Theory questions and answers

Q.1.Define Statics, Dynamics, Kinetics and kinematics.

Ans:

Statics :- It is the branch of engineering which deals with study of forces and its effect on bodies at rest.

Dynamics :- It is the branch of engineering which deals with the study of forces and its effect on bodies in motion.

Kinetics :- It is the branch of dynamics which deals with study of forces and their effect on bodies in motion considering mass of the body.

Kinematics :- It is the branch of dynamics which deals with the study of forces and their effect on bodies in motion without considering mass.

Q.2.Define Kinematic link,Kin. pair, Kin. chain,Mechanism & inversion

a] Kinematic link (or element) :

It is defined as a **resistant body** which has **relative motion** with some other element. e.g. crank, Piston, cylinder, frame

b] Kinematic pair :

When two links are connected in such a manner that **relative motion** between them take place in a **definite way** then it is called kinematic pair.

c] Kinematic chain :

When **two or more kinematic pairs are joined together**, they form kinematic chain.

d] Mechanism :

If **one link** of a kinematic chain is **fixed** it is called mechanism.

e] Inversion :

When different links of a kinematic chain are fixed **we get different mechanisms**, these mechanisms are called inversions of that   kinematic chain. The number of inversions of a kinematic chain are equal to number of links in that chain.

Q.3. Classify kinematic link. Or What are the types of links.?

Ans. Types of links

1.Rigid link – e.g. connecting rod, lever.

2.Flexible link – e.g. chain , belt, rope etc.

3.Fluid link – e.g. oil in hydraulic system,air in pneumatic system

4.Types of links based on attachment.

Binary link	- *one with two nodes.*	a] Binary link - Having two connection
Ternary link	- *one with three nodes.*	b] Ternary link - Having three connections
Quaternary link	- *one with four nodes.*	c] Quaternary link - Having four connection

Nodes

Binary link   Ternary link   Quaternary link
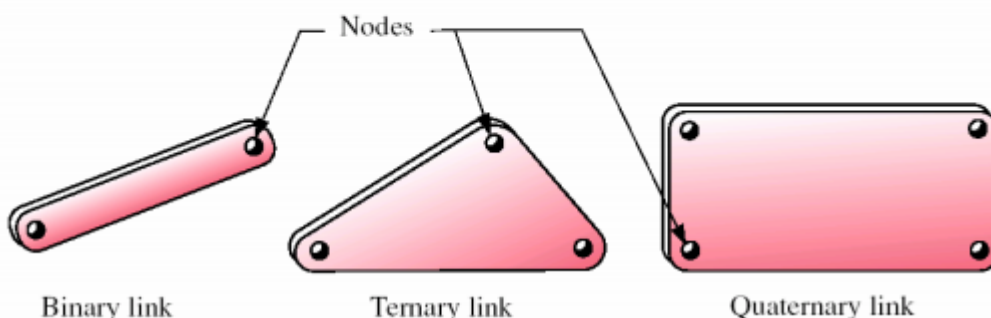
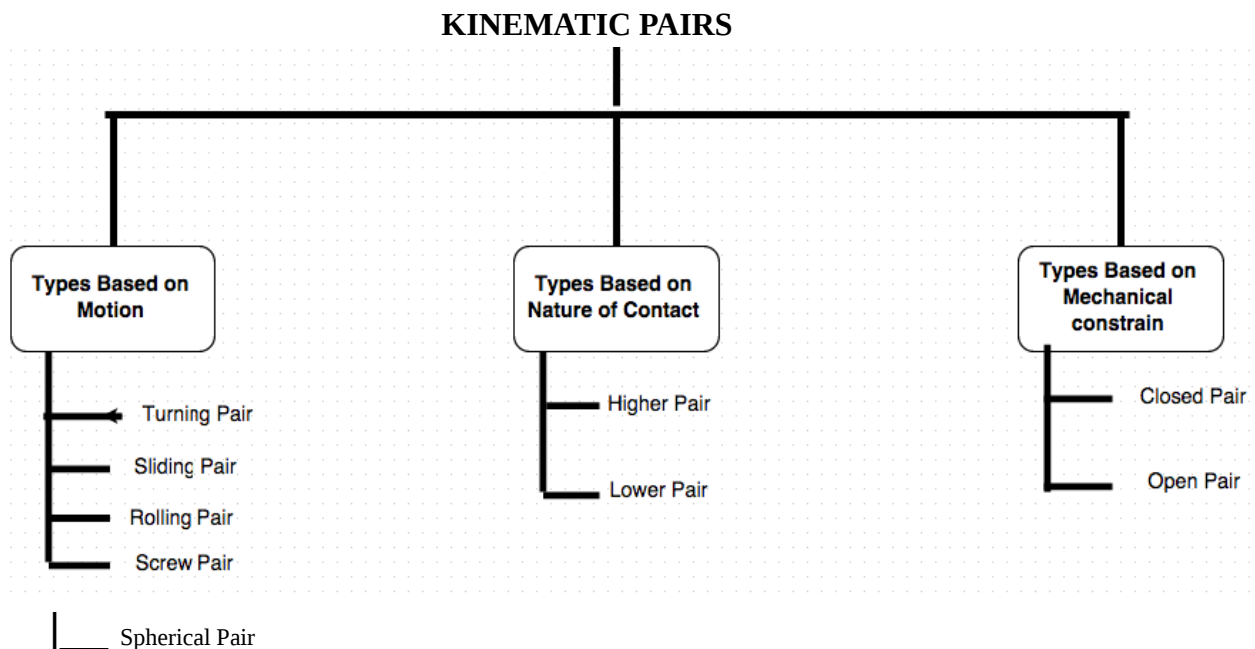## Q.4.Differentiate Between Structure and Machine

Structure	Machine
1. A structure is a skeleton build to bear the load, mainly compressive load.	A machine converts the available energy into some useful work.
2.No relative motion exists between its members.	2.Links are meant to transmit motion and forces which are dynamic.
3. Structure serves to modify and transmit forces only.	3. Machine serves to modify and transmit mechanical work.
4.Roof trusses,bridges,buildings,machine frames etc.	4. Shaping machine, lathe machine,screw jack etc

Q.5.Differentiate Between Machine and Mechanism

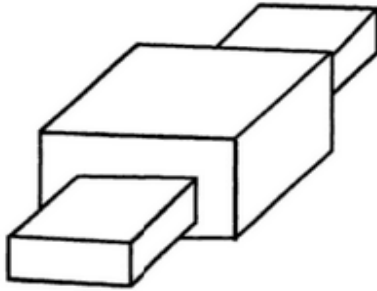| Mechanism	Machine
1. A mechanism is formed when a link of kinematic chain is fixed.	A machine converts the available energy into some useful work.
2.Primary function of mechanism is to transmit or modify motion.	2.Machines are meant for doing some useful work.
3. A mechanism consists of several links joined together.	3. A machine may contain several mechanism and other elements.
4.Oscillating cylinder mechanism, Scotch yoke mechanism.	4. Shaping machine, lathe machine,screw jack.etc

Q.6.State Different types of pairs and explain with sketch.

Ans :

KINEMATIC PAIRS

Types Based on Motion
- Turning Pair
- Sliding Pair
- Rolling Pair
- Screw Pair
- Spherical Pair

Types Based on Nature of Contact
- Higher Pair
- Lower Pair

Types Based on Mechanical constrain
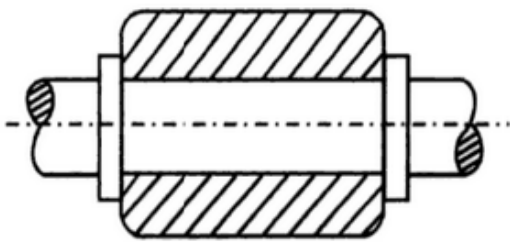- Closed Pair
- Open Pair

A) Kinematic pairs according to the relative motion

Sliding pair: "*When relative motion between two elements of a pair takes place in the form of PURE SLIDING, then the pair is called sliding pair.*"

Example, a rectangular bar in a rectangular hole, the piston and cylinder of an engine, the cross-head and guides of a steam engine, the ram and its guides of a steam engine, the ram and its guides in a shaper, the tail-stock on the lathe bed etc.

(a) Sliding pair

**Turning pair:** "*When relative motion between two elements of a pair takes place in the form of PURE TURNING only, then the pair is called turning pair.*" Example, a shaft with a collar at both ends revolving in a circular hole. The collars prevent the sliding motion of the shaft in the bearing.
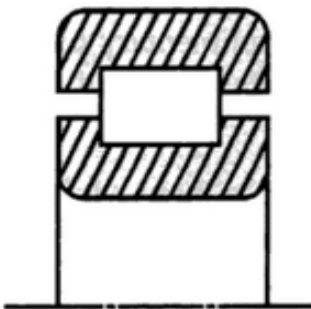
(b) Turning pair

Rolling pairs: "*When two elements are so connected that one is constrained to roll on another element which is fixed, they from a rolling pair.* "

Example Ball and roller bearings, a wheel rolling on a flat surface etc. are examples of rolling pairs.
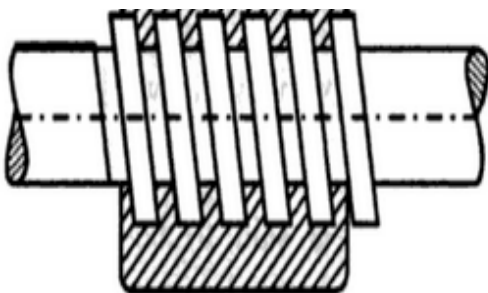
(c) Rolling pair

Screw (or helical) pair: "*When one element turns about the other element by means of threads, they form a screw pair.*" The motion in this case is a combination of sliding and turning.
Example the lead screw of a lathe with a nut, a bolt with a nut, Screw and nut of screw jack are some examples of screw pairs.
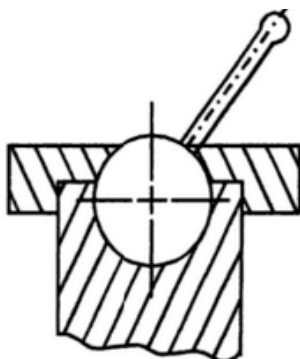
(e) Screw pair

Spherical pair: "*When one element in the form of sphere turns about the other element which is fixed they form a spherical pair.*"

Example-the ball and socket joint, a pen stand, the mirror attachment of vehicles etc, are some examples of spherical pairs.

(d) Spherical pair

**B) Kinematic pairs according to the type of contact.**

Lower pair: *"When the two elements of a pair have __surface(area) contact__ while in motion the pair is called a lower pair."*

All sliding pairs, turning pairs and screw pairs form lower pair. for example, a nut turning on a screw, a shaft rotating in a bearing, an universal joint, all pairs of a slider crank mechanism, a pantograph etc.

Higher pair: *"When the two elements have __point or line contact__ while in motion then the pair is known as higher pair."*

Belt, rope and chain drives, gears, the cam and follower ball and roller bearings, a wheel rolling on a surface etc all etc. All form higher pairs.

C) Kinematic pairs according to the type of mechanical constraint
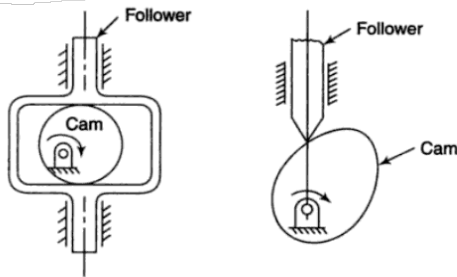

closed pair   open pair

Closed pair: When the two elements of pair are held together mechanically in such a manner the only the required type of relative motion occurs, they are called a close pair. All lower pairs and some higher pairs (for example, the enclosed cam and follower) are closed pairs.

Open pair: When the two elements of a pair are not held mechanically and are held in contact by the action of external forces, the pair is called an unclosed pair. for example, the can and spring loaded follower pair.
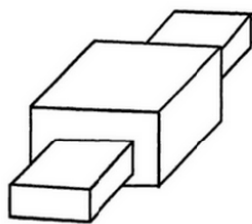
Q.7. What do you mean by constrained motion ? What are types of constrained motion.

Incompletely constrained motion.
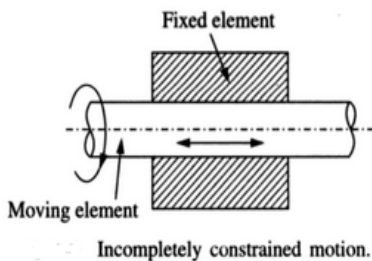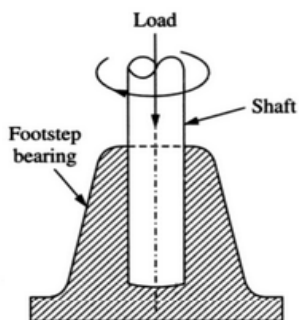
Ans: 1) Incompletely constrained motion:
When the motion between a pair can take place in more than direction, it is said to be incompletely constrained motion. For example, a circular shaft revolving in a circular hole.

Completely constrained

2) Completely constrained motion:
When the motion between a pair can take place in one and only one way , it is said to be completely constrained motion For example, a rectangular shaft revolving in a rectangular hole.

Partially constrained motion.

3) Partially (or successfully) constrained motions:
When the constrained motion between a pair is not completed by itself but by some other means, it is said to be partially constrained motion. The motion of shaft in a footstep bearing is successfully a constrained motion when compressive load is applied to the shaft.
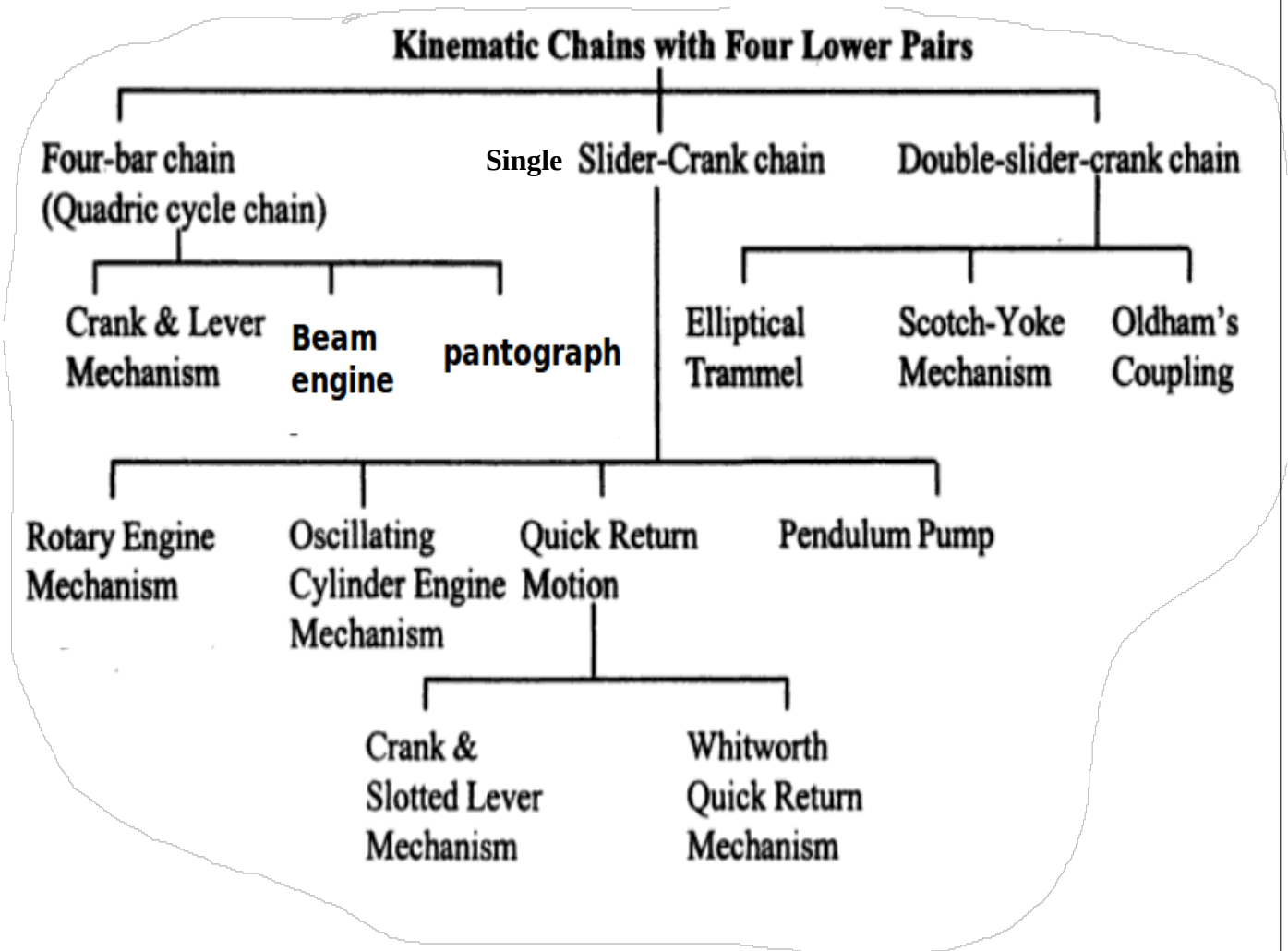
Q.8. What are different types of Kinematic Chains ?

Ans: The various type of kinematic chain are
1. Four bar chain or quadric cycle chain
2. Single slider crank chain
3. Double slider crank chain

1.2 : Inversions of Kinematic chains

Q.1.Enlist various Inversion of three types of Kinematic chains?

Kinematic Chains with Four Lower Pairs

- Four-bar chain (Quadric cycle chain)
  - Crank & Lever Mechanism
  - Beam engine
  - pantograph
- Single Slider-Crank chain
  - Rotary Engine Mechanism
  - Oscillating Cylinder Engine Mechanism
  - Quick Return Motion
    - Crank & Slotted Lever Mechanism
    - Whitworth Quick Return Mechanism
  - Pendulum Pump
- Double-slider-crank chain
  - Elliptical Trammel
  - Scotch-Yoke Mechanism
  - Oldham's Coupling

Inversions of Four bar chain

Q.1.Explain the coupled wheels of locomotive mechanism.

Ans.
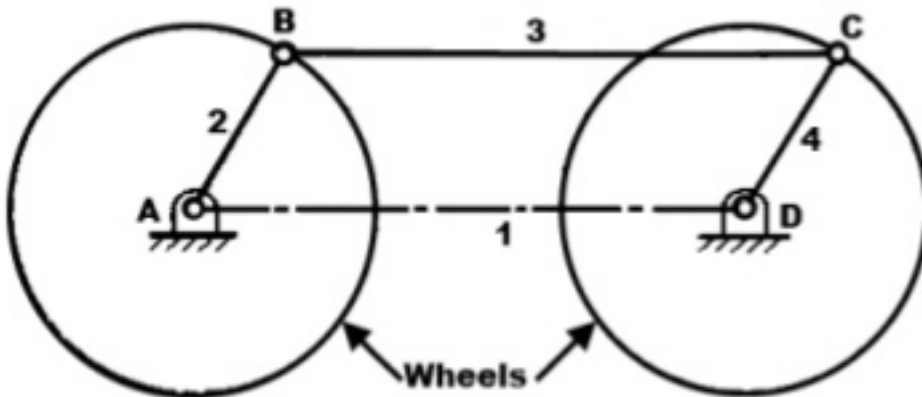
Links -

link AD frame (Fixed)

link AB (Crank)

link BC (Coupling Rod)

link CD (Crank)

Pairs -

Turning Pair = AD (Frame) & AB (Crank)

Turning Pair = AD (Frame) & CD (Crank)

Turning Pair = AB (Crank) & BC (Connecting Rod)

Turning Pair = CD (Crank) & BC (Connecting Rod)

Construction:

This mechanism is an inversion four bar kinematic chain . This has four turning pairs.

It is consists of frame AD which is fixed, on which two cranks AC & BD are fitted on it .The cranks are free to rotate about points A and D. Both the cranks have same lengths. Two cranks are connected to each other by means of coupling rod, which connects the other ends B and C of both cranks. At the connections B and C there is turning pair.

Working –

When link AB starts rotating about fixed point A. The rotary motion of wheel is transmitted to next wheel by means of coupling rod BC. As a result the other wheel also starts rotating in same direction and same speed, because both cranks have same radius of rotation.

Application –

The mechanism is used to connect driving & driven shaft of locomotive. Here both driving & driven wheels always rotate in same direction.

Q.2. Explain with sketch Beam engine

Ans.
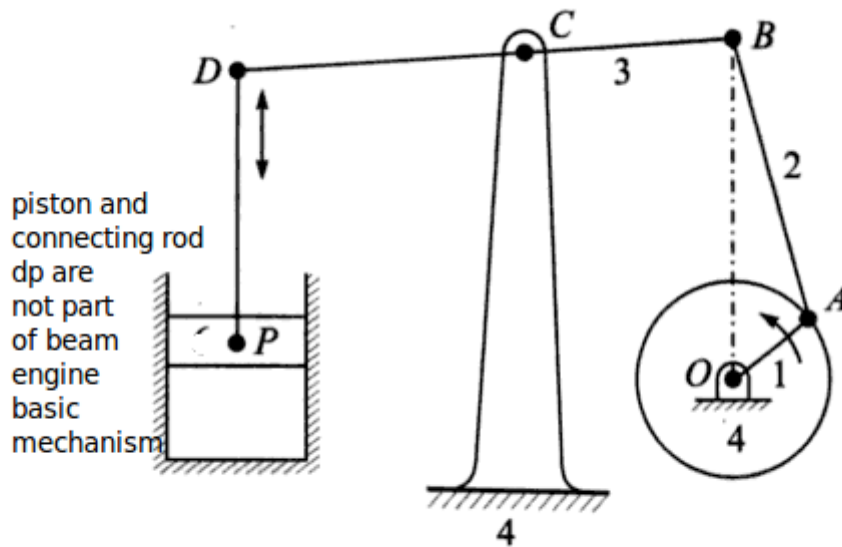
Beam engine mechanism.

links -
Link 4 OC (frame)
Link 1 OA (Crank)
Link 2 AB (connecting Rod)
Link 3 BCD (lever)
Pairs -
Turning Pair = Frame OC & Crank OA
Turning Pair = Crank OA & Connecting Rod AB
Turning Pair = Connecting Rod AB & lever BCD
Turning Pair =   Frame OC & lever BCD

Construction –
　　This mechanism is an inversion of four bar chain . It has four turning pair. It consists of frame OC which is fixed and on which all other elements are fitted. The Crank is fixed at pt. 'O' at frame. The crank is free rotates about pt.'O' . Other end of crank is connected to connectin rod AB. Other end of connecting rod AB is linked to one end of lever. The lever is pivoted at pt 'C' other end of lever 'D' is attached to piston -cylinder mechanism as shown.

Working –
　　As the crank starts rotating this motion is transmitted to lever by connection rod. As crank continues to rotate the lever starts to oscillate about pt. 'C', this oscillatory motion is transmitted to piston & cylinder.

Application – The mechanism converts rotary motion to reciprocating motion. This is used in machine tools & pumps. It is used for extracting oil from oil wells, the equipment is called **Pump-jack**.

Q.3.Explain with Sketch Pantograph
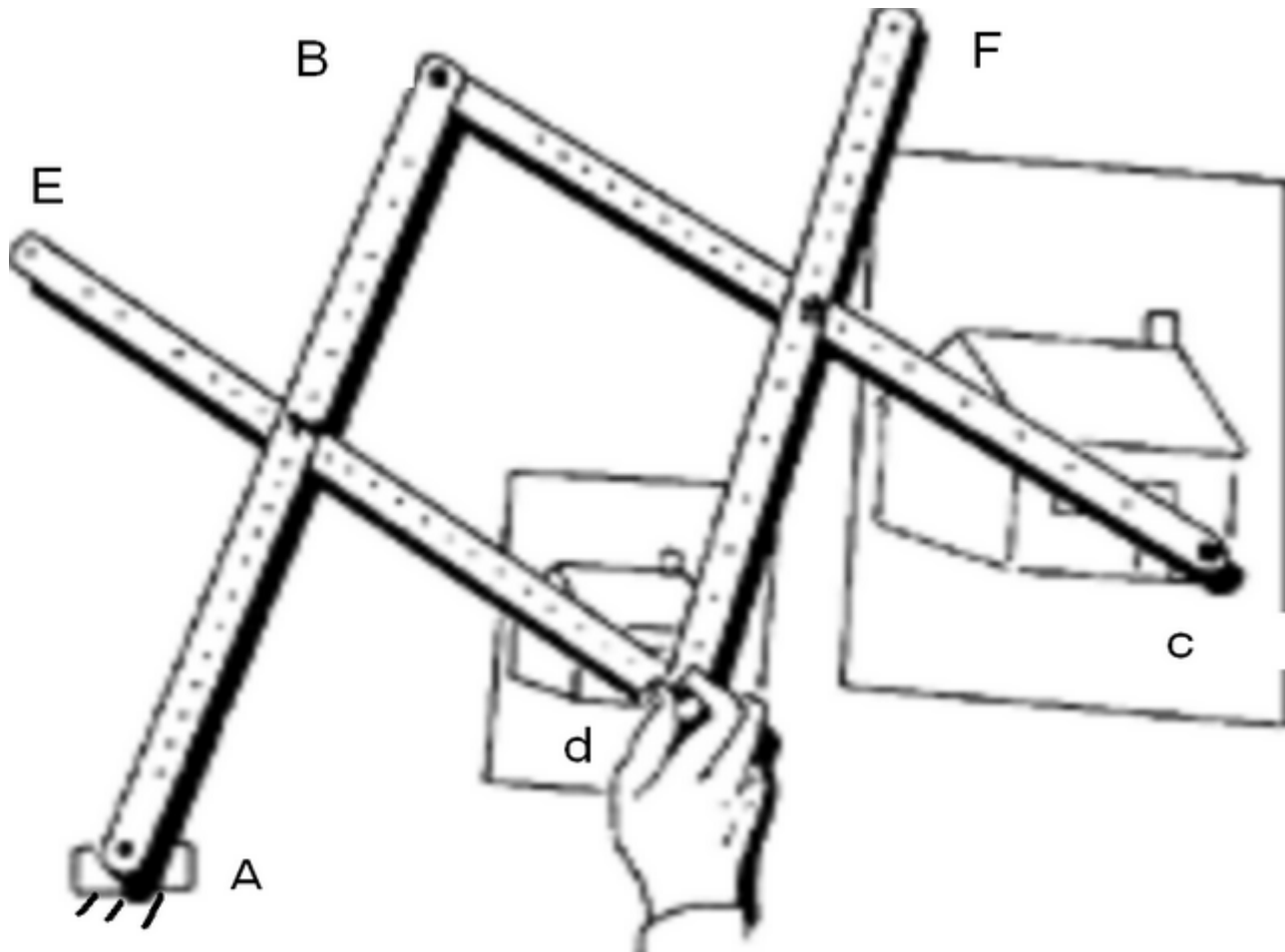
Links
Link AB - End A is fixed
link BC
link DE
link DF
Pairs -
Turning Pair - AB & BC
Turning Pair – AB & DE
Turning Pair – BC & DF
Turning Pair – ED & DF
Construction –
This mechanism is an inversion of four bar chain . It has four turning pairs. One link is fixed to the table. The stylus is attached to the junction of link DE and DF and the pen is attached to the end C of the link BC. The lengths of all links are adjustable through the holes provided on the links.
Working –
As the operator traces the "Drawing" with the stylus, the same drawing is reproduced by the pen either in enlarged or reduced scale depending upon the links lengths. The links have holes for the adjustment of magnitude of enlargement or reduction.
**Application –** The mechanism is used for
1. Reducing large drawing.
2.Used in copy machining such as copying lathe using hydraulic system.3.Used in electric train supply system on top of train, which supplies current to electric train from cables on top.
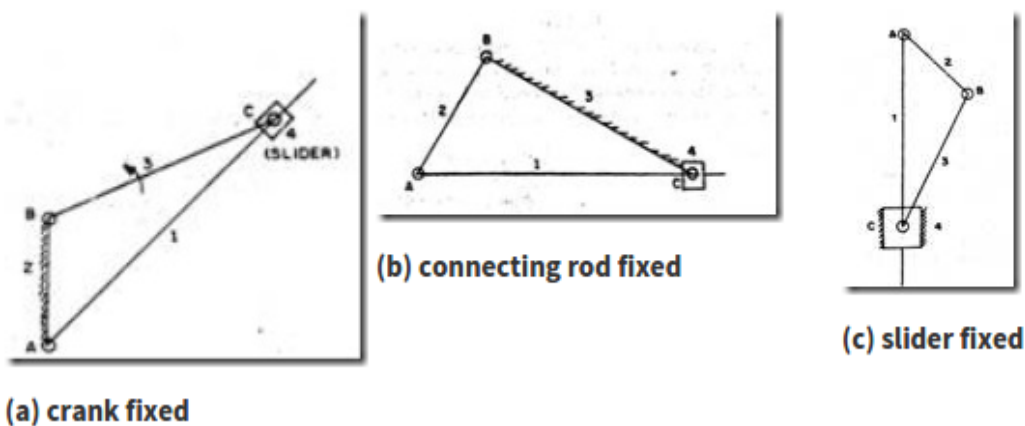
Inversions of Single slider crank chain

Q.1. Draw the basic single slider crank chain and explain how different inversions are obtained by fixing different links.

Ans: Basic structure of single slide crank chain is shown below

SLIDER   CONNECTING ROD   CRANK
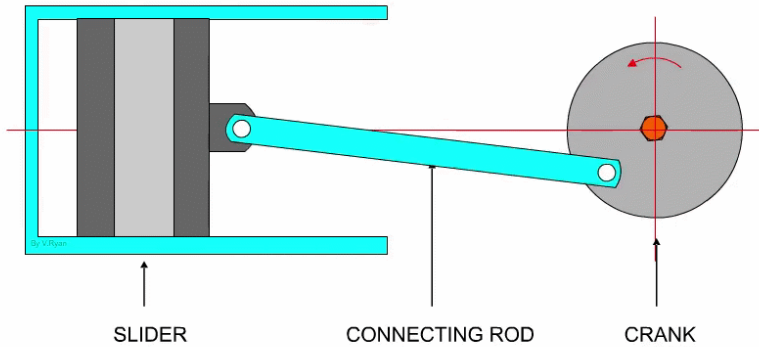
Inversions of slider crank chain: Inversions of slider crank mechanism is obtained by fixing links 2, 3 and 4.

(a) crank fixed

(b) connecting rod fixed

(c) slider fixed

FIXED LINK	Applications of inversion
Frame fixed	Basic single slider mechanism
Crank Fixed	Gnome engine Whit-worths Quick return mechanism
Connecting rod Fixed	Oscillating cylinder mechanism Crank and slotted lever quick return mechanism
Slider fixed	Pendulum pump

Q.2.Explain with Sketch Oscillating Cylinder Mechanism.
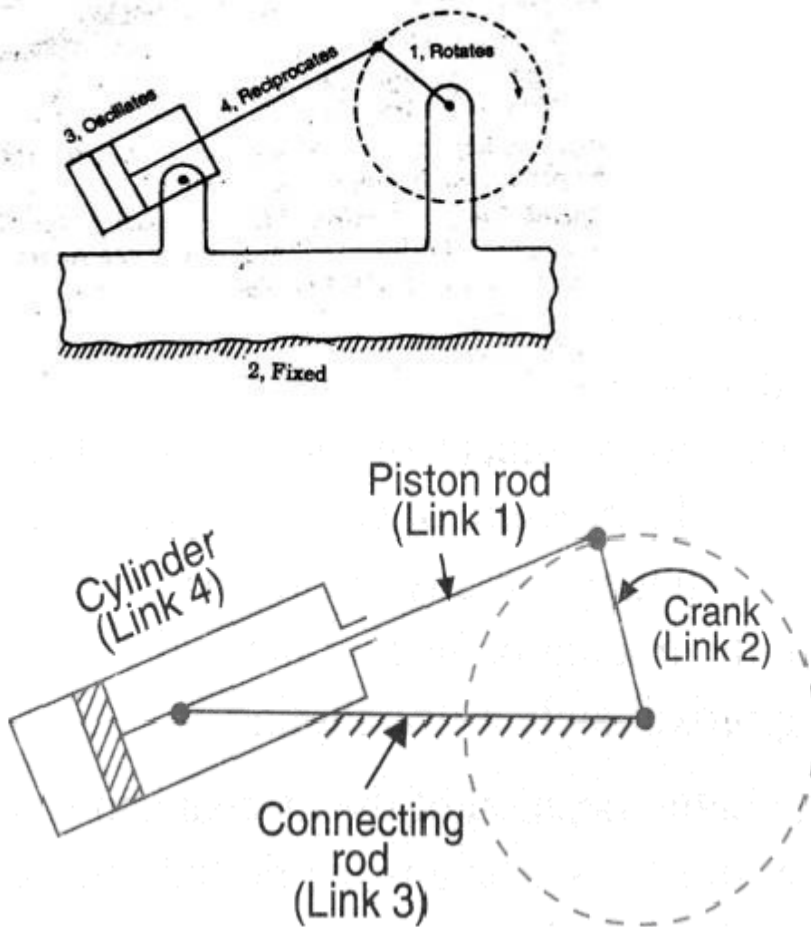
links -
Connecting rod (link 3) - Fixed
Crank (Link 2)
Piston and rod (link 1)
Cylinder (link 4)
Pairs -
Turning – Crank and Connecting rod
Turning – Crank & piston rod
Sliding – Piston rod & Cylinder.
Turning – Cylinder and connecting rod

Construction –
  This mechanism is an inversion of Single slider crank chain , which is obtained by fixing connecting rod. It has three turning pairs & one Sliding pair. As shown in figure. both rod & piston form one link . There is no relative motion between rod & Piston . The cylinder is pivoted to frame, due to which whole cylinder is free to oscillate about the frame.
**Working –**
  When crank starts rotating, it causes the piston to reciprocate inside the cylinder. A piston while reciprocating causes the cylinder oscillate about pt.'O' ,because there is no relative motion between connecting rod and piston.
Application –
The mechanism is used where rotary transmitted into oscillating motion. It is used in printing press m/c.

Q.3.State and explain Bull engine mechanism {Pendulum Pump}
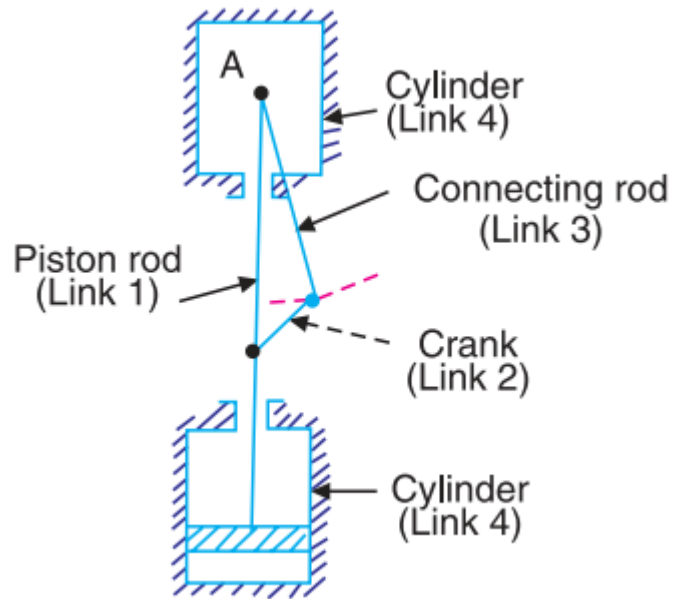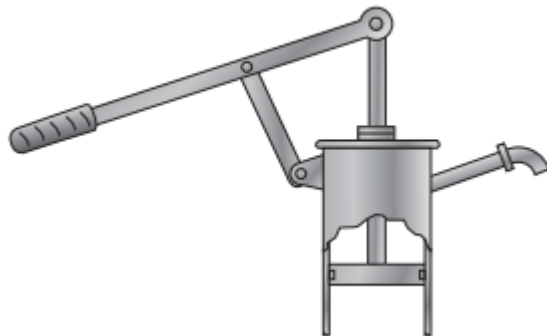
Links -
Crank
Cylinder
Piston & Piston Rod
Connecting Rod.
Pairs-
Turning – Piston & Piston Rod & Connecting Rod
Turning – Connected Rod & Crank
Sliding – Piston - Piston Rod & Cylinder.
Turning – Crank & Cylinder.

Construction –
        This mechanism is an inversion of Single slider crank chain it is obtained by fixing the slider of the basic chain .It has three turning pairs & one Sliding pair. As shown in figure the first link is piston and piston rod, second is connecting rod which is extended beyond its connection to crank. the third link is crank and fourth link is cylinder which is placed vertically and is fixed.
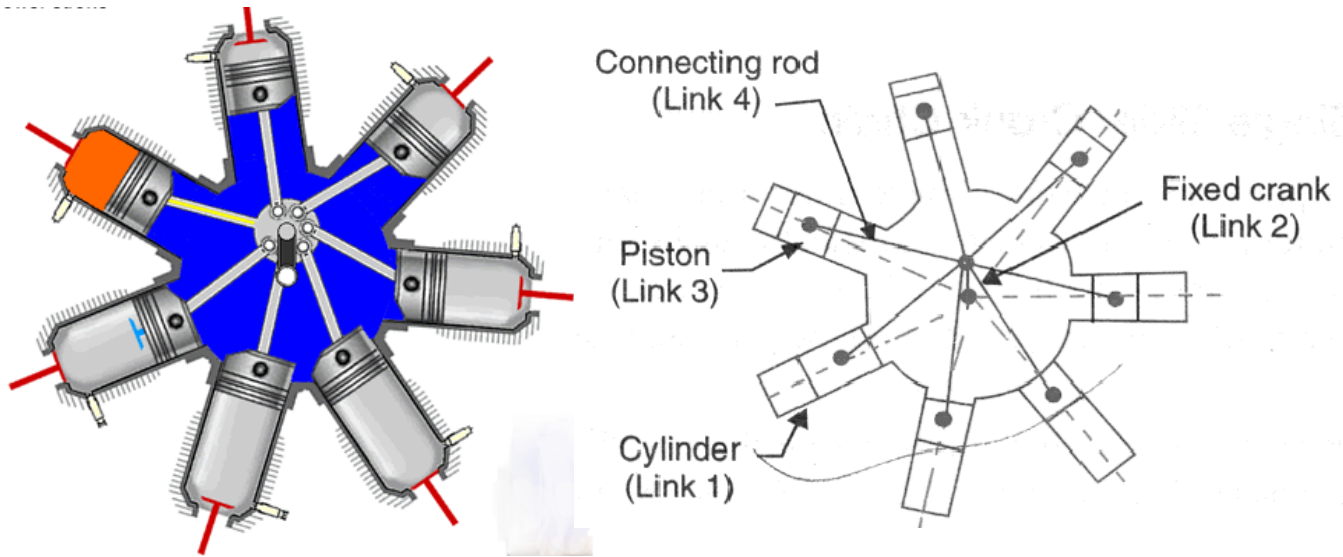**Working –**
When the upward motion is given to connected Rod it causes downward motion of piston & vice versa.

Application –
The mechanism is used in duplex pump in boilers, and also in manual hand pumps fitted on bore well.

Q.4. Explain with sketch Gnome Engine or Rotary Engine

Connecting rod (Link 4)
Piston (Link 3)
Cylinder (Link 1)
Fixed crank (Link 2)

Links -
1.Crank (fixed)
2.Piston
3.Connecting Rod
4.Cylinder & Frame

Pairs-
Crank & Connecting Rod – turning
Connected Rod & Frame – turning
Crank & Frame – turning
Piston & cylinder - Sliding

Construction –
      This mechanism is an inversion of Single slider crank chain, obtained by fixing the crank .It has three turning pairs & one Sliding pair.As shown in diagram it has 5 or 7 cylinders and connecting rods of all pistons are connected to one point which is another end of crank. In this mechanism crank itself is fixed.

Working –
      As pistons start reciprocating inside cylinders, whole frame starts rotating about fixed pt 'O' the crank remains at its place. The rotation of frame causes suction, comp,expansion & exhaust strokes in different cylinders at same time.
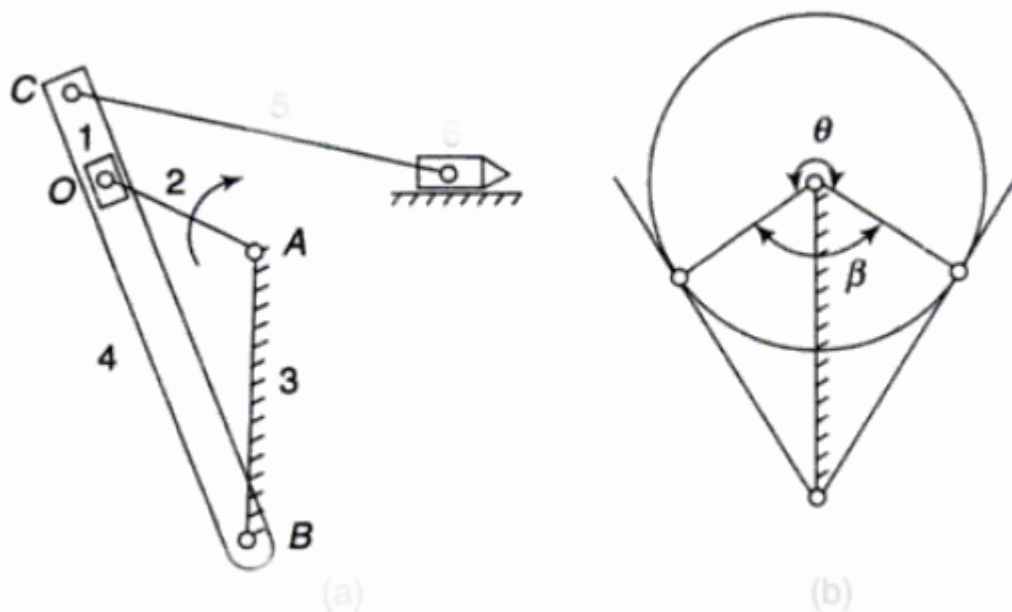
Application –
It was used in airplane engines in past, now a days it is not used.

Q.5. Explain with sketch Crank and Slotted lever quick mechanism used in shaping machine.

Ans:

(a)   (b)

Links -
1.Slider
2. Crank
3.Frame
4.Slotted Lever

Pairs-
Frame & Slotted lever – turning
Frame & Crank – turning
Crank & Slider – turning
Slider & Slotted lever - Sliding

Construction –
This mechanism is inversion of Single slider crank chain, which is obtained by fixing connecting rod of basic chain.It has three turning pair & one Sliding pair.
   Crank is fitted to frame at pt.'A' & slotted lever is fitted to frame at pt.'B'. The crank & slotted lever are connected to each other through slider. The slider is free to slide in side slotted lever. The upper end of slotted lever is attached to the ram of shaping machine through a linkage {The ram and lever connecting to ram are not part of the basic inversion}

Working –
As the crank starts rotating about pt.'A', it also transmits motion to slider. As the slider is fitted inside the slotted lever, the slotted lever starts oscillating about pt.'B'.
   As shown in second fig. The forward stroke is making an angle of θ,Whereas the return stroke covers and angle of β.From the figure it is clear that angle $\theta > \beta$,hence forward stroke is takes more time than return stroke . Hence this mechanism is called as quick Return mechanism.

Application –
The mechanism is used in shaping machine.

Q.6. Explain with sketch Whitworth's quick return Mechanism?

Ans:
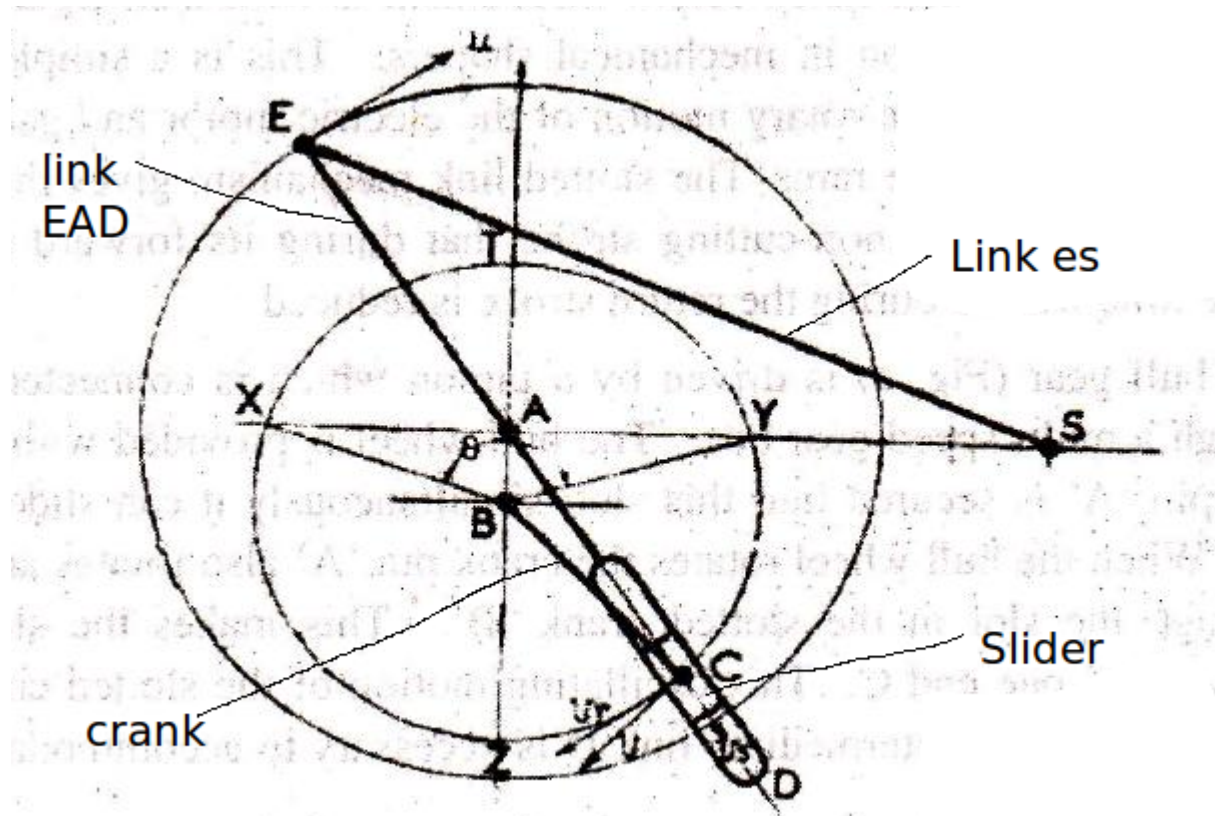
Links: Crank BC
      Slotted lever EAD
      Slider
      Frame AB (FIXED)
      {Link Es is not part of basic mechanism}

Pairs: Crank BC and frame AB   : Turning Pair
      Slotted lever EAD and frame AB : Turning Pair
      Crank Bc and slider   : Turning Pair
      Slider and Slotted lever EAD   : Sliding pair

Construction : This mechanism is an inversion of single slider crank chain, obtained by fixing the crank of the connecting rod. It has three turning pairs and one sliding pair.

      It has crank BC turning about point B. Other end of crank carries a slider, connected with turning pair. The slide fits inside the slotted lever EAD. The slider is free to slide inside the slotted lever. The lever is pivoted at point A. The lever rotates about the point A. End E of this lever is connected to the Ram of the shaper machine.

Working: As the crank starts rotating about the point B. It transmits the motion to the Lever EAD through the slider . As a result the lever EAD starts rotating about the point A. As shown in figure the forward stroke of the ram is slower and return stroke is faster (Angle theta is greater than angle beta). Hence this mechanism is called quick return mechanism.

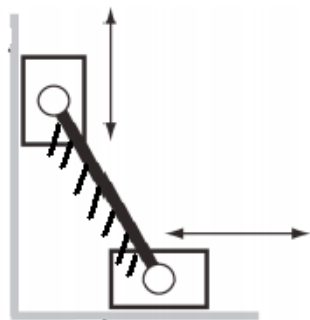**Application :** This mechanism is used in Shaping machine.

Inversions of Double slider crank chain

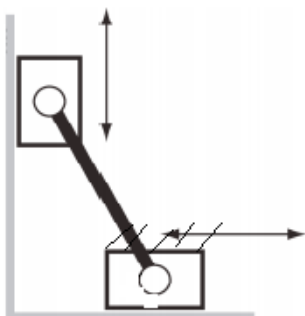## Q.1. Draw Basic double slider crank chain and explain how different inversions are obtained from it?

Ans:Basic Double slider crank chain is shown below, It has two truning and two sliding pairs
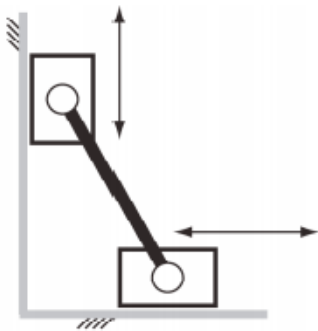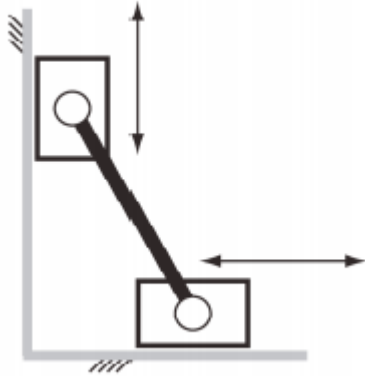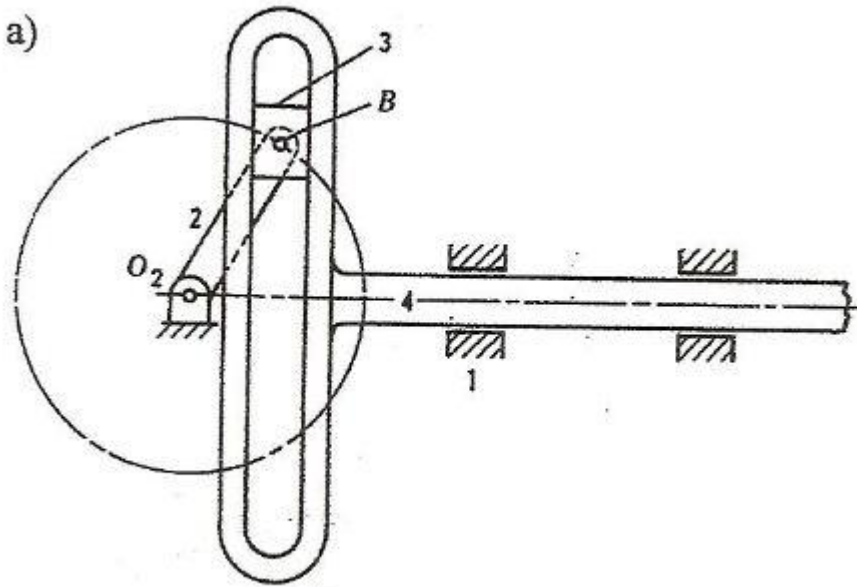
Frame Fixed
Elliptical
Trammel

Crank Fixed
Oldhams
Coupling

One Slider
Fixed
Scotch Yoe
mechanism

Q.2. Explain with sketch Scotch Yoke Mechanism?

Ans:

a)

b)

Links: 1.Frame (fixed)
   2.Crank
   3.Slider
   4. Yoke

Pairs -
1.Frame & Crank – turning
2.Crank & Slider – turning
3.Yoke & Slider – Sliding
4.Frame & Yoke - Sliding

Construction –
This mechanism is inversion of Single slider Crank Chain .It has two turning pair & two Sliding pair.
  As shown in fig. The crank is fitted to frame at pt 'O' .A slider is attack to other end of crank at pt 'B'. The slider fits inside Yoke. A Yoke is free to slide inside frame.
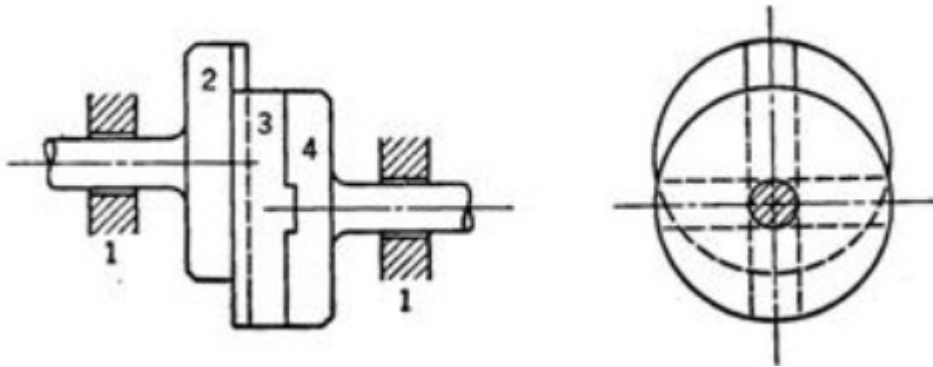
Working –
As the crank starts rotating about pt.'O' it causes the slider to slide inside Yoke. As the crank changes it's position it pulls or pushes the Yoke . Thus Rotary motion of crank is converted into Reciprocating motion of Yoke.

Application –
This mechanism is used to convert Rotary motion into reciprocating motion.

Q.3. Explain with sketch Oldham's Coupling

Ans:

Links: Frame (fixed) :1
Shaft & Flange on left hand :2
Shaft & Flange on right hand :4
Intermediate piece : 3

Pairs: Frame & Shaft LH – turning pair
Frame & Shaft RH – turning pair
Flange LH & Intermediate piece – Sliding pair
Flange RH & Intermediate piece - Sliding pair

Construction : This mechanism is inversion of Double slider Crank Chain .It has two turning & two Sliding pair.

Two flanges with respective shafts are free to rotates with respect to frame both flanges have rectangular slots . An intermediate piece has two rectangular projections on both sides, both projections are perpendicular to each other , each projection fits inside the slot of flange.

Working: When one shaft is given rotary motion,it is transmitted to another shaft the intermediate piece. The intermediate piece slides & adjusts itself, to keep both shafts runnings. The centre of the intermediate piece traces the path of a circle with radius equal to offset between shafts.

Application : This coupling is used to connect two shaft having some eccentricity (offset).

Q.4. Explain with sketch Elliptical Trammel Mechanism?

Ans:

(drawing equipment)
P
Slider 1
A
Slider 2
B

Link 3
Link 4
Link 2
Link 1 (fixed)
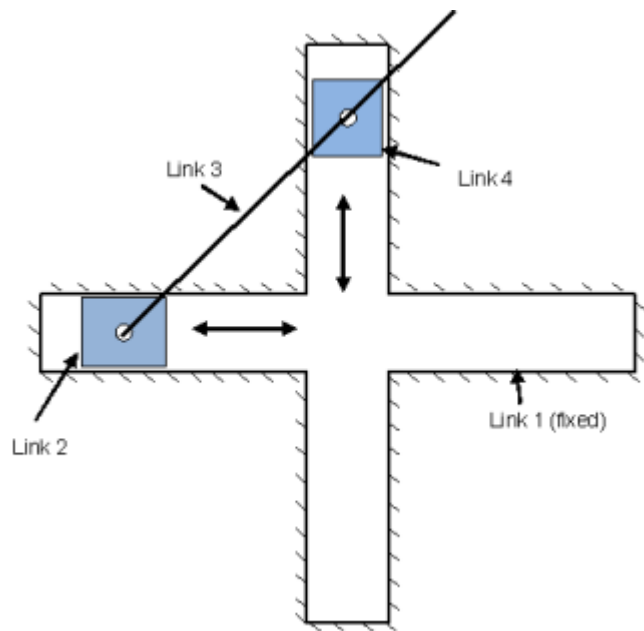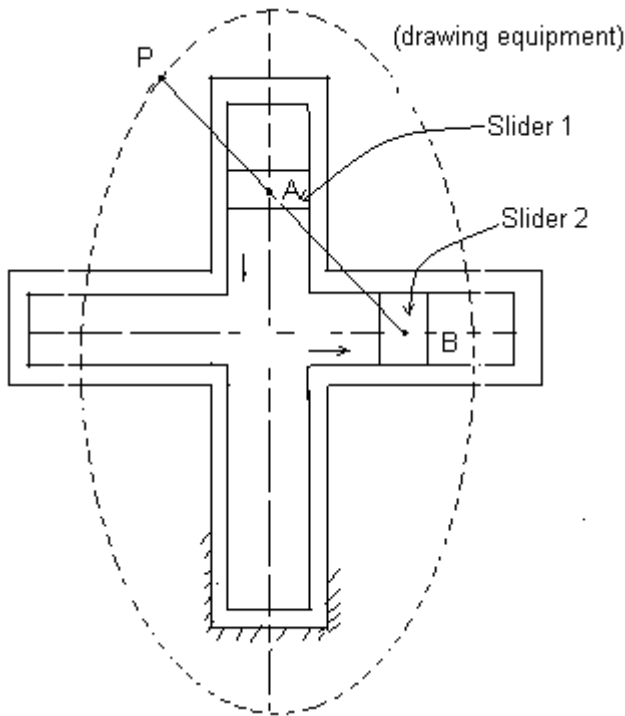
Links: 1. Frame
2.PB
3.Slider 1
4.Slider 2

Pairs: 1.Slider 1 & Frame – Sliding
2. Slider 2 & Frame – Sliding
3.Slider 1 & link PB – turning
4.Slider 2 & link PB - turning

Construction : This mechanism is an inversion of Double slider crank Chain .It has two sliding & two turning pairs. As shown in figure it has rectangular frame with vertical and horizontal slots. Two sliders are free to slide inside both slots. A link PB connects two sliders.

Working: When one of the slider is given reciprocating motion it is transmitted to another slider through the link PB . It is observed that while the two sliders slide into respective slots the pt.'P' traces the path of an ellipse.

Application : This mechanism is used for drawing ellipse of required size..