Winter 2022-23

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Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

School of Mechanical Engineering

B.Tech. – Mechatronics and Automation

BMEE207L Kinematics & Dynamics of Machines

MODULE 4

Synthesis of mechanisms

By

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Kinematic Synthesis (Design of Mechanism)

- Two position synthesis
- Three position synthesis
  - Graphical
  - Analytical (Freudenstein's Equation)

Ampere defined **Kinematics** as

"The study of the motion of the mechanisms and the methods of creating them".

Ampere's Definition may be paraphrased in to two ways

1. The study of methods of creating a given motion by means of mechanism
2. The study of methods of creating mechanisms having a given motion

Kinematic Synthesis

- The study of motions in machines may be considered from the two different points of view generally identified as kinematic analysis and kinematic synthesis.
- In kinematic analysis, displacement, velocity and acceleration characteristics of mechanisms are studied.
- In kinematic synthesis, mechanisms are designed or created to meet certain motion specifications.
- Therefore, kinematic synthesis is the reverse problem as compared to kinematic analysis.

Kinematic Synthesis

- To design a cam to give a follower given displacements OR to determine number of teeth on the members in a gear train in order to produce a desired velocity ratio, are also examples of synthesis of mechanisms.

- Most engineering design practice involves a combination of synthesis and analysis

- Various types of mechanisms such as bar linkages, cams, or rolling surfaces, including gears, can be used to obtain a desired output from a given input.

- Thus, it becomes important to the designer to be familiar with the methods of synthesis of these different types.

Kinematic Synthesis

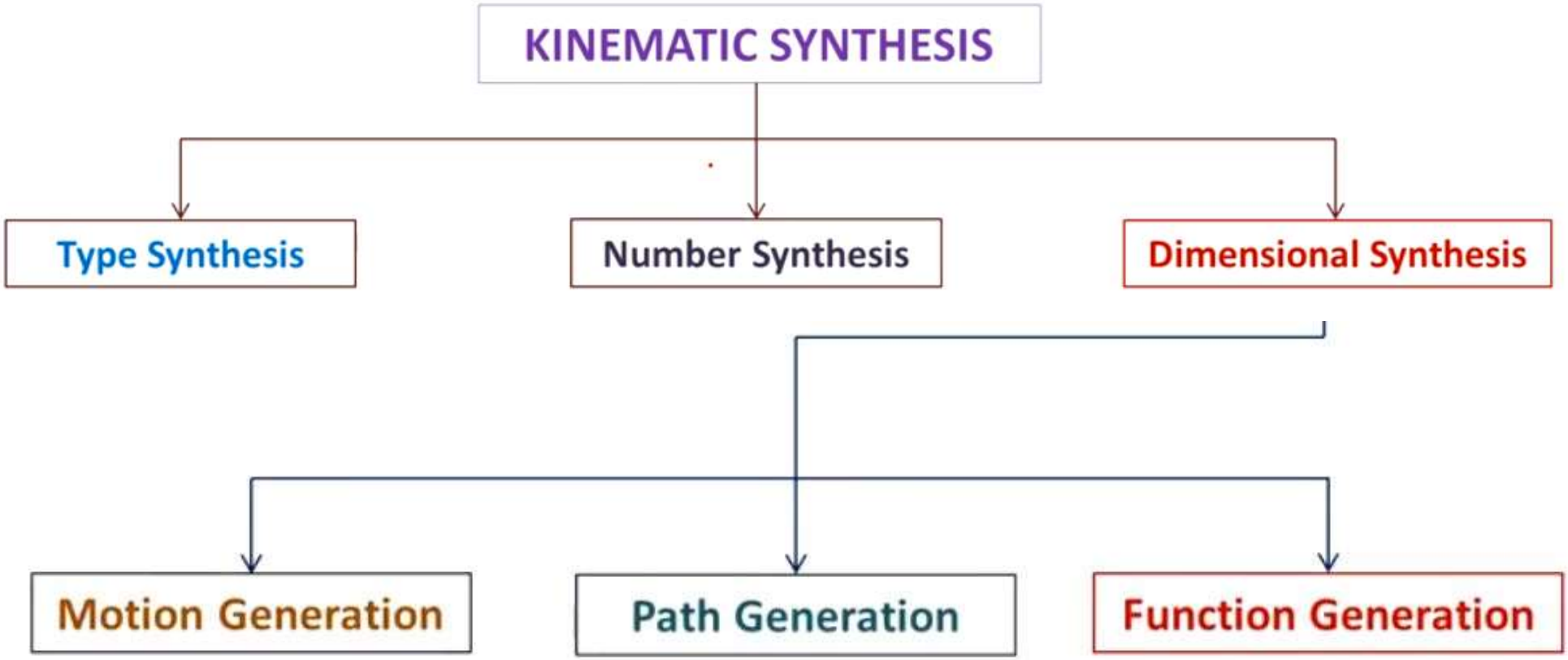
- Thus, in the design of a mechanism for a given application, a decision must be reached regarding the type of mechanism to be employed, as for example, deciding between a cam or a gear or a linkage.

- The number of links and connections required to give the desired degree of freedom must then be determined.

- Finally, the required dimensions needed to bring about a particular motion must be deduced.

- In the broadest sense, kinematic synthesis thus consists of the three interrelated areas of type, number and dimensional synthesis, which are known as kind of synthesis.

Kinematic Synthesis



Type Synthesis

- In the design of a mechanism for a given application, a decision must be reached regarding the type of mechanism to be employed.
- This is the first phase in the kinematic synthesis. Here, the kind of links or constructional units is determined such as line work, gears, cams, belts, etc.
- The selection of type of mechanism needed to accomplish a given purpose depends to a great extent on considerations of usage, materials available, manufacturing processes, etc. which lie outside the field of kinematics.
- Further, it is impossible to solve the problem without first assuming the type of mechanism which is to be used.

Number Synthesis

- This is the second phase in the kinematic synthesis. Determination of the number and order of links and joints necessary to produce motion of a particular degree of freedom is done here.
- The order of links here refers to the number of nodes per link i.e., binary, ternary, quaternary, etc.
- The value of number synthesis is to allow the exhaustive determination of all possible combinations of links which will yield any chosen degree of freedom.
- Grubler's criterion is used for movability studies based on only two factors the number of links and the number of joints, in number synthesis.
- A kinematic chain is said to be movable when its number of degrees of freedom one or greater, it is otherwise locked. If the number of degree of freedom is equal to unity, the chain is said to be constrained.

Dimensional Synthesis

- This is the third phase in the kinematic synthesis. By dimensional analysis, we understand the determination of the dimensions of parts lengths and angles necessary to create a mechanism that will effect a desired motion transformation

- Dimensional synthesis involves the determination of link-lengths of a given linkage so as to fulfil the prescribed motion (kinematic) characteristics.

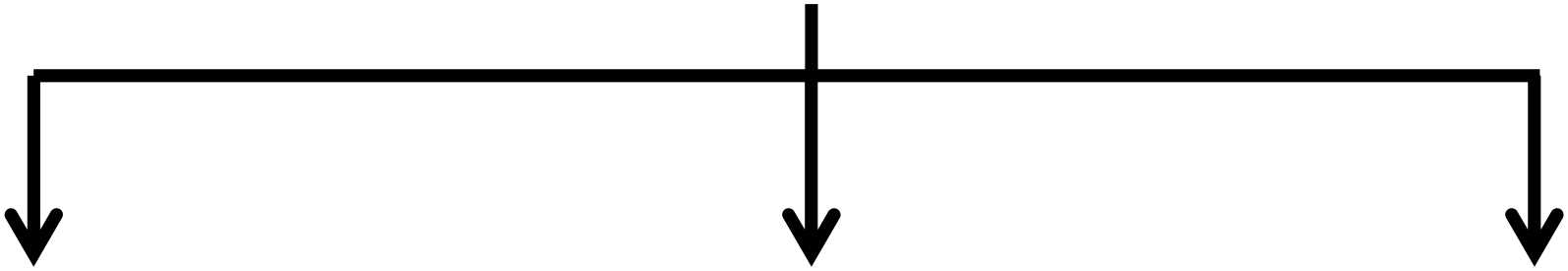
- Like kinematic analysis, dimensional synthesis can also be accomplished by both graphical and analytical methods. The choice of the proper method is very often decided by the class of synthesis problem.

Dimensional Synthesis of Linkages

By dimensional synthesis we mean the determination of kinematic dimensions so as to satisfy some prescribed motion characteristics

Classification of the problem

Dimensional Synthesis of Linkages



Motion Generation (Guidance Problem)

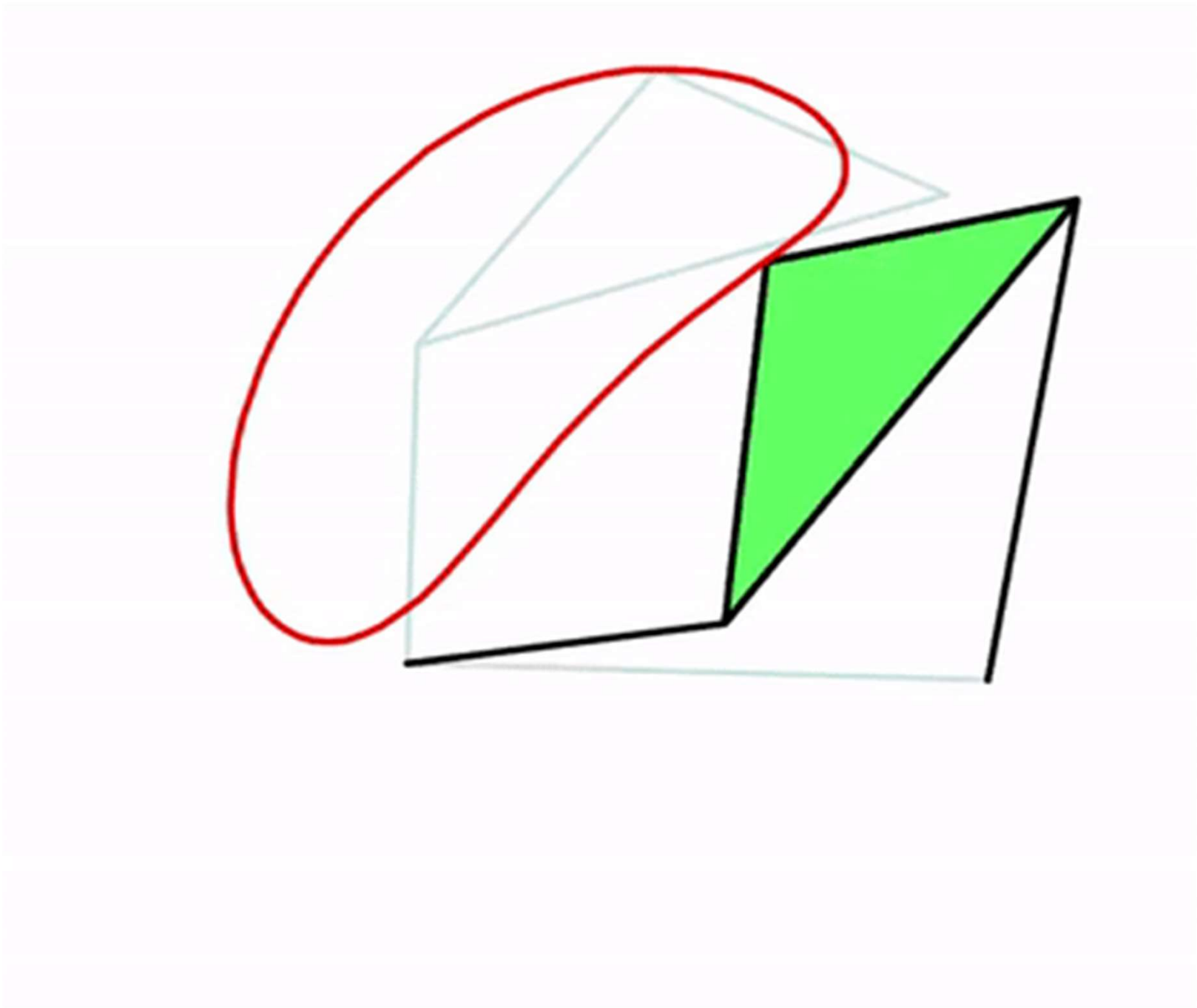
The design a linkage so that a rigid body (say the coupler of a 4R-linkage) can be guided in a prescribed manner. The guidance may or may not be coordinated with the input movement.

Path Generation

A point on the floating link (e.g., the coupler of a 4R-linkage) is to be guided along a prescribed path. The movement along the path may or may not be coordinated with the input movement.

Function Generation

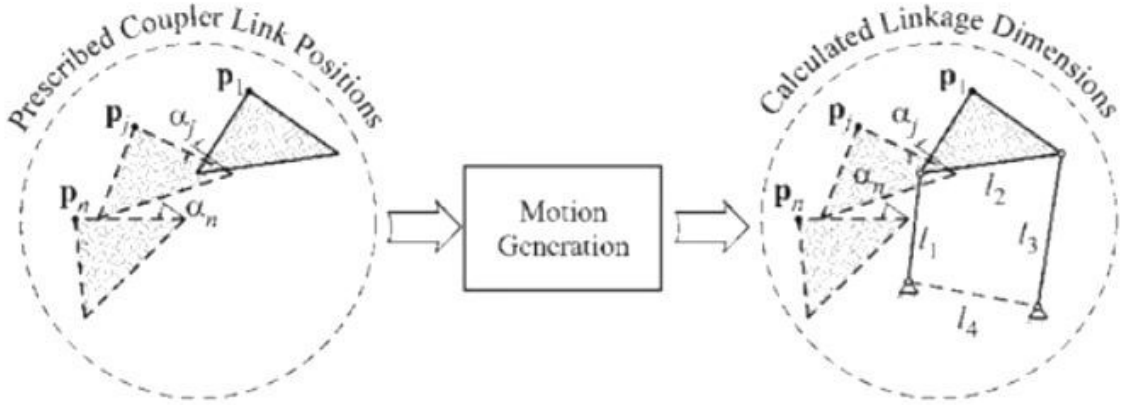
To maintain a prescribed relationship between the output and input motions

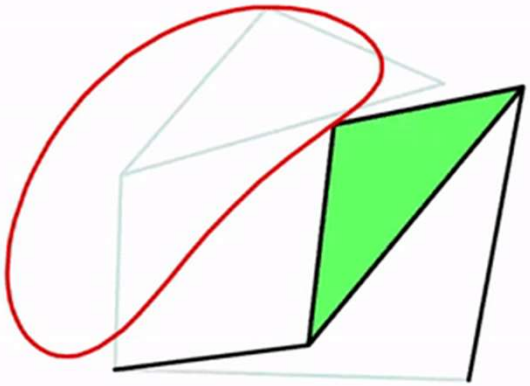


Motion Generation (Guidance Problem)

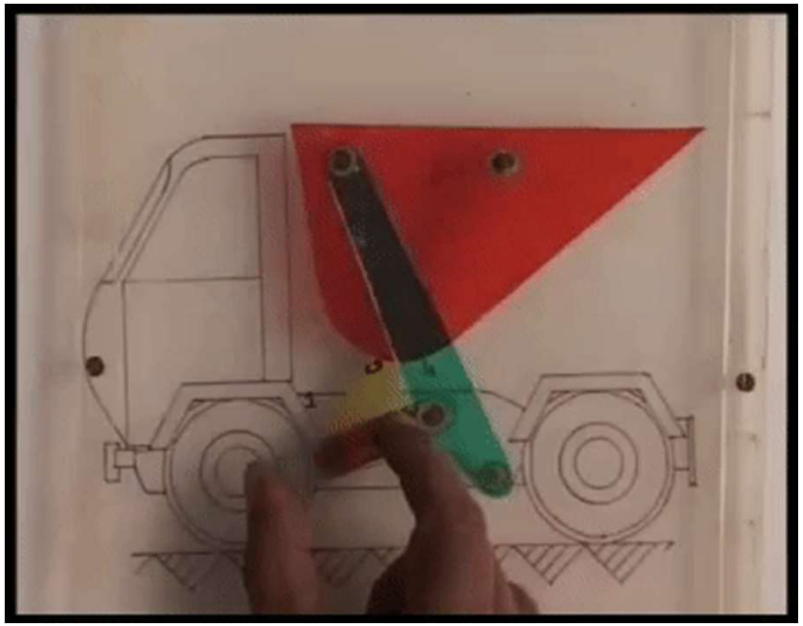
- By motion generation we mean that a rigid body (i.e., one link of the given mechanism) has to be guided in a prescribed manner.

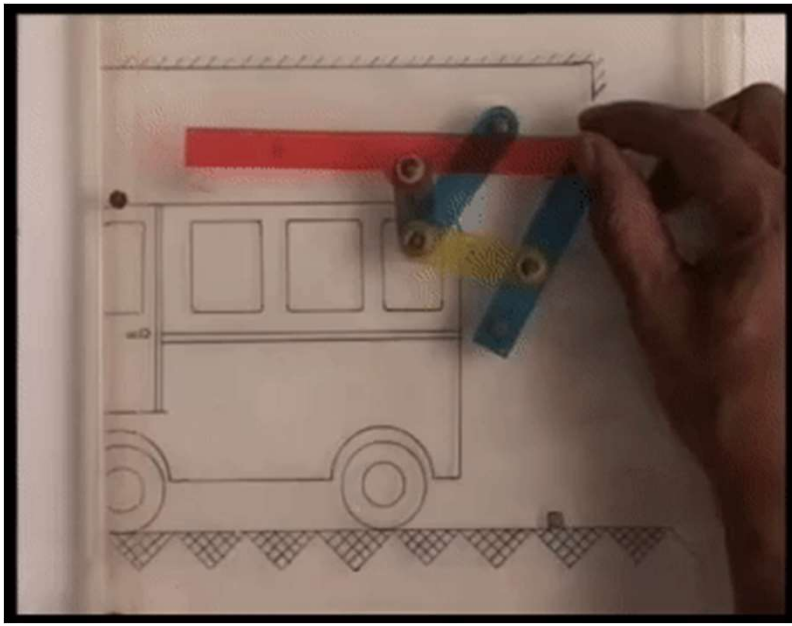
- The guidance may or may not be coordinated with the input motion.



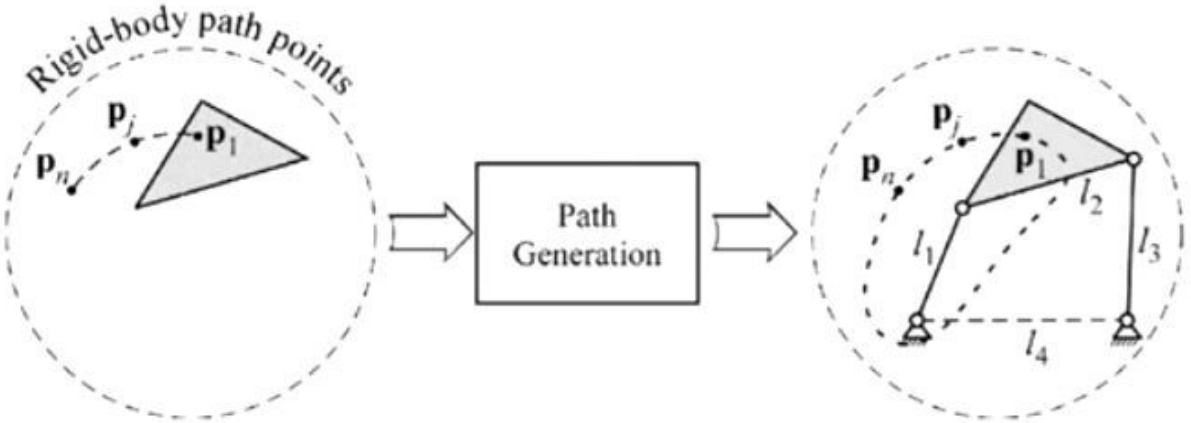


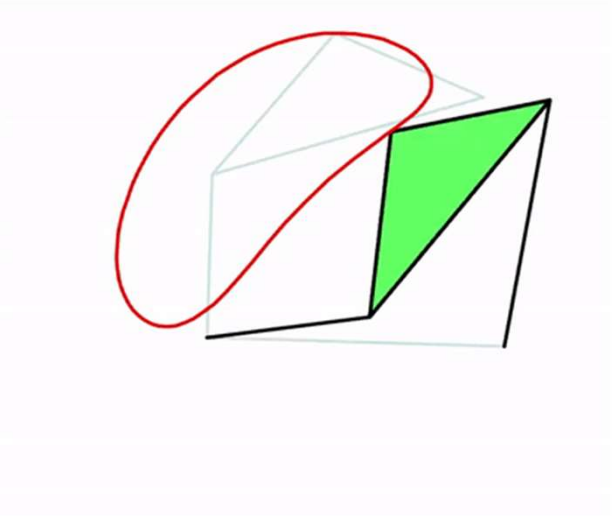
Motion Generation (Guidance Problem)





Path Generation

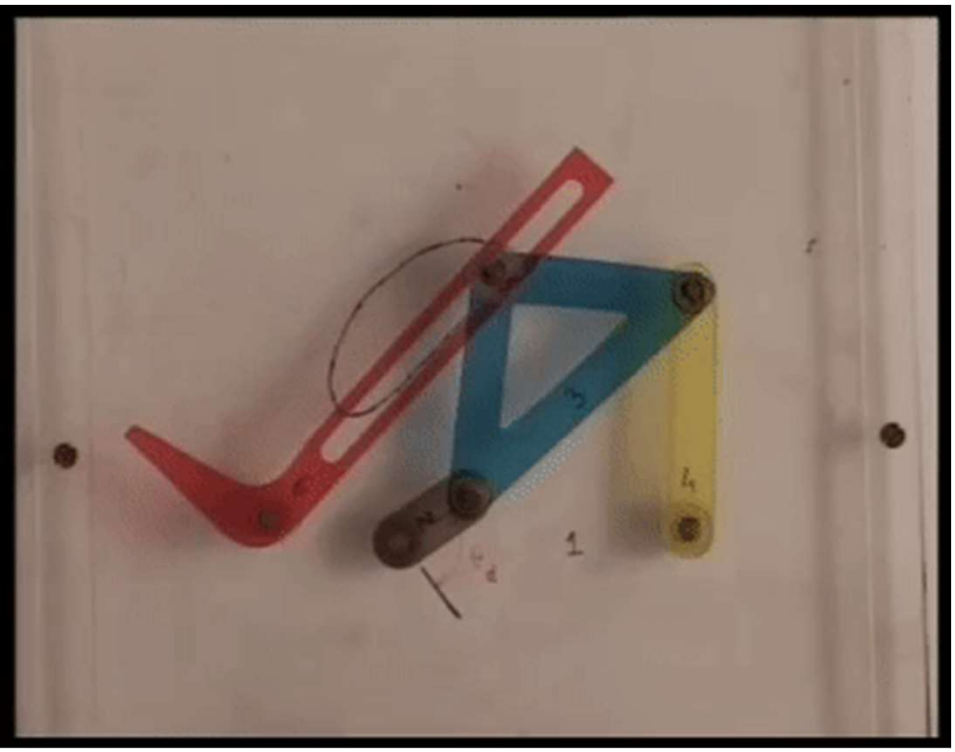


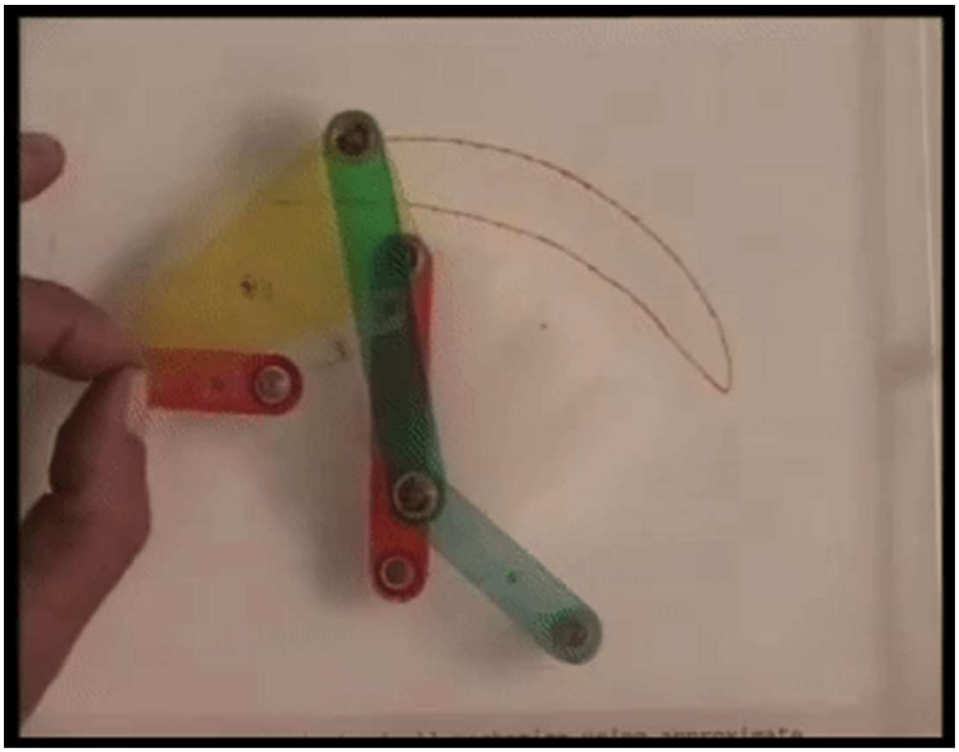


- If a point on a floating link (i.e., a link not connected to the frame) of the mechanism has to be guided along a prescribed path, then such a problem is classified as a problem of path generation.

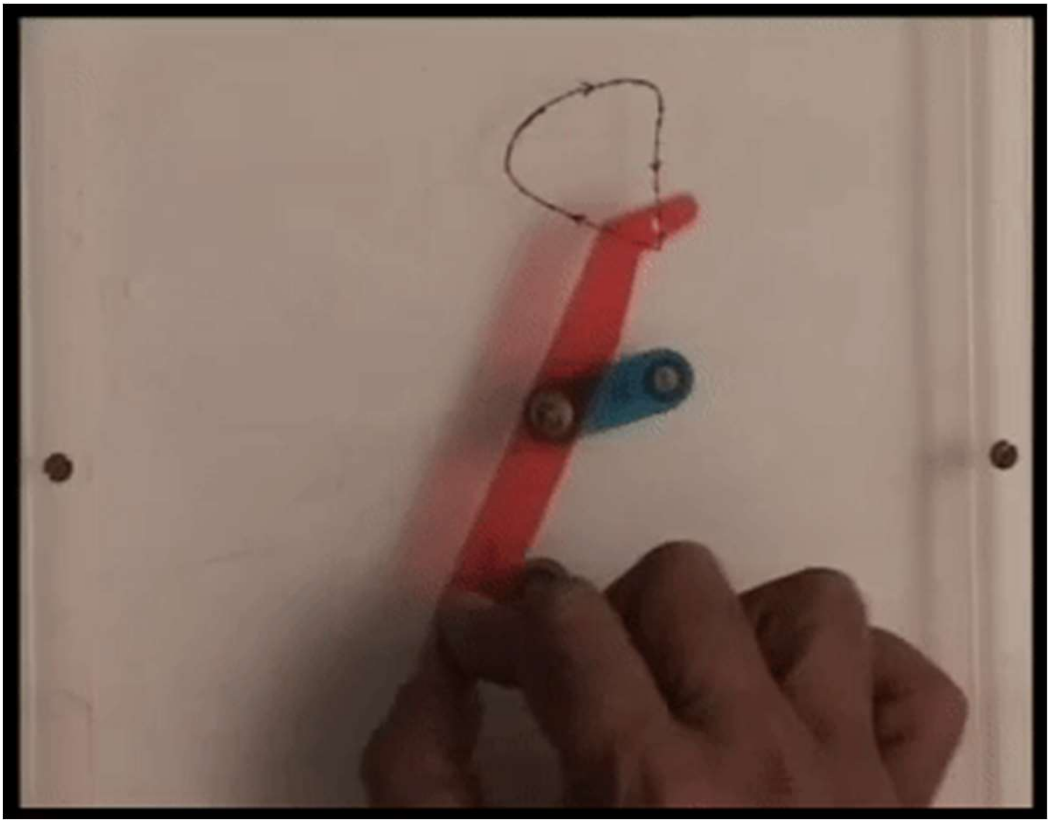
- The generation of a prescribed path may or may not be coordinated with the input motion.

Path Generation

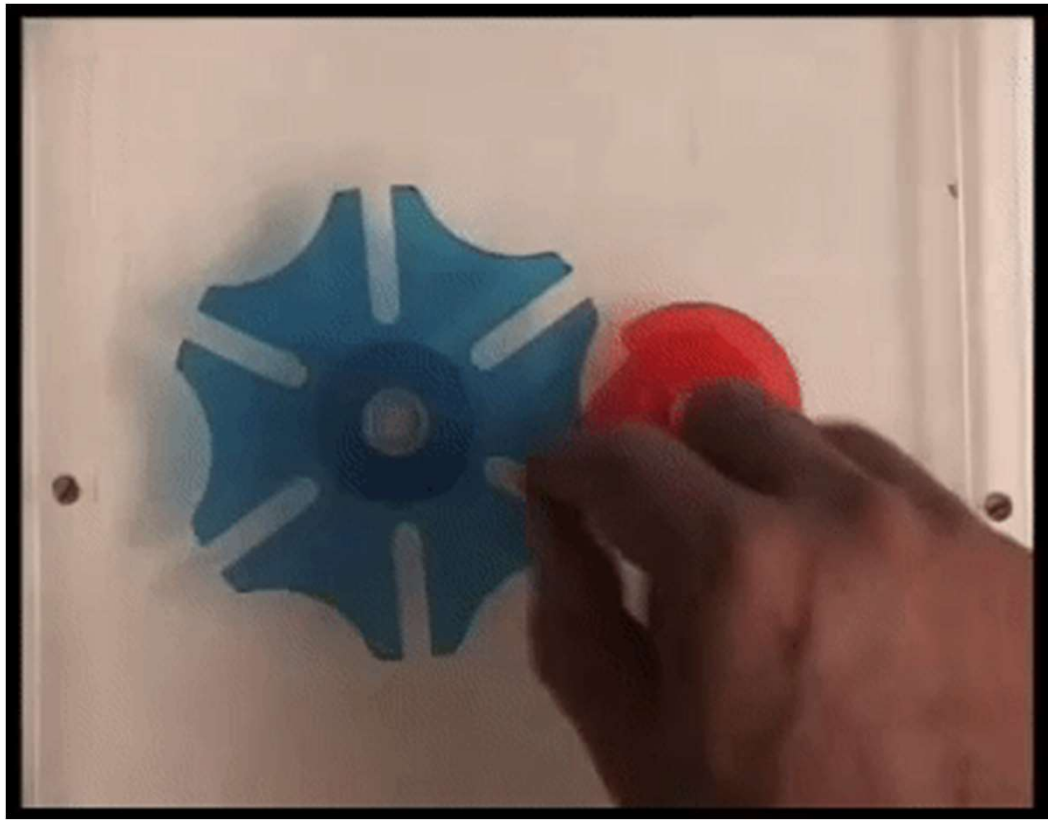




Path Generation

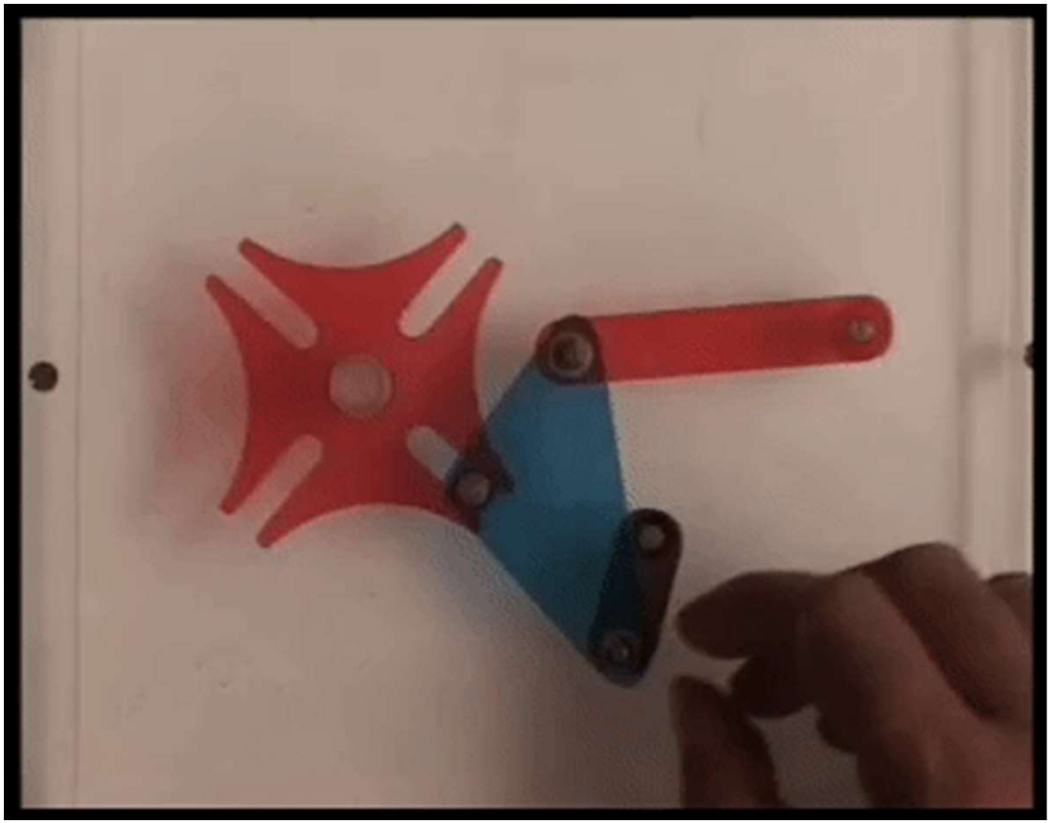


Film Drive Mechanism

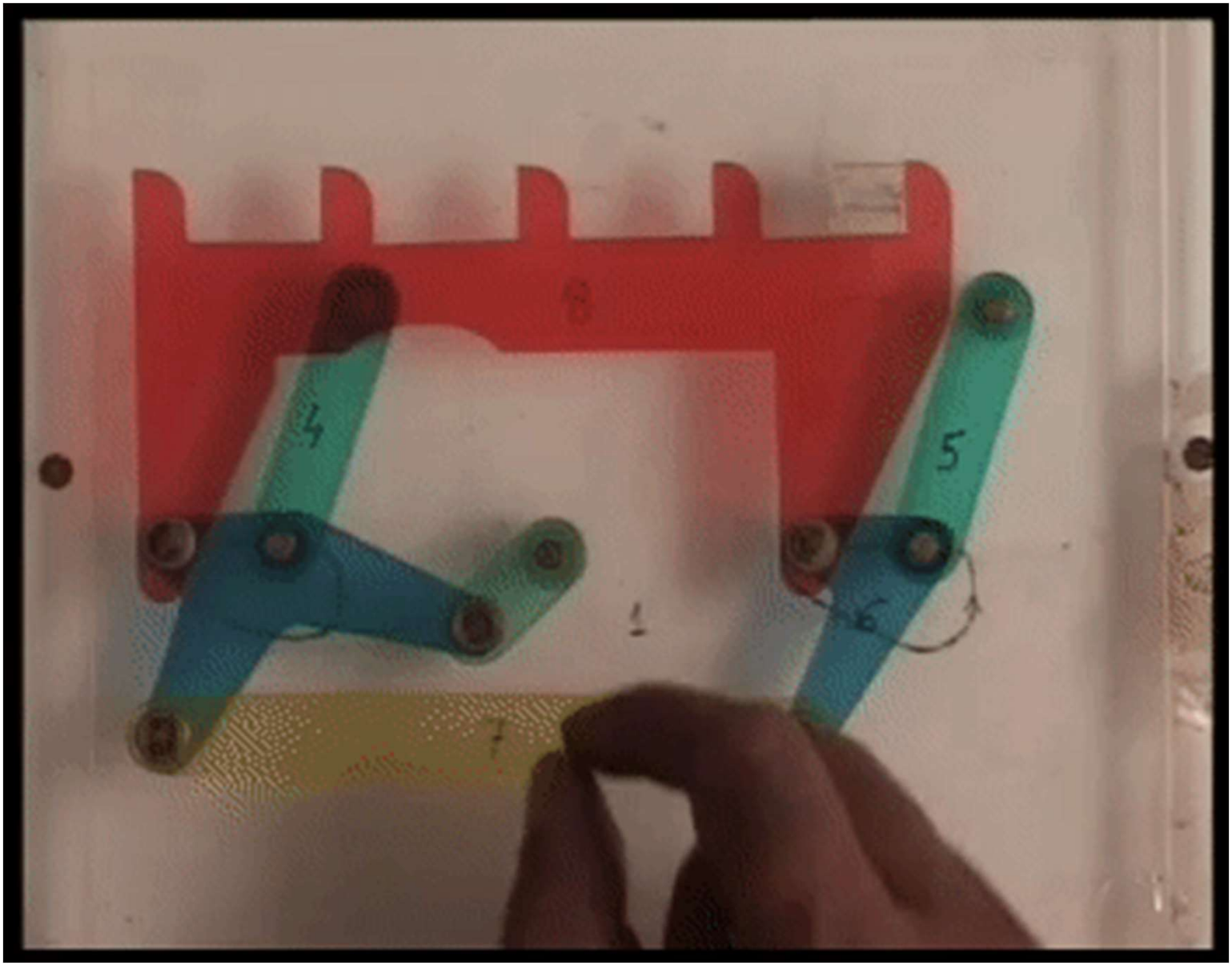


Geneva Mechanism

Path Generation



Path Generation



8-Link Transporter Mechanism

Function Generation - to maintain a prescribed relationship between the output and input motions

Function Generation

- In this class of problems, the motion parameters (displacement, velocity, acceleration, etc.) of the output and input links are to be coordinated so as to satisfy a prescribed functional relationship.

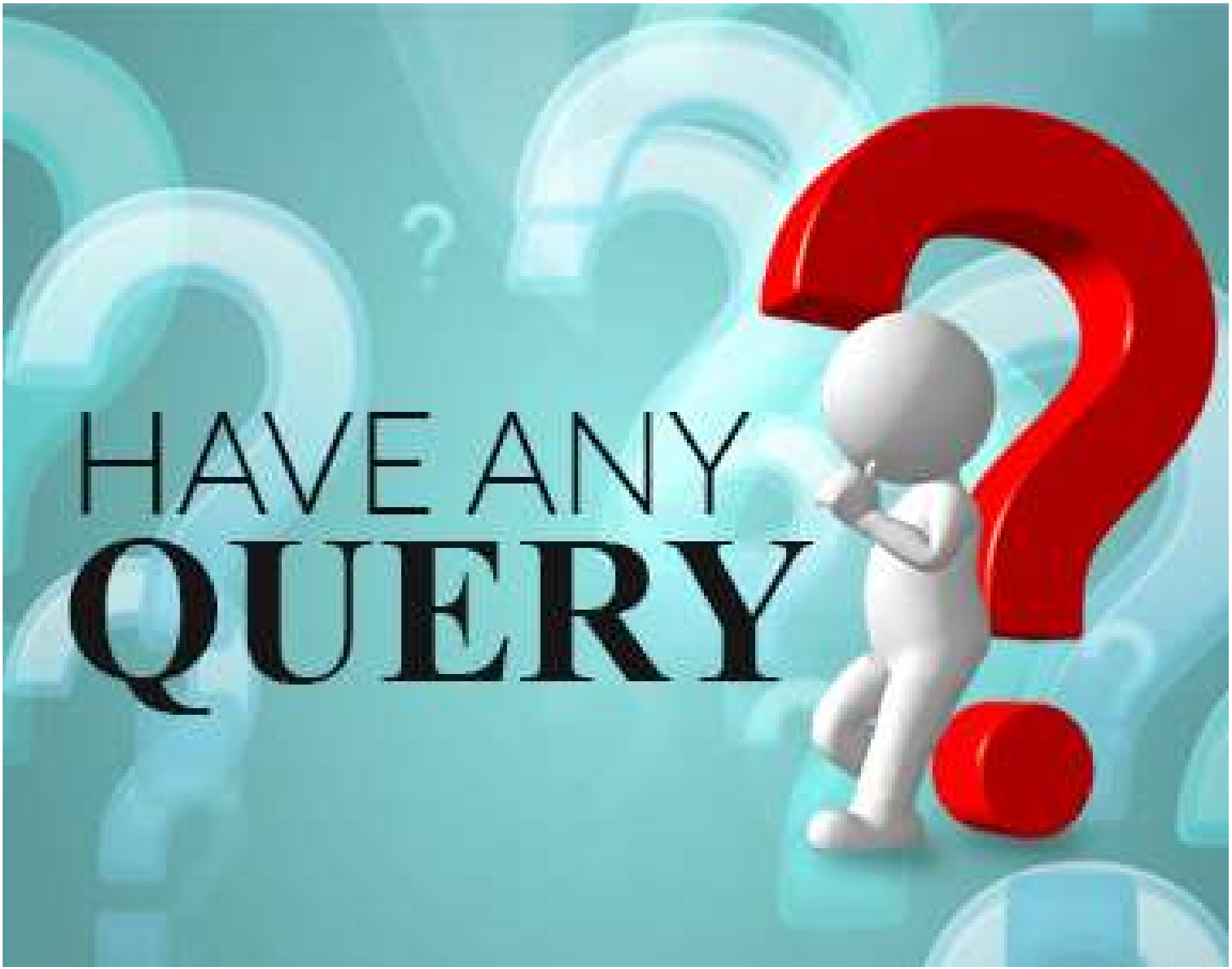
- It is often of engineering importance to design (synthesize) a four-bar mechanism that gives angular positions of an output part (usually a oscillating shaft) that are a function of the angular positions of the input part (usually a oscillating shaft).

- The motion of the output and the input links may be prescribed by an arbitrary function $y = f(x)$. This means if the input link moves by x, the output link moves by $y = f(x)$

- Example Functions generation are: $y = \sin(x)$, $y = 1/x$, $y = x^2$, $y = 1 / x^2$, $y = e^x$, $y = \log_{10} x$ etc...

Function Generation

- Correlation of an input function with an output function in a mechanism
- A double-rocker or crank-rocker is the result, with pure rotation input and pure rotation output
- A slider-crank linkage can be a function generator as well, driven from either end, i.e., rotation in and translation out or vice versa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