the link 2 such as P traces out an ellipse on the surface of link 4, as shown in Fig. (a). A little consideration will show that AP and BP are the semi-major axis and semi-minor axis of the ellipse respectively. This can be proved as follows :



(a) (b)

Let us take O X and O Y as horizontal and vertical axes and let the link B A is inclined at an angle θ with the horizontal, as shown in Fig. (b). Now the co-ordinates of the point P on the link B A will be

$$x = PQ = AP \cos\theta \text{ ; and } y = PR = BP \sin\theta$$

Squaring on both sides and adding the equations.

$$(x/AP)^2 + (y/BP)^2 = \cos^2\theta + \sin^2\theta = 1$$

$$(x/AP)^2 + (y/BP)^2 = 1$$

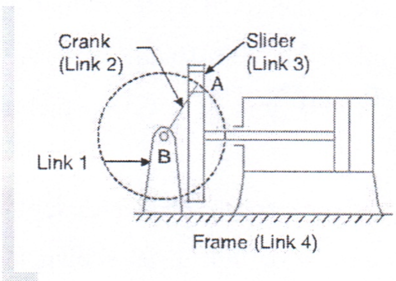
This is the equation of an ellipse. Hence the path traced by point P is an ellipse whose semi-major axis is AP and semi-minor axis is BP.

Note : If P is the mid-point of link BA, then AP = BP.

Then it becomes an equation of a circle with radius as AP. Hence if P is the mid-point of link BA, it will trace a circle.

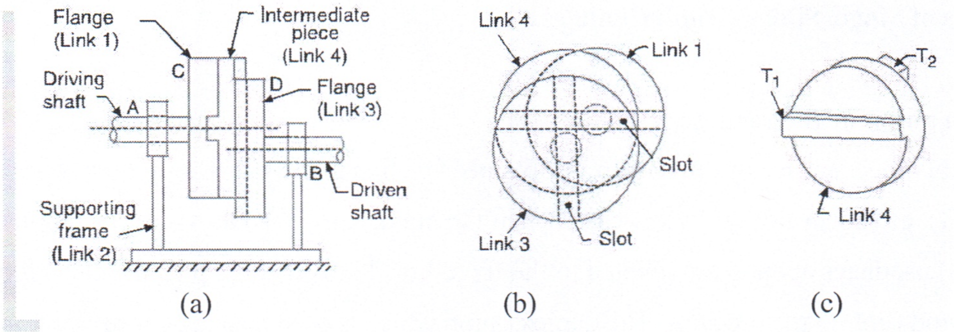
Scotch yoke mechanism:

This mechanism is used for converting rotary motion into a reciprocating motion. The inversion is obtained by fixing either the link 1 or link 3. In Fig., link 1 is fixed. In this mechanism, when the link 2 (which corresponds to crank) rotates about B as centre, the link 4 (which corresponds to a frame) reciprocates. The fixed link 1 guides the frame.



Oldham's coupling.

An oldham's coupling is used for connecting two parallel shafts whose axes are at a small distance apart. The shafts are coupled in such a way that if one shaft rotates, the other shaft also rotates at the same speed. This inversion is obtained by fixing the link 2, as shown in Fig. (a). The shafts to be connected have two flanges (link 1 and link 3) rigidly fastened at their ends by forging. The link 1 and link 3 form turning pairs with link 2. These flanges have diametrical slots cut in their inner faces, as shown in Fig. (b). The intermediate piece (link 4) which is a circular disc, have two tongues (i.e. diametrical projections) T_1 and T_2 on each face at right angles to each other, as shown in Fig. (c). The tongues on the link 4 closely fit into the slots in the two flanges (link 1 and link 3). The link 4 can slide or reciprocate in the slots in the flanges.



Previous questions:

1) Sketch and explain the mechanism, which is used to connect two parallel non collinear shafts. (2013-April-Set-2)

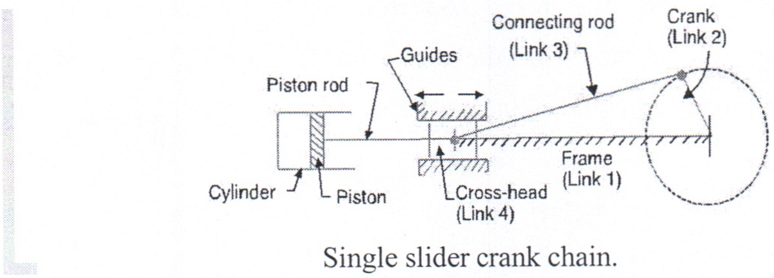
2) Sketch and explain the applications of double lever mechanism. (2013-April-Set-4)

Day-5:

Q) Explain Single Slider Crank Chain with inversions:

A single slider crank chain is a modification of the basic four bar chain. It consist of one sliding pair and three turning pairs. It is, usually, found in reciprocating steam engine mechanism. This type of mechanism converts rotary motion into reciprocating motion and vice versa.

In a single slider crank chain, as shown in Fig. the links 1 and 2, links 2 and 3, and links 3 and 4 form three turning pairs while the links 4 and 1 form a sliding pair.



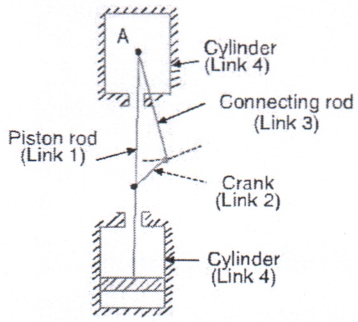
Single slider crank chain.

The link 1 corresponds to the frame of the engine, which is fixed. The link 2 corresponds to the crank ; link 3 corresponds to the connecting rod and link 4 corresponds to cross-head. As the crank rotates, the cross-head reciprocates in the guides and thus the piston reciprocates in the cylinder.

Inversions of Single Slider Crank Chain are

Pendulum pump or Bull engine.

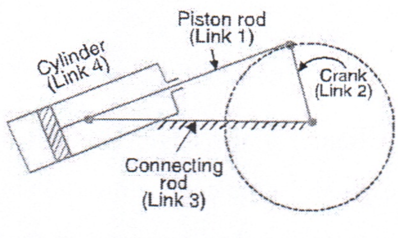
In this mechanism, the inversion is obtained by fixing the cylinder or link 4 (i.e. sliding pair), as shown in Fig. In this case, when the crank (link 2) rotates, the connecting rod (link 3) oscillates about a pin pivoted to the fixed link 4 at A and the piston attached to the piston rod (link 1) reciprocates. The duplex pump which is used to supply feed water to boilers have two pistons attached to link 1, as shown in Fig.



Pendulum pump.

Oscillating cylinder engine:

The arrangement of oscillating cylinder engine mechanism, as shown in Fig. is used to convert reciprocating motion into rotary motion. In this mechanism, the link 3 forming the turning pair is fixed. The link 3 corresponds to the connecting rod of a reciprocating steam engine mechanism. When the crank (link 2) rotates, the piston attached to piston rod (link 1) reciprocates and the cylinder (link 4) oscillates about a pin pivoted to the fixed link at A.



Oscillating cylinder engine.

Crank and slotted lever quick return motion mechanism:

This mechanism is mostly used in shaping machines, slotting machines and in rotary internal combustion engines. In this mechanism, the link *AC* (*i.e.* link 3) forming the turning pair is fixed, as shown in Fig. The link 3 corresponds to the connecting rod of a reciprocating steam engine. The driving crank *CB* revolves with uniform angular speed about the fixed centre *C*. A sliding block attached to the crank pin at *B* slides along the slotted bar *AP* and thus causes *AP* to oscillate about the pivoted point *A*. A short link *PR* transmits the motion from *AP* to the ram which carries the tool and reciprocates along the line of stroke *R*1*R*2. The line of stroke of the ram (*i.e.* *R*1*R*2) is perpendicular to *AC* produced. In the extreme positions, *AP*1 and *AP*2 are tangential to the circle and the cutting tool is at the end of the stroke. The forward or cutting stroke occurs when the crank rotates from the position *CB*1 to *CB*2 (or through an angle β) in the clockwise direction. The return stroke occurs when the crank rotates from the position *CB*2 to *CB*1 (or through angle α) in the clockwise direction. Since the crank has uniform angular speed, therefore,

$$\frac{\text{Time of cutting stroke}}{\text{Time of return stroke}} = \frac{\beta}{\alpha} = \frac{\beta}{360^\circ - \beta} \quad \text{or} \quad \frac{360^\circ - \alpha}{\alpha}$$

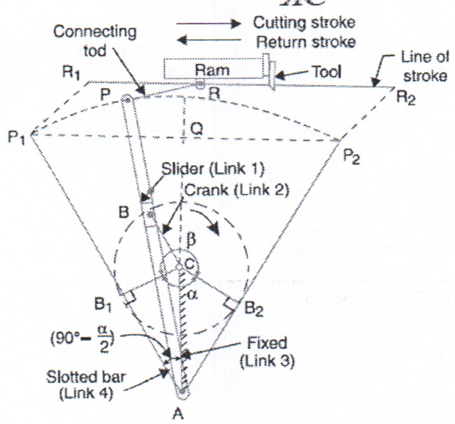
Since the tool travels a distance of $R_1 R_2$ during cutting and return stroke, therefore travel of the tool or length of stroke

$$= R_1R_2 = P_1P_2 = 2P_1Q = 2AP_1 \sin \angle P_1AQ$$

$$= 2AP_1 \sin\left(90^\circ - \frac{\alpha}{2}\right) = 2AP \cos\frac{\alpha}{2}$$

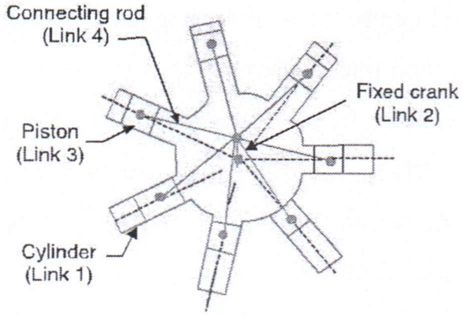
$$= 2AP \times \frac{CB_1}{AC}$$

$$= 2AP \times \frac{CB}{AC}$$



Rotary internal combustion engine or Gnome engine:

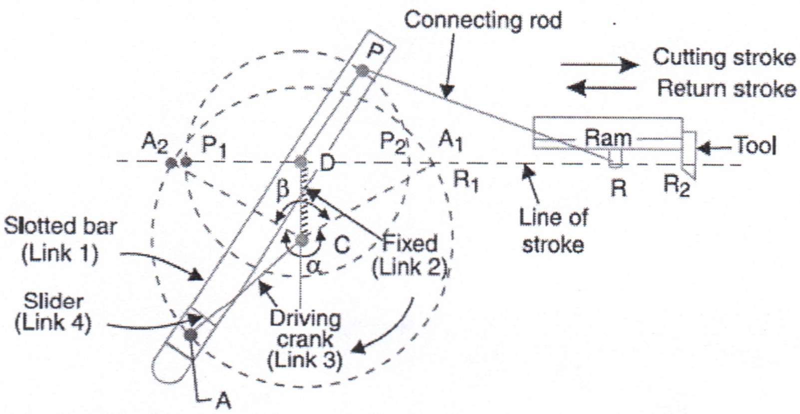
Sometimes back, rotary internal combustion engines were used in aviation. But now-a-days gas turbines are used in its place. It consists of seven cylinders in one plane and all revolves about fixed centre D, as shown in Fig., while the crank (link 2) is fixed. In this mechanism, when the connecting rod (link 4) rotates, the piston (link 3) reciprocates inside the cylinders forming link 1.



Rotary internal combustion engine.

Whitworth quick return motion mechanism:

This mechanism is mostly used in shaping and slotting machines. In this mechanism, the link CD (link 2) forming the turning pair is fixed, as shown in Fig. The link 2 corresponds to a crank in a reciprocating steam engine. The driving crank CA (link 3) rotates at a uniform angular speed. The slider (link 4) attached to the crank pin at A slides along the slotted bar PA (link 1) which oscillates at a pivoted point D. The connecting rod PR carries the ram at R to which a cutting tool is fixed. The motion of the tool is constrained along the line RD produced, i.e. along a line passing through D and perpendicular to CD.

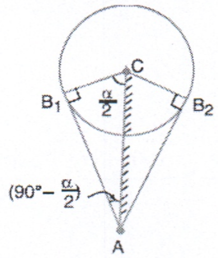


$$\frac{\text{Time of cutting stroke}}{\text{Time of return stroke}} = \frac{\alpha}{\beta} = \frac{\alpha}{360^\circ - \alpha} \quad \text{or} \quad \frac{360^\circ - \beta}{\beta}$$

Day-6

1) A crank and slotted lever mechanism used in a shaper has a centre distance of 300 mm between the centre of oscillation of the slotted lever and the centre of rotation of the crank. The radius of the crank is 120 mm. Find the ratio of the time of cutting to the time of return stroke.

Given : A C = 300 mm ; CB_1 = 120 mm The extreme positions of the crank are shown



$$\sin \angle CAB_1 = \sin(90° - \alpha/2)$$

$$= \frac{CB_1}{AC} = \frac{120}{300} = 0.4$$

$$\therefore \quad \angle CAB_1 = 90° - \alpha/2$$

$$= \sin^{-1} 0.4 = 23.6°$$

or $\quad \alpha/2 = 90° - 23.6° = 66.4°$

and $\quad \alpha = 2 \times 66.4 = 132.8°$

We know that

$$\frac{\text{Time of cutting stroke}}{\text{Time of return stroke}} = \frac{360° - \alpha}{\alpha} = \frac{360° - 132.8°}{132.8°} = 1.72$$

2) In a crank and slotted lever quick return motion mechanism, the distance between the fixed centres is 240 mm and the length of the driving crank is 120 mm. Find the inclination of the slotted bar with the vertical in the extreme position and the time ratio of cutting stroke to the return stroke. If the length of the slotted bar is 450 mm, find the length of the stroke if the line of stroke passes through the extreme positions of the free end of the lever.

Given : AC = 240 mm ; CB_1 = 120 mm ; AP_1 = 450 mm

Inclination of the slotted bar with the vertical

$$\sin \angle CAB_1 = \sin\left(90^\circ - \frac{\alpha}{2}\right)$$

$$= \frac{B_1C}{AC} = \frac{120}{240}$$

$$\therefore \angle CAB_1 = 90^\circ - \frac{\alpha}{2}$$

$$= \sin^{-1} 0.5 = 30^\circ$$

We know that

$$90^\circ - \alpha/2 = 30^\circ$$

$$\therefore \quad \alpha/2 = 90^\circ - 30^\circ = 60^\circ$$

or

$$\alpha = 2 \times 60^\circ = 120^\circ$$

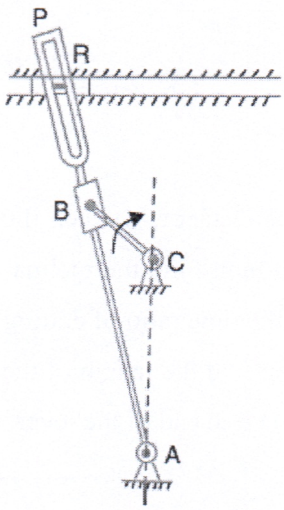
$$\therefore \quad \frac{\text{Time of cutting stroke}}{\text{Time of return stroke}} = \frac{360^\circ - \alpha}{\alpha} = \frac{360^\circ - 120^\circ}{120^\circ} = 2$$

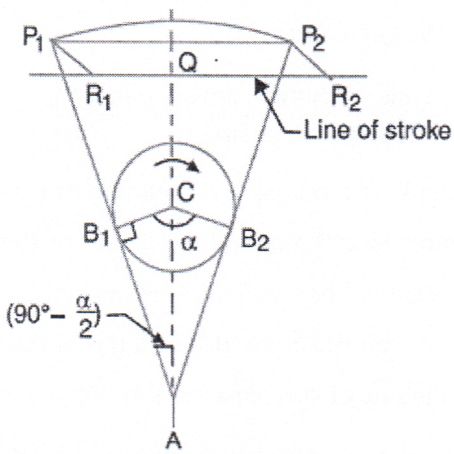
We know that length of the stroke,

$$R_1R_2 = P_1P_2 = 2P_1Q = 2AP_1 \sin(90^\circ - \alpha/2)$$

$$= 2 \times 450 \sin(90^\circ - 60^\circ) = 900 \times 0.5 = 450 \text{ mm}$$

3) Fig shows the layout of a quick return mechanism of the oscillating link type, for a special purpose machine. The driving crank BC is 30 mm long and time ratio of the working stroke to the return stroke is to be 1.7. If the length of the working stroke of R is 120 mm, determine the dimensions of AC and AP.





We know that

$$\frac{\text{Time of working stroke}}{\text{Time of return stroke}} = \frac{360 - \alpha}{\alpha} \quad \text{or} \quad 1.7 = \frac{360 - \alpha}{\alpha}$$

$$\therefore \qquad \alpha = 133.3° \quad \text{or} \quad \alpha/2 = 66.65°$$

The extreme positions of the crank are shown in Fig. 5.31. From right angled triangle $A B_1 C$, we find that

$$\sin(90° - \alpha/2) = \frac{B_1C}{AC} \quad \text{or} \quad AC = \frac{B_1C}{\sin(90° - \alpha/2)} = \frac{BC}{\cos \alpha/2}$$

... ($\because B_1C = BC$)

$$\therefore \qquad AC = \frac{30}{\cos 66.65°} = \frac{30}{0.3963} = 75.7 \text{ mm}$$

We know that length of stroke,

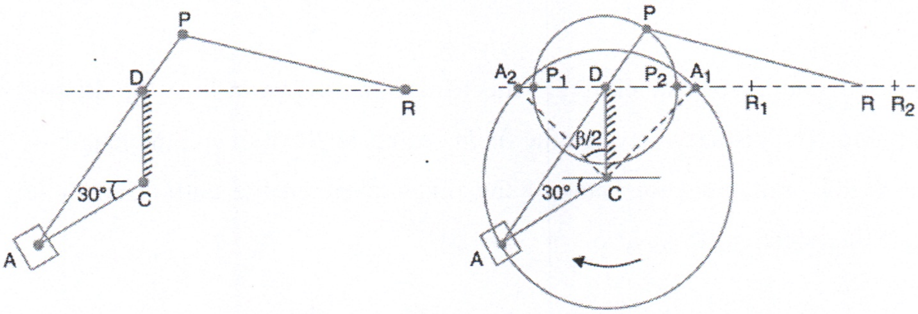
$$R_1R_2 = P_1P_2 = 2P_1Q = 2\,AP_1 \sin(90° - \alpha/2) = 2\,AP_1 \cos \alpha/2$$

$$120 = 2\,AP \cos 66.65° = 0.7926\,AP$$

... ($\because AP_1 = AP$)

$$AP = 120/0.7926 = 151.4 \text{ mm}$$

4) In a Whitworth quick return motion mechanism, as shown in Fig. 5.32, the distance between the fixed centers is 50 mm and the length of the driving crank is 75 mm. The length of the slotted lever is 150 mm and the length of the connecting rod is 135 mm. Find the ratio of the time of cutting stroke to the time of return stroke and also the effective stroke.



The extreme positions of the driving crank are shown in Fig. From the geometry of the figure,

$$\cos \beta/2 = \frac{CD}{CA_2} = \frac{50}{75} = 0.667$$

... ($\because CA_2 = CA$)

$$\therefore \qquad \beta/2 = 48.2° \quad \text{or} \quad \beta = 96.4°$$

$$\frac{\text{Time of cutting stroke}}{\text{Time of return stroke}} = \frac{360 - \beta}{\beta} = \frac{360 - 96.4}{96.4} = 2.735$$

Length of effective stroke

In order to find the length of effective stroke (i.e. R_1R_2), draw the space diagram of the mechanism to some suitable scale, as shown in Fig. Mark $P_1R_2 = P_2R_2 = PR$. Therefore by measurement we find that,

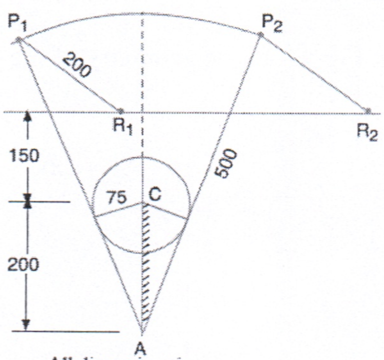
Length of effective stroke = R_1R_2 = 87.5 mm

Previous questions:

1) The whitworth quick return motion mechanism has the driving crank 150 mm long. The distance between fixed centres is 100 mm. The line of stroke of the ram passes through the centre of rotation of the slotted lever whose free end is connected to the ram by a connecting link. Find the ratio of time of cutting to time of return. (2013-April-Set-4)

Assignment Problems:

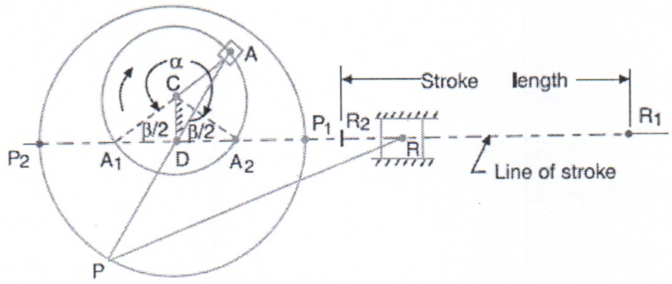
1. In a crank and slotted lever quick return mechanism, the distance between the fixed centres is 150 mm and the driving crank is 75 mm long. Determine the ratio of the time taken on the cutting and return strokes.
2. In a crank and slotted lever quick return motion mechanism, the distance between the fixed centres *O* and *C* is 200 mm. The driving crank *CP* is 75 mm long. The pin *Q* on the slotted lever, 360 mm from the fulcrum *O*, is connected by a link *QR* 100 mm long, to a pin *R* on the ram. The line of stroke of *R* is perpendicular to *OC* and intersects *OC* produced at a point 150 mm from *C*. Determine the ratio of times taken on the cutting and return strokes.
3. In a crank and slotted lever quick return mechanism, as shown in Fig., the driving crank length is 75 mm. The distance between the fixed centres is 200 mm and the length of the slotted lever is 500 mm. Find the ratio of the times taken on the cutting and idle strokes. Determine the effective stroke also.



All dimensions in mm

4. The Whitworth quick return motion mechanism has the driving crank 150 mm long. The distance between fixed centres is 100 mm. The line of stroke of the ram passes through the centre of rotation of the slotted lever whose free end is connected to the ram by a connecting link. Find the ratio of time of cutting to time of return.

5. A Whitworth quick return motion mechanism, as shown in Fig., has the following particulars :



Length of stroke = 150 mm ; Driving crank length = 40 mm; $\frac{\text{Time of cutting stroke}}{\text{Time of return stroke}} = 2$

Find the lengths of *CD* and *PD*. Also determine the angles α and β.