Kinematics

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Kinematics

Kinematics is the branch of mechanics concerned with the study of motion, i.e., displacement and its derivatives such as velocity, acceleration, and jerk.

A rigid body is defined as one in which the relative positions of all particles remain unchanged throughout its function as kinematic element.

A mechanism is a combination of mechanical elements selected so as to produce a desired motion.

If the mechanism transmits substantial forces it is called a machine.

If the forces in a machine are derived from the transformation of energy from high temperature fluids into shaft power then the system may be called an engine.

Kinematics

Kinematic chains (or linkages) are combinations of rigid bodies (or links) connected by joints.

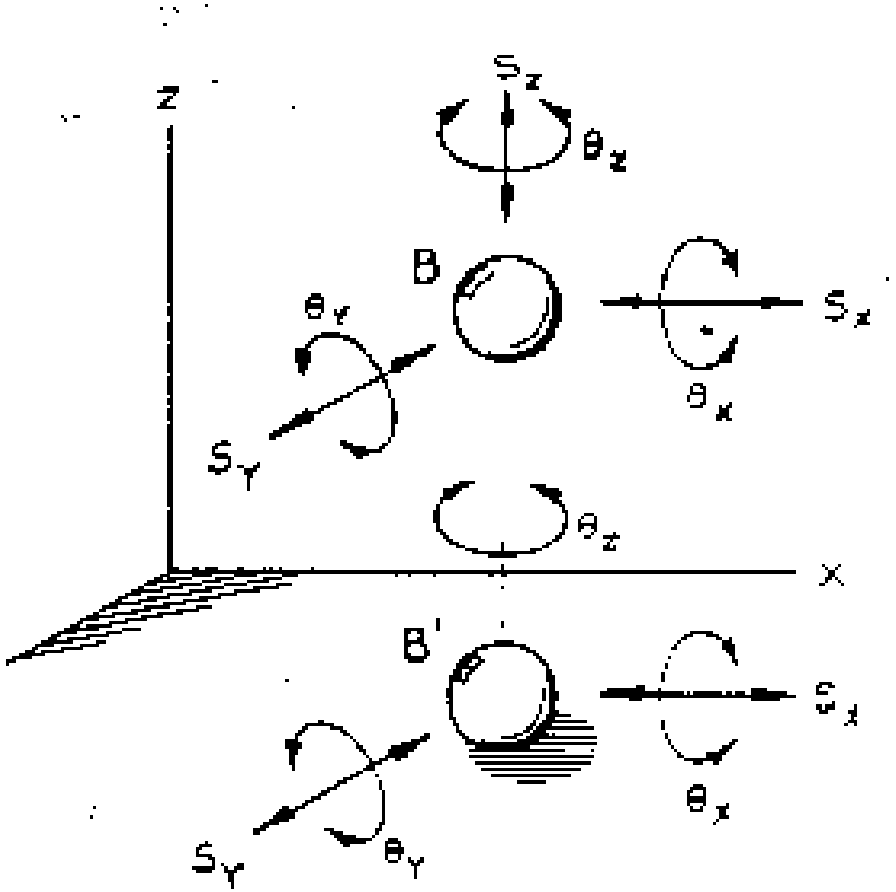
Kinematic joints are the contacts between links that define the constraints.

Kinematic chains can be movable or immovable. An immovable chain is called a structure.

A movable chain can be made into a mechanism by fixing one of its links which is then called ground or frame. It is essential for a mechanism that its function be predictable and unchangeable such that for every input motion there be exactly the same output.

The design of such chains for specific purpose is the main objective of the study of kinematics in mechanical engineering.

Degrees of Freedom

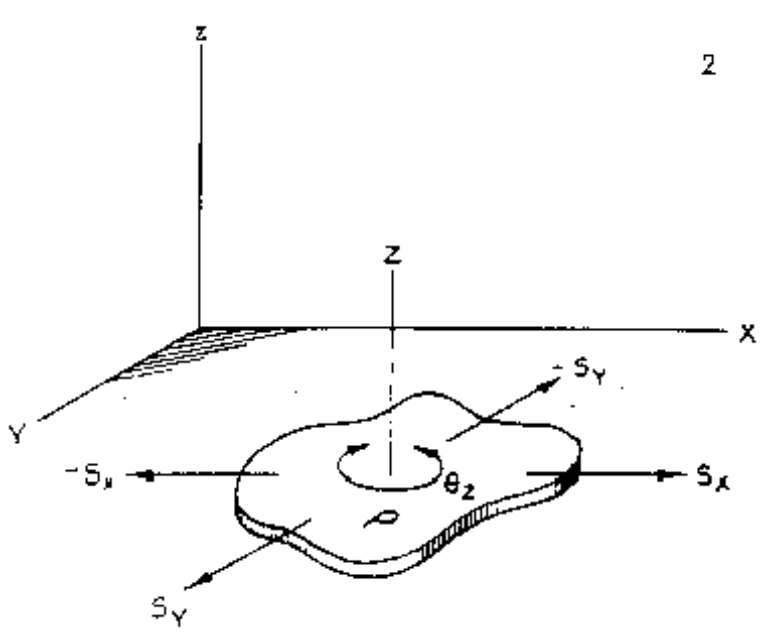


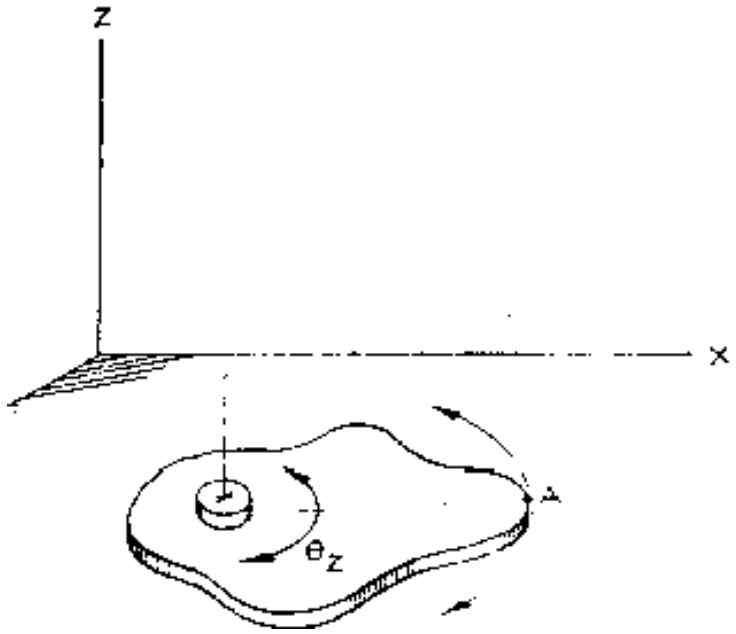
A body in space has six degrees of freedom, three in translation, and three in rotation.

A ball on a plane has five degrees of freedom.

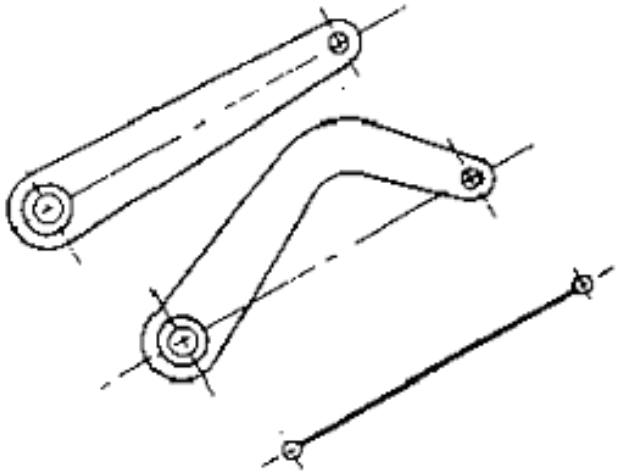
Degrees of Freedom

A flat body resting on a plane has three degrees of freedom.
Two degrees in translation and one degree in rotation about the axis normal to the plane.

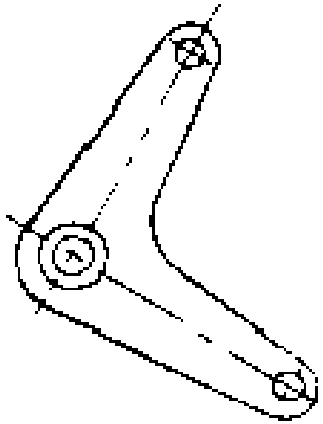




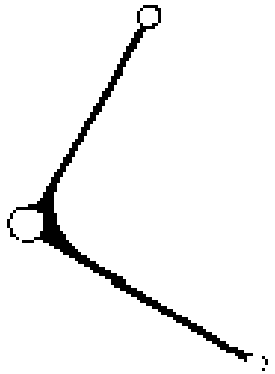
Links



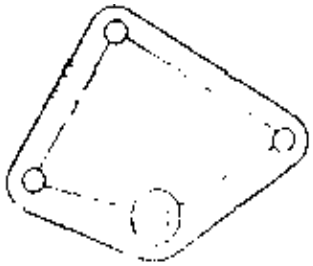
Kinematically identical binary links (two joints)



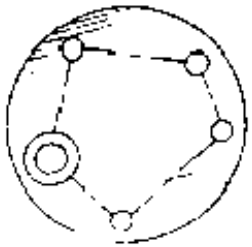
Ternary link (three joints)



Skeleton of ternary link

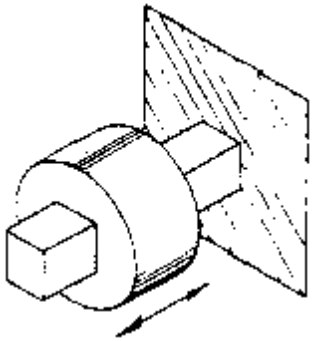


Quarternary link

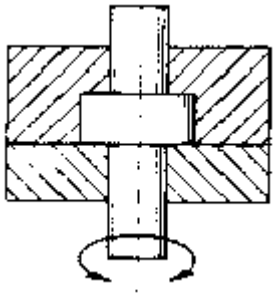


Quintary link

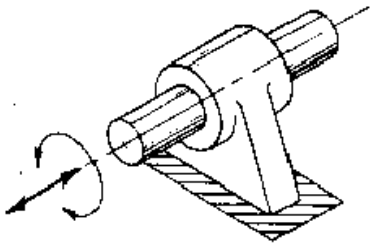
Joints



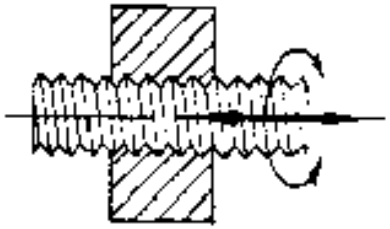
Sliding pair



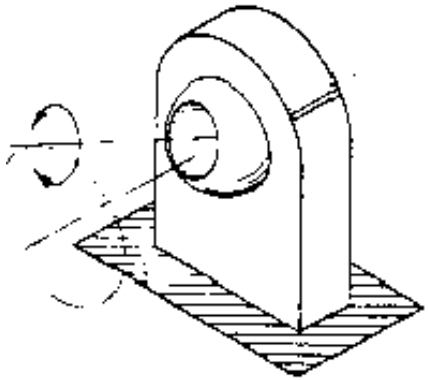
Turning pair



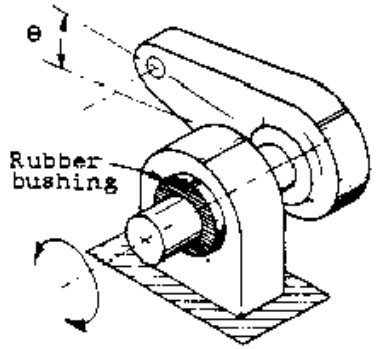
Sliding and turning



Screw Pair

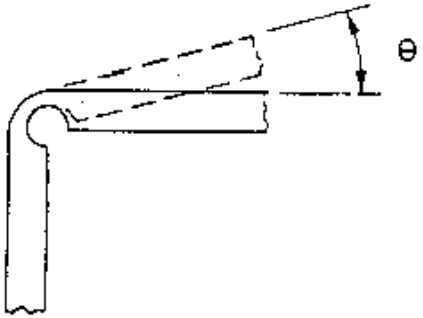


Ball & socket pair.



Elastomeric pair.

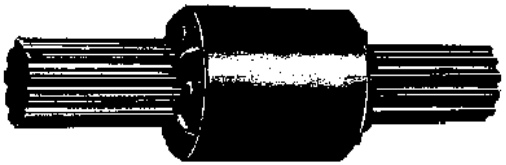
Links



Flexural pair. Used for limited turning.

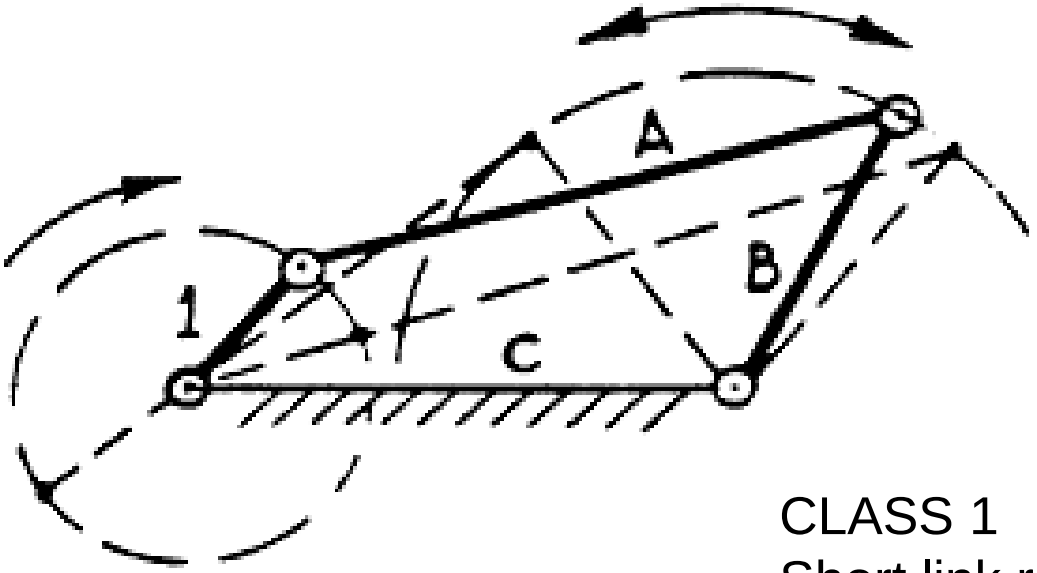
Low-friction ball-screw pair.

Adjustable-length binary link. Ball & socket pairs.



Sliding pair. Ball-spline.

Four-bar Linkage

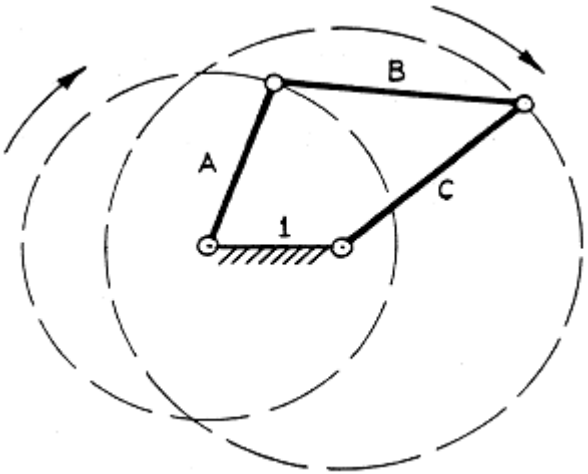


CLASS 1
Short link revolves continuously.
Called Crank & Rocker type.
Dimensional conditions are:

$C + 1 < A + B$ and $C - 1 > |A - B|$

1 – Crank driver
A – Coupler Bar (connecting rod)
B – Rocker follower (follower crank)
C – Ground (line of centers)

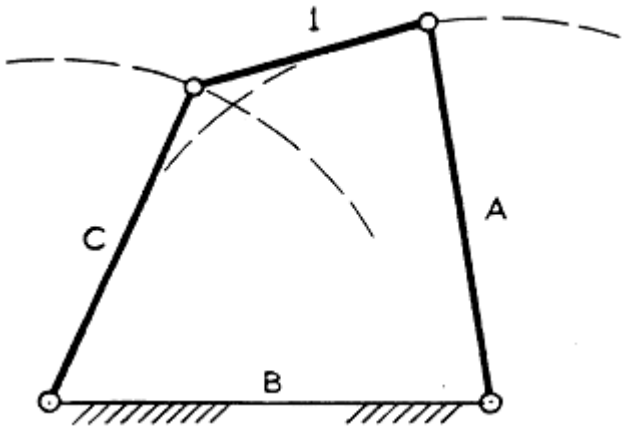
Four-bar Linkage



CLASS 2

Shorter link is fixed becoming ground. The two cranks revolve continuously.

Dimensional conditions are the same as those of Class 1.

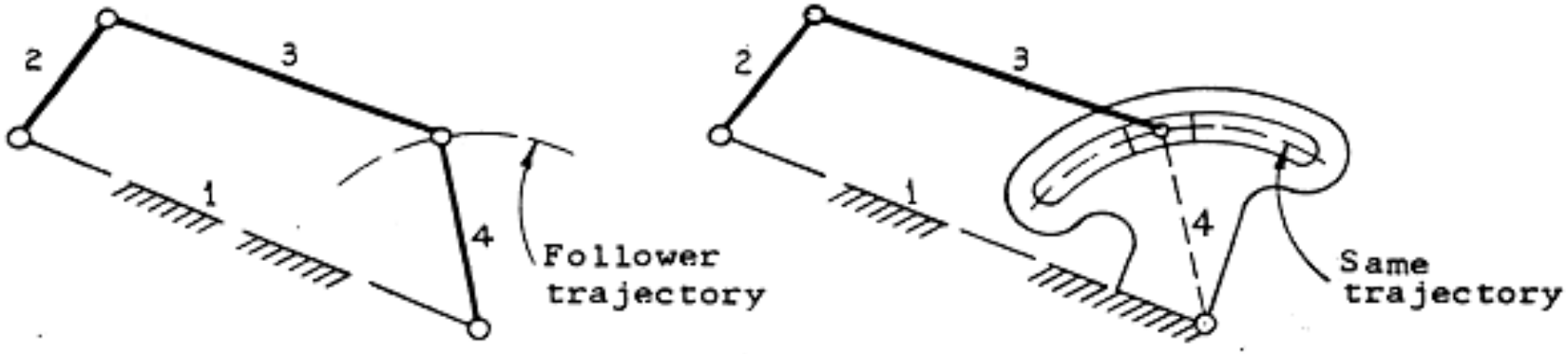


CLASS 3

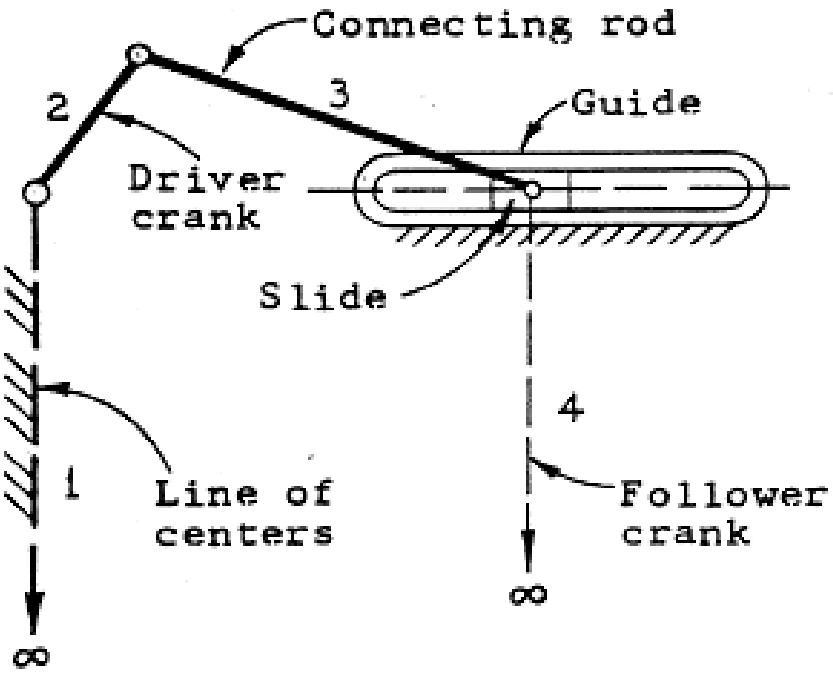
Either crank can be driver or follower. Neither crank can revolve completely.

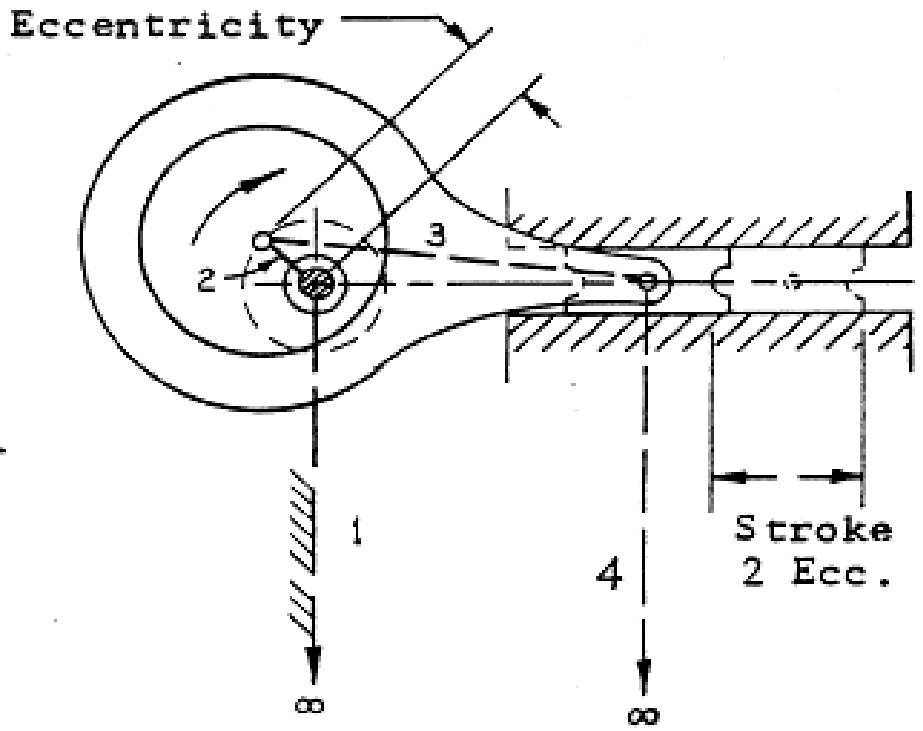
This is called a Rocker Linkage.

Four-bar Linkage

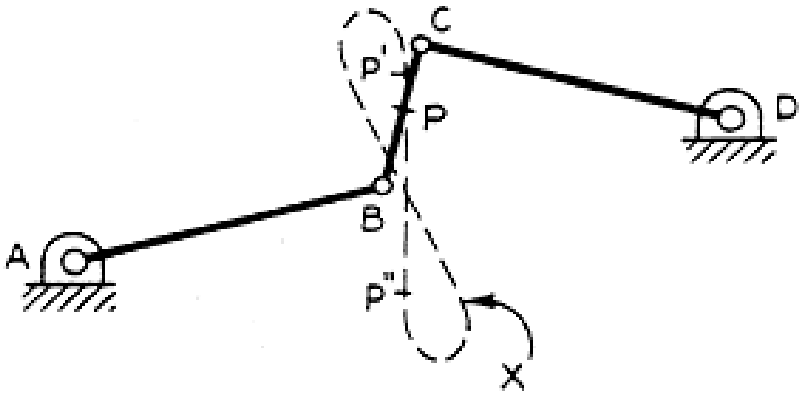


Slider-crank Linkage

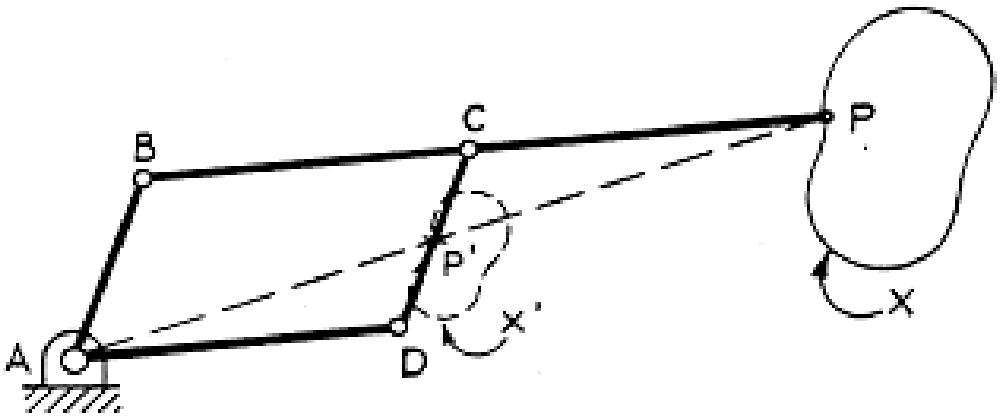




Special Linkages

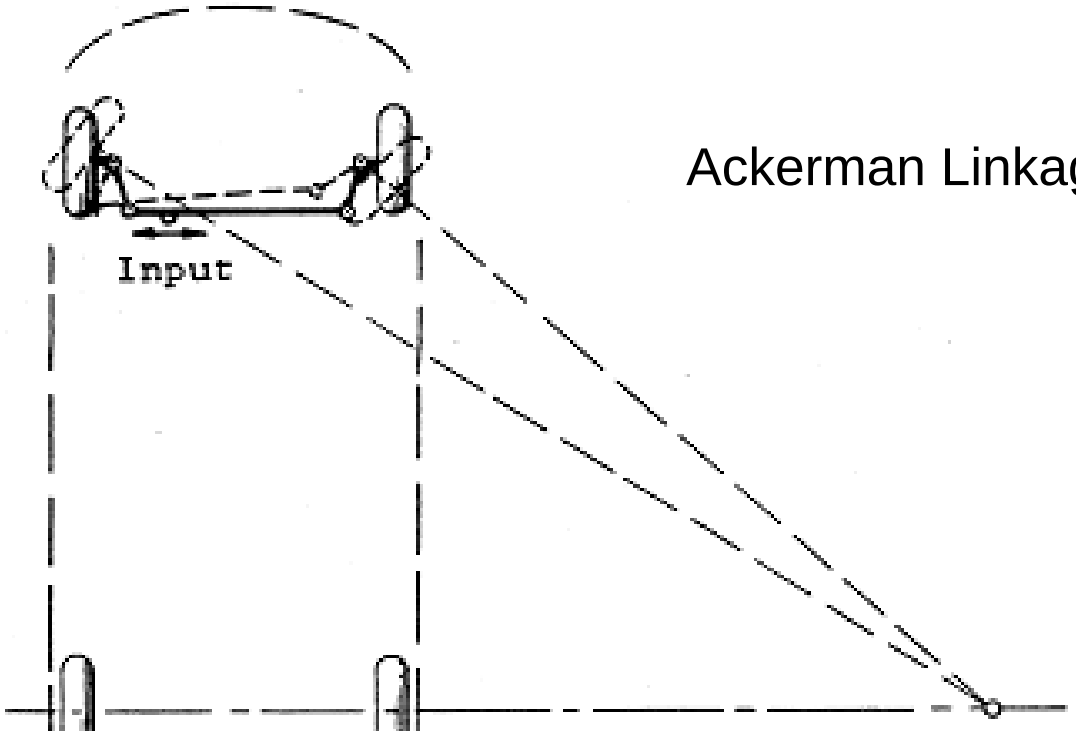


James Watt's approximate straight-line linkage.

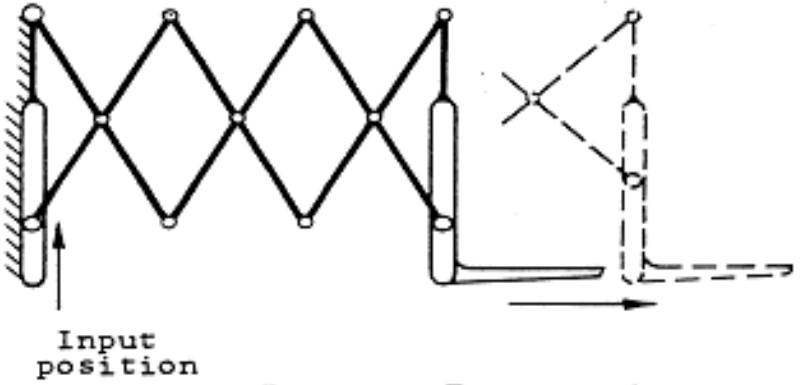


Pantograph

Special Linkages

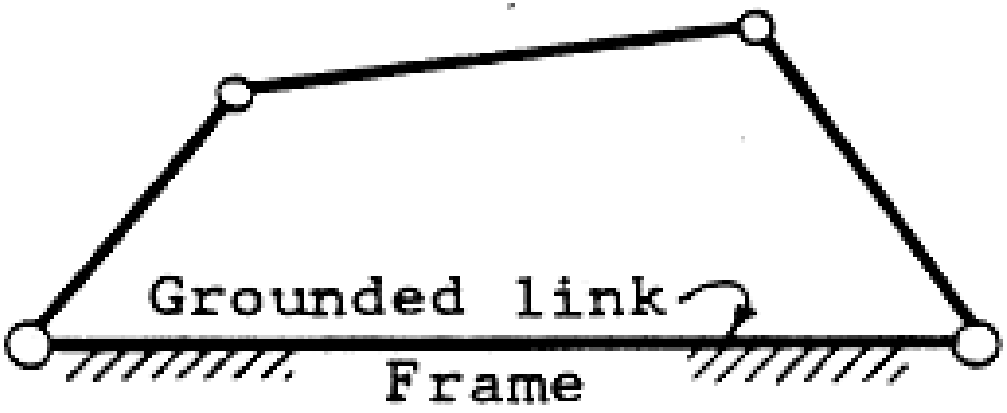


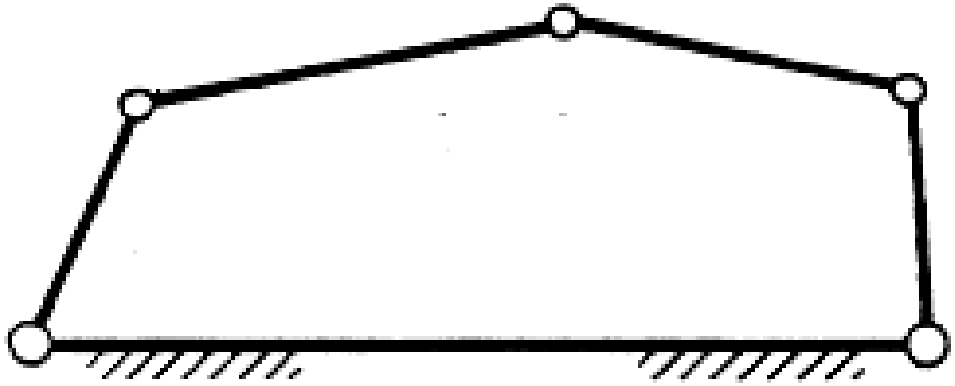
Ackerman Linkage



Lazy Tongs Linkage

Equivalent Linkages





Analysis of Moveability

Grubler's criterion of moveability in mechanisms

F=3(L-1) - 2J

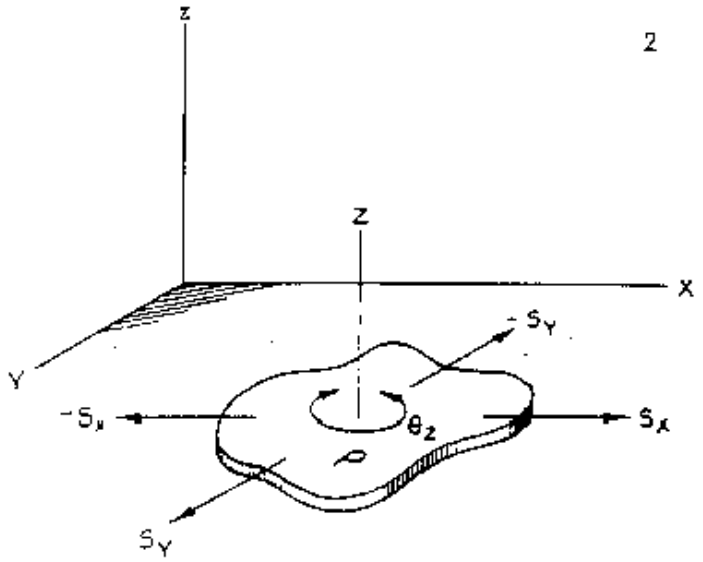
F=Degrees of freedom

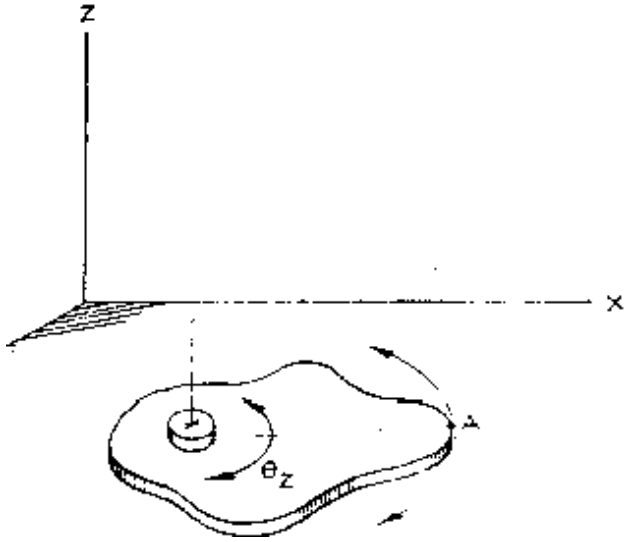
L=Number of links

J=Number of joints.

When several links are attached to one joint,

J=N-1 where N is the number of links attached to the joint.





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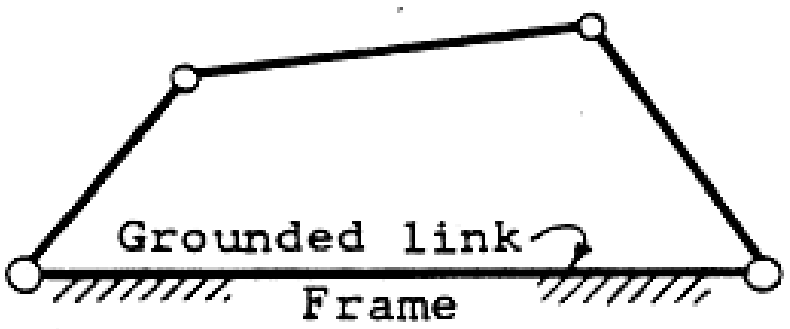
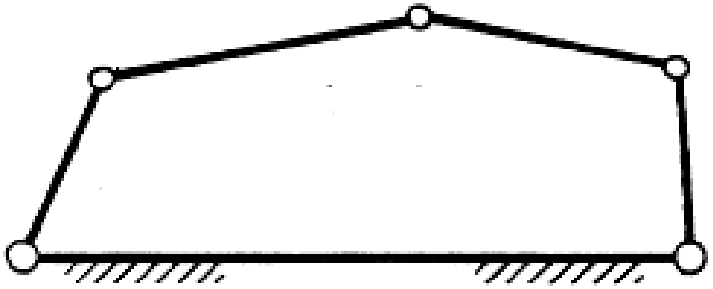


L=4, J=4, F=1

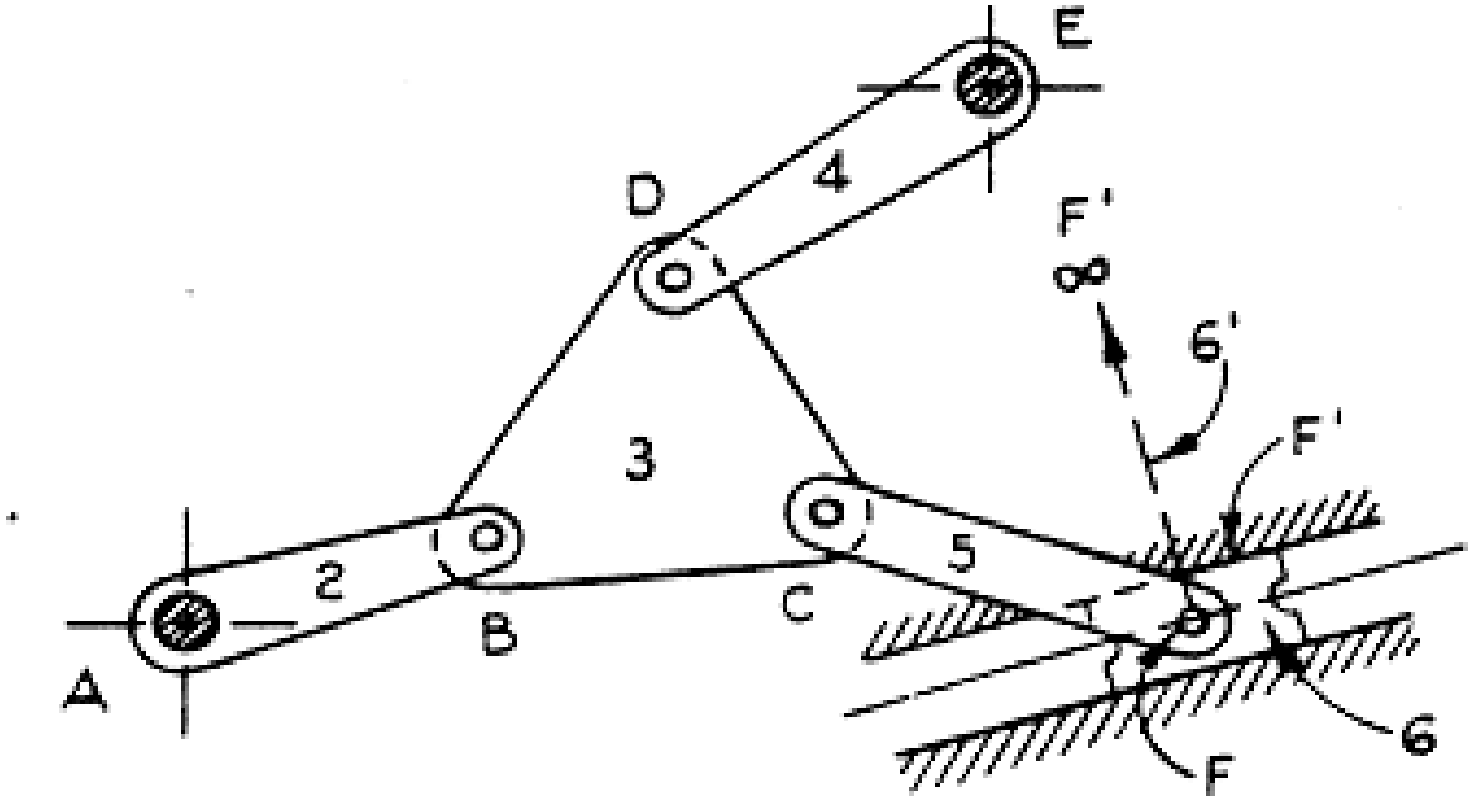
A movable chain can be made into a mechanism by fixing one of its links which is then called ground or frame. It is essential for a mechanism that its function be predictable and unchangeable such that for every input motion there be exactly the same output.



L=5, J=5, F=2
Unconstrained Linkage

Analysis of Moveability

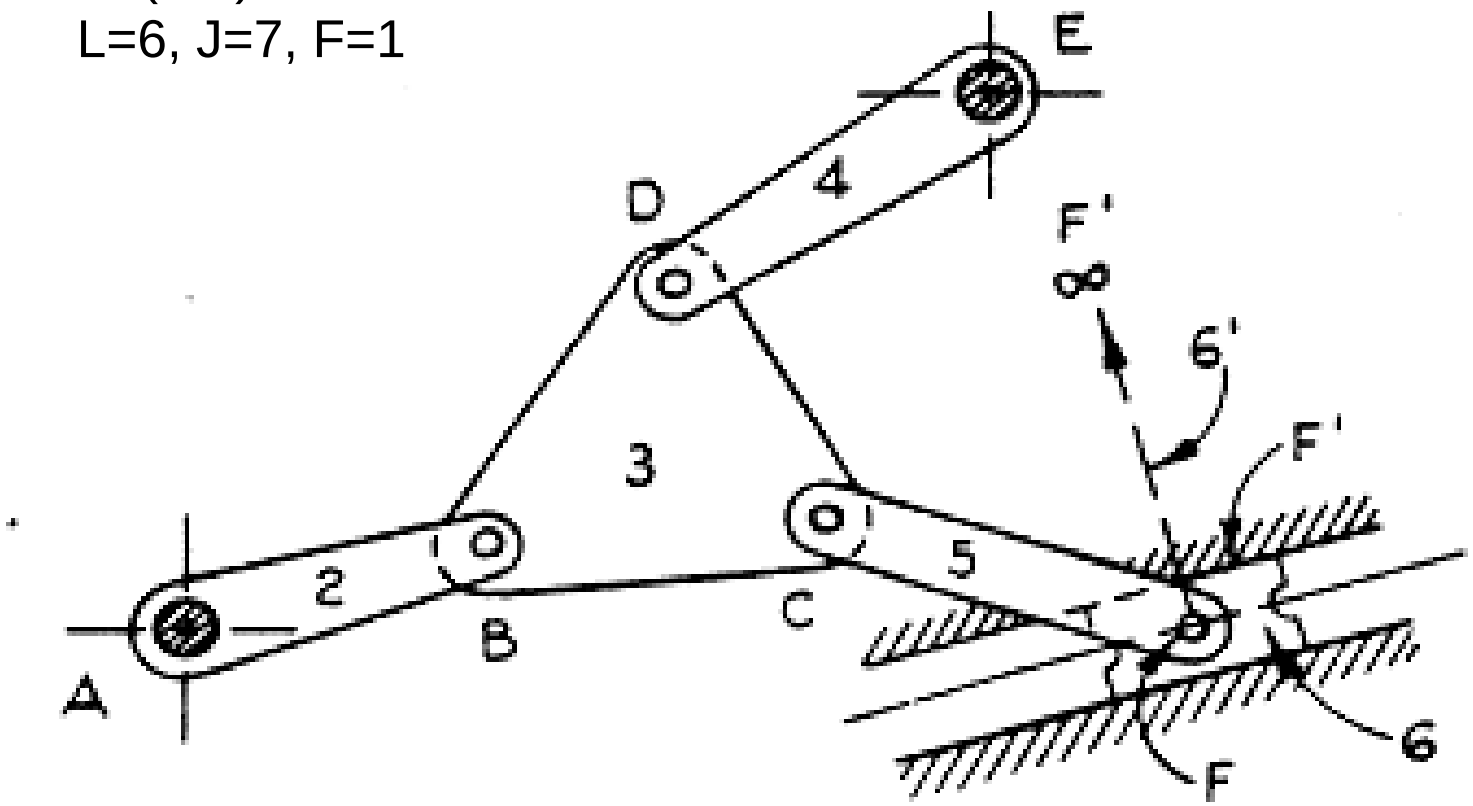
F=3(L-1) - 2J



Analysis of Moveability

F=3(L-1) - 2J

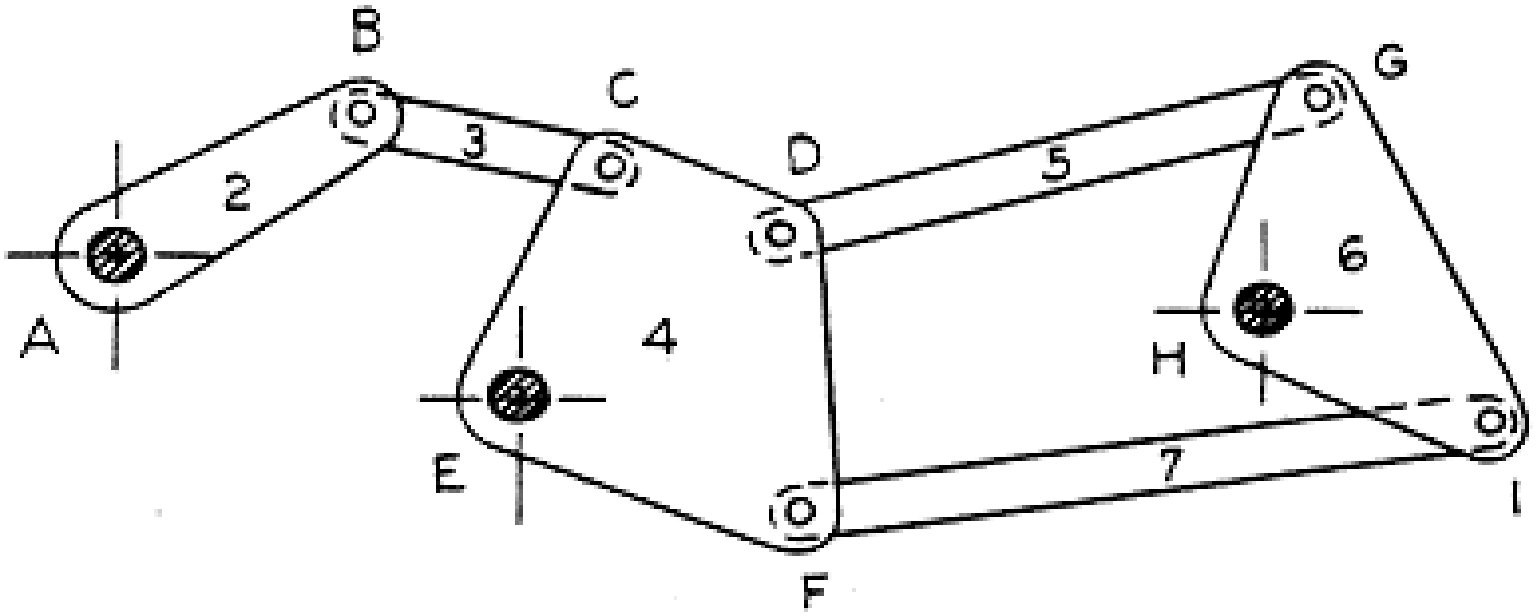
L=6, J=7, F=1



Analysis of Moveability

F=3(L-1) - 2J

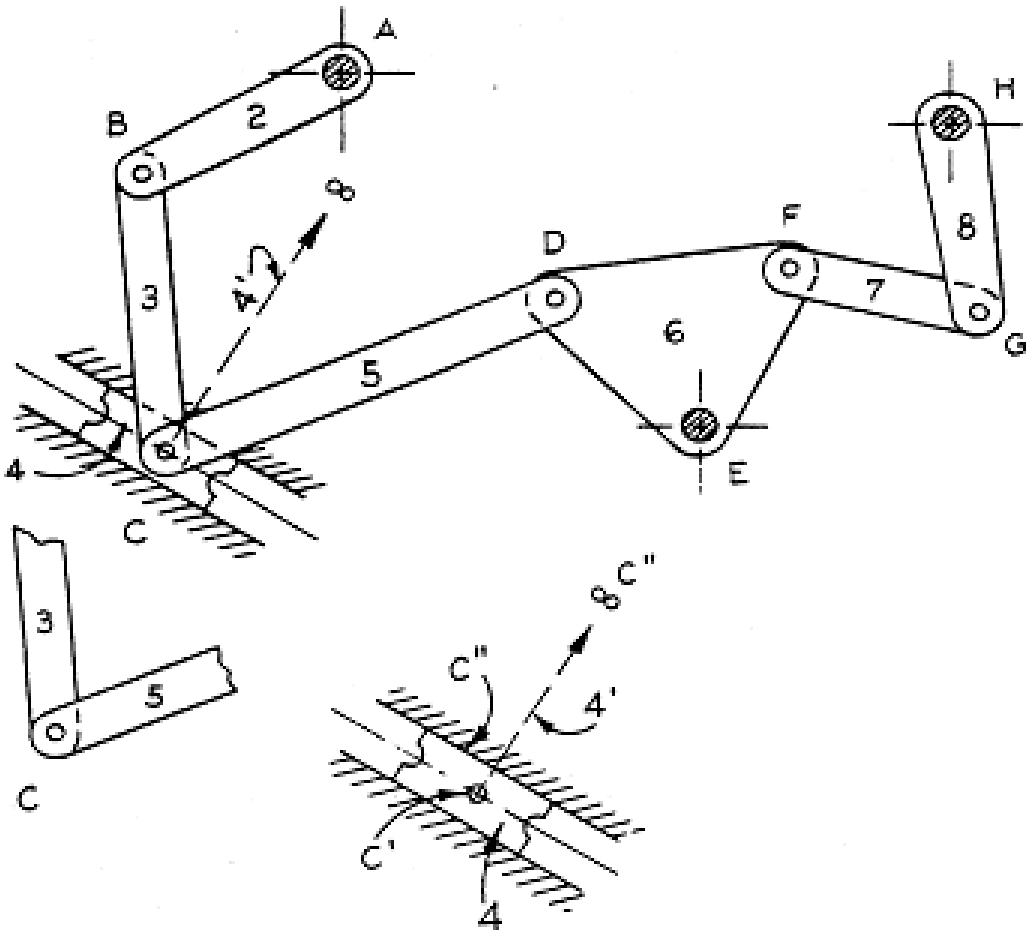
L=7, J=9, F=0



Analysis of Moveability

F=3(L-1) - 2J

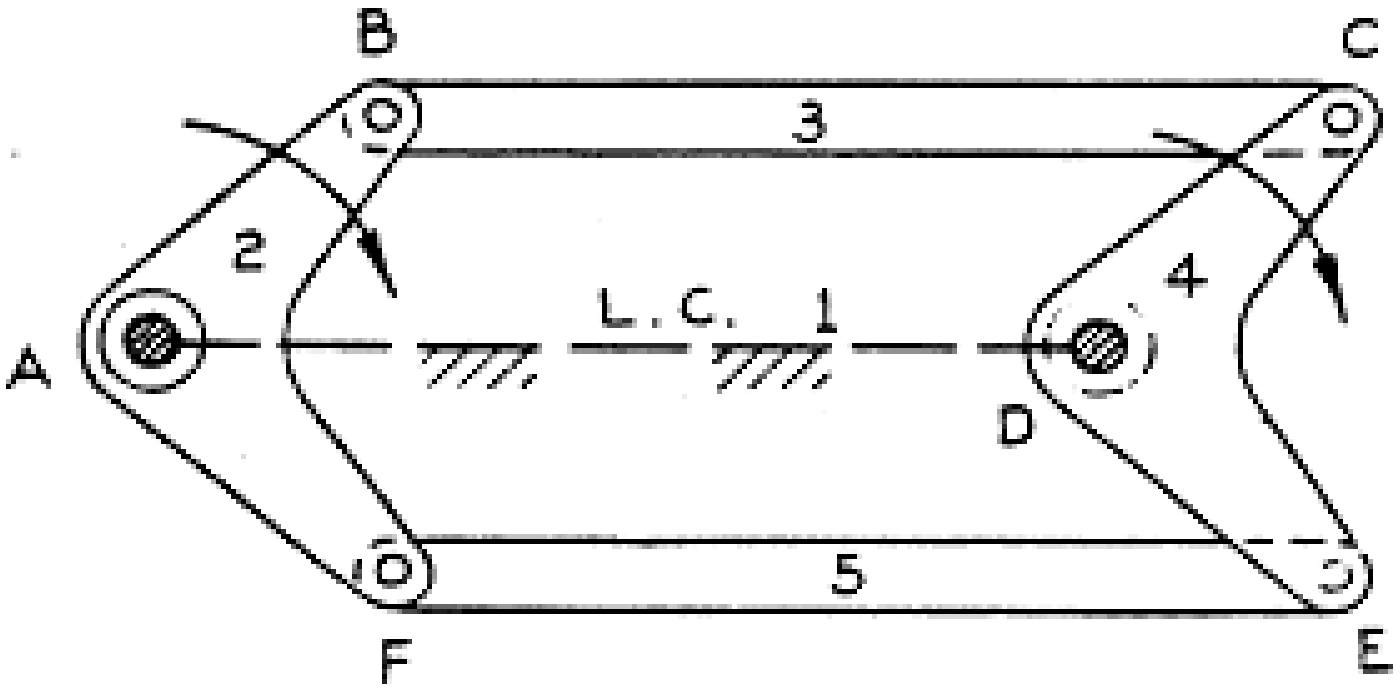
L=8, J=10, F=1



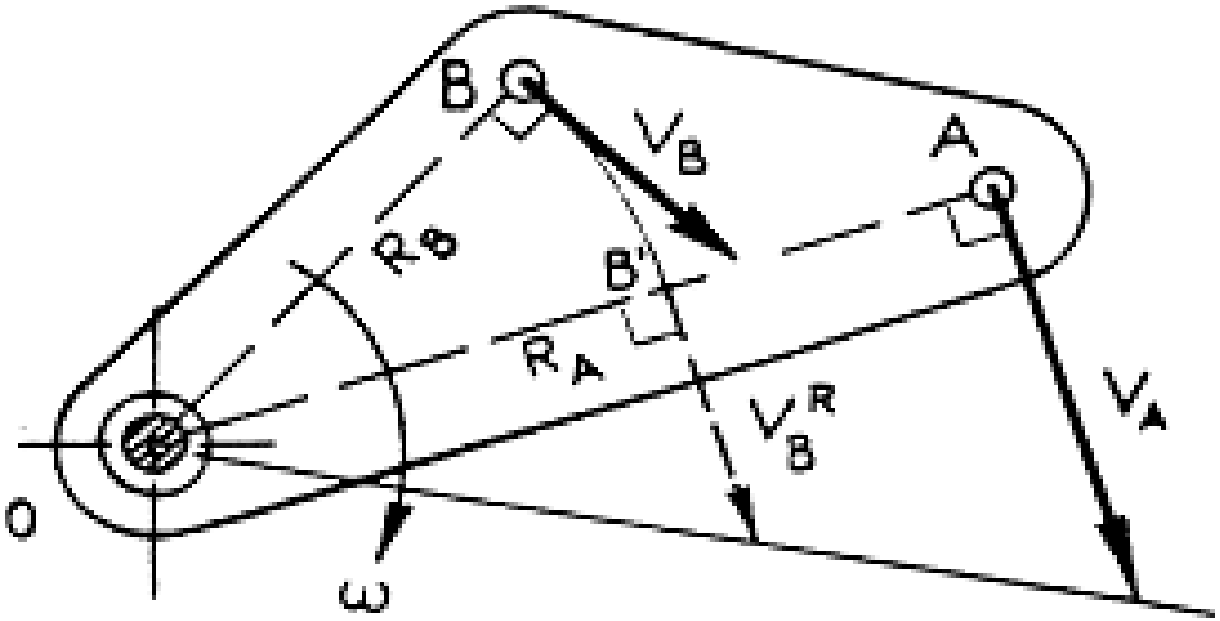
Analysis of Moveability

F=3(L-1) - 2J

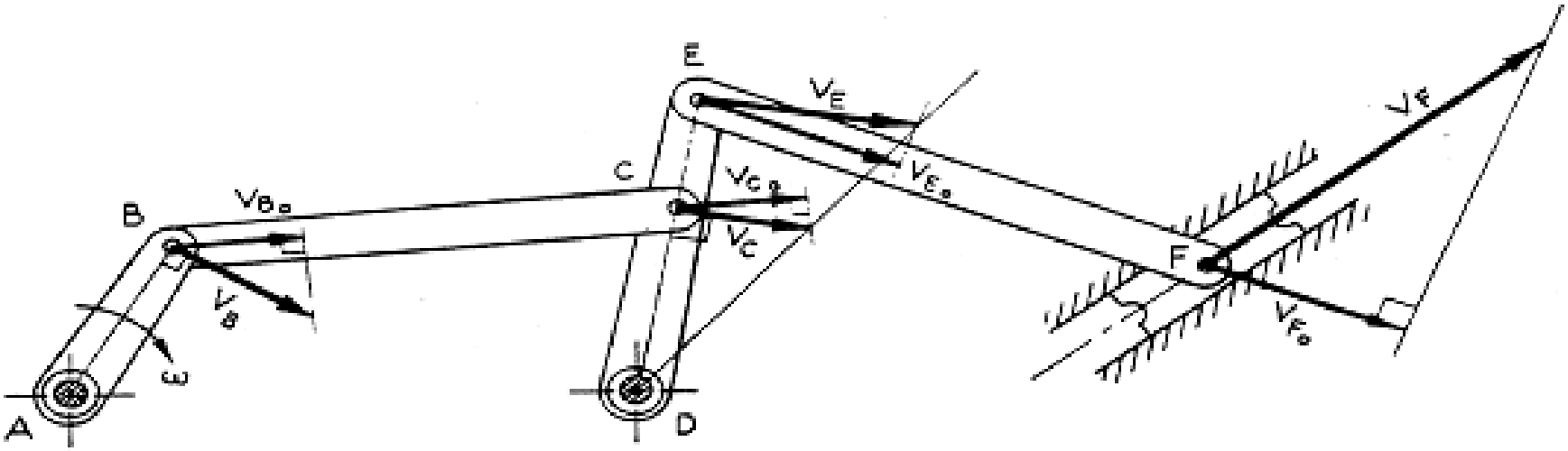
L=5, J=6, F=0



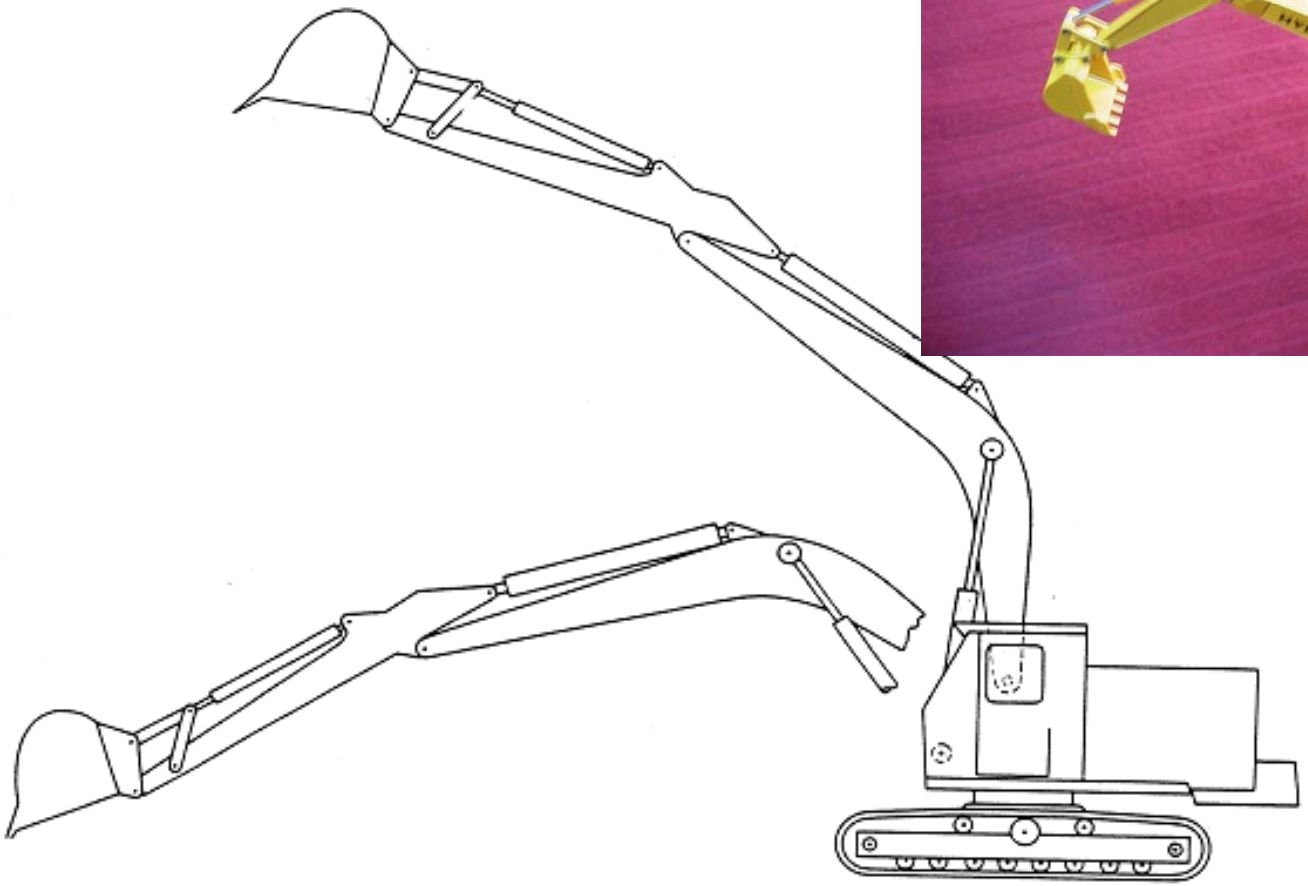
Analysis of Velocity



Analysis of Velocity

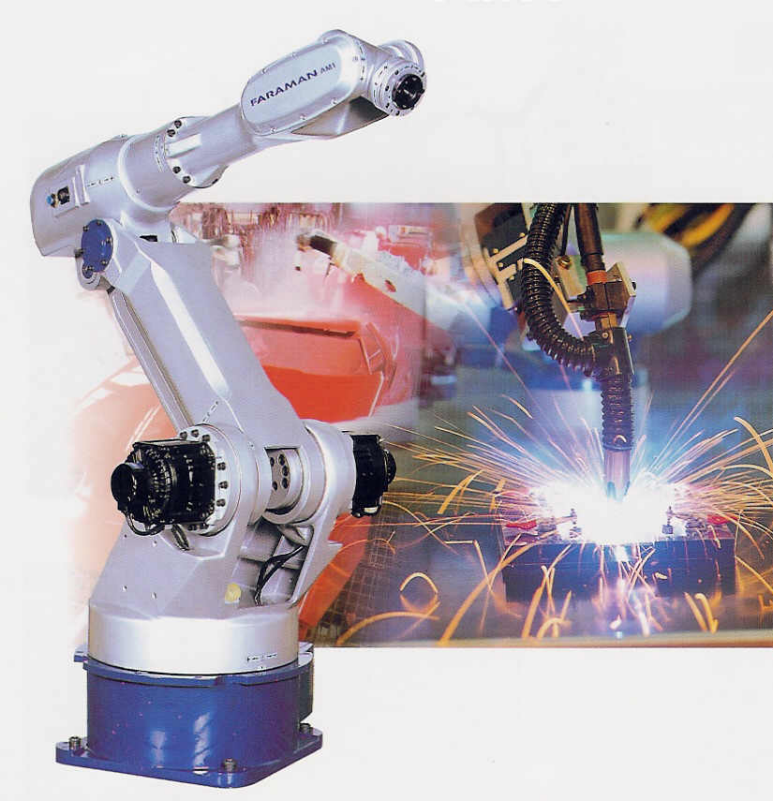


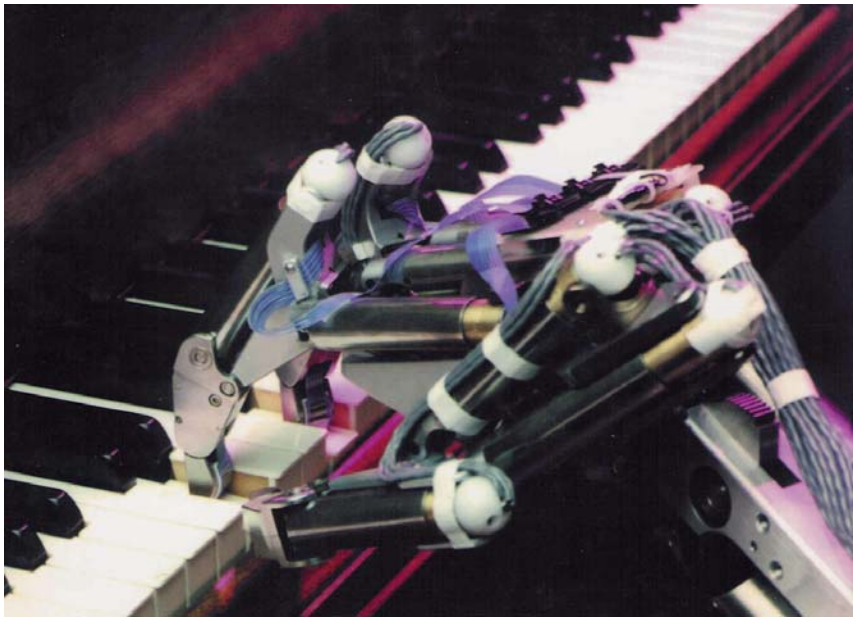
Homework



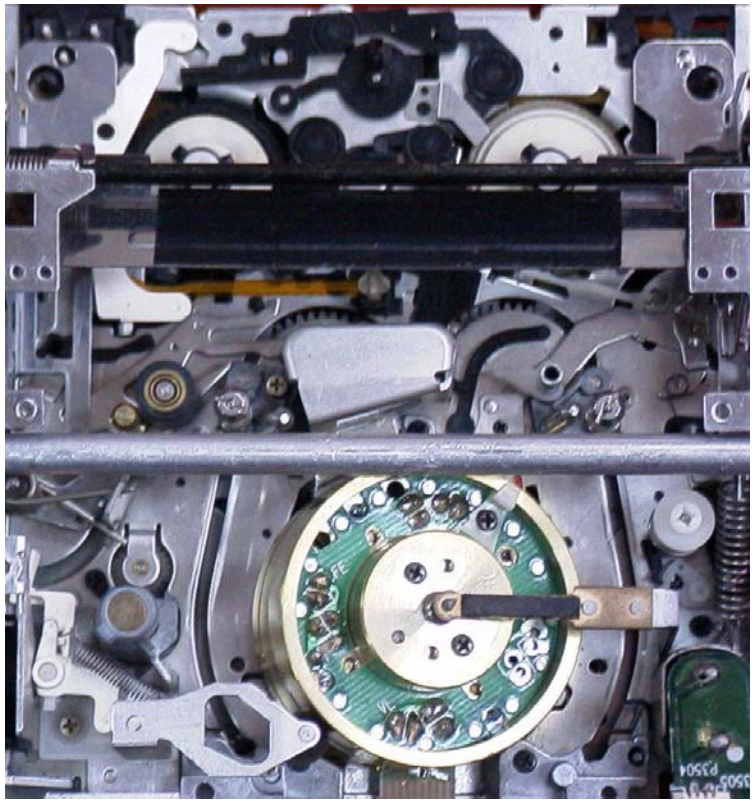
PREMA
PRECISION ENGINEERING & MANUFACTURING

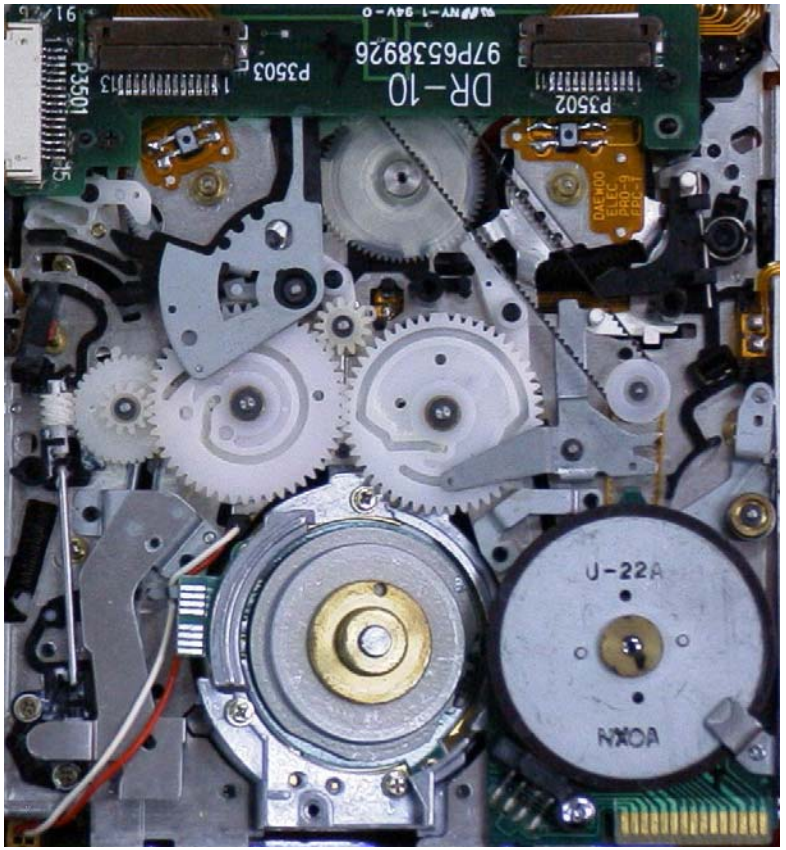
Robot



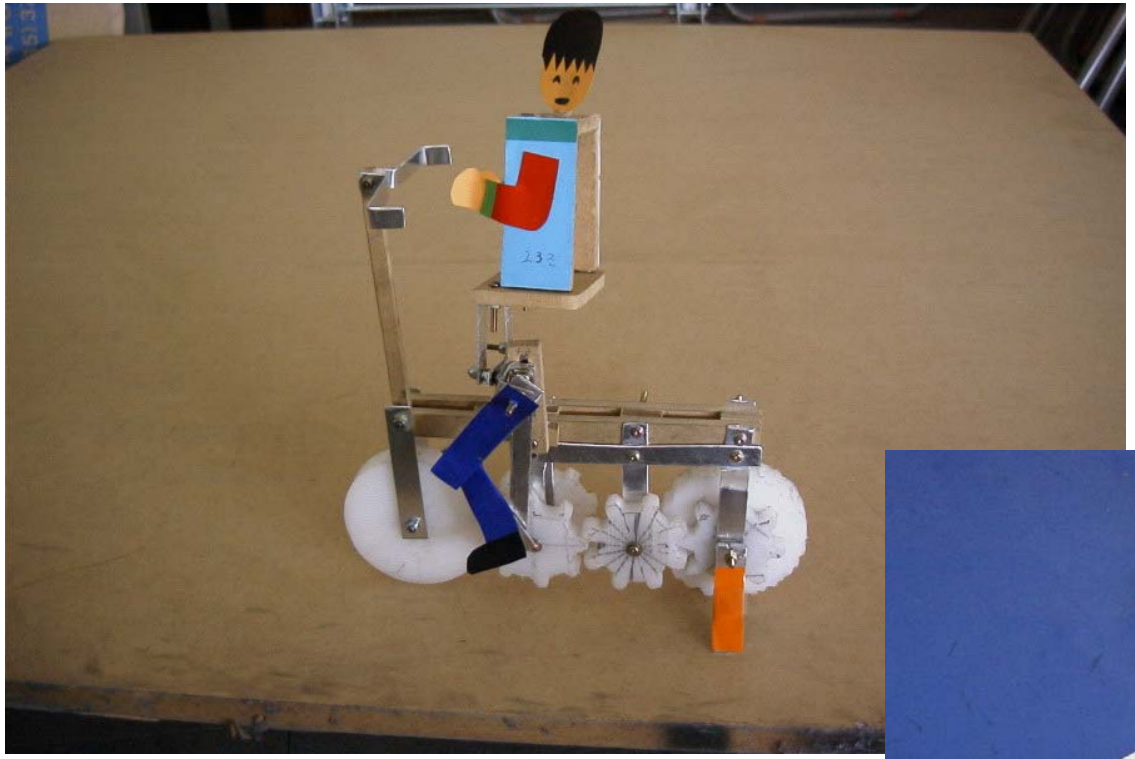


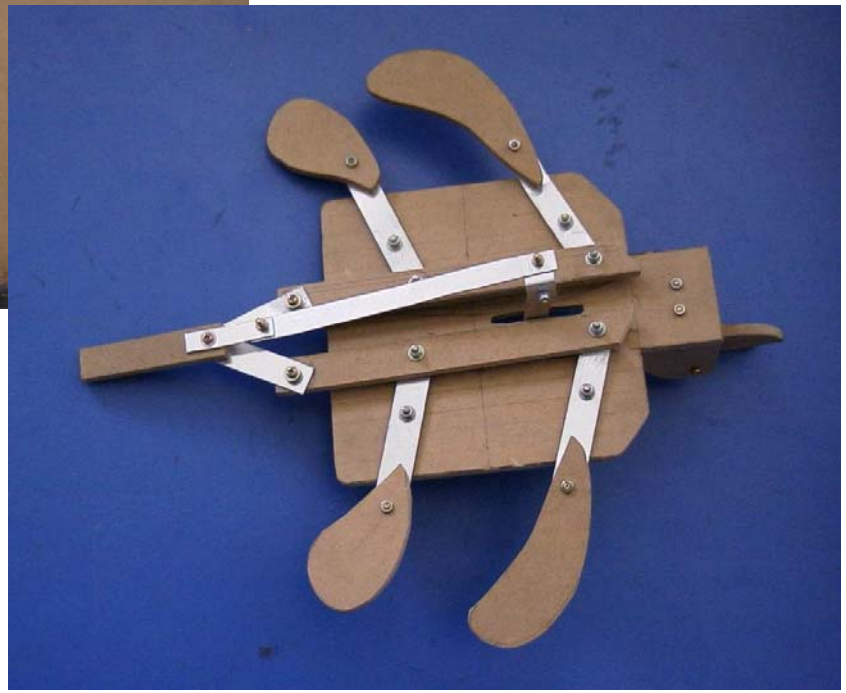
VCR





Linkage Project





Linkage Project