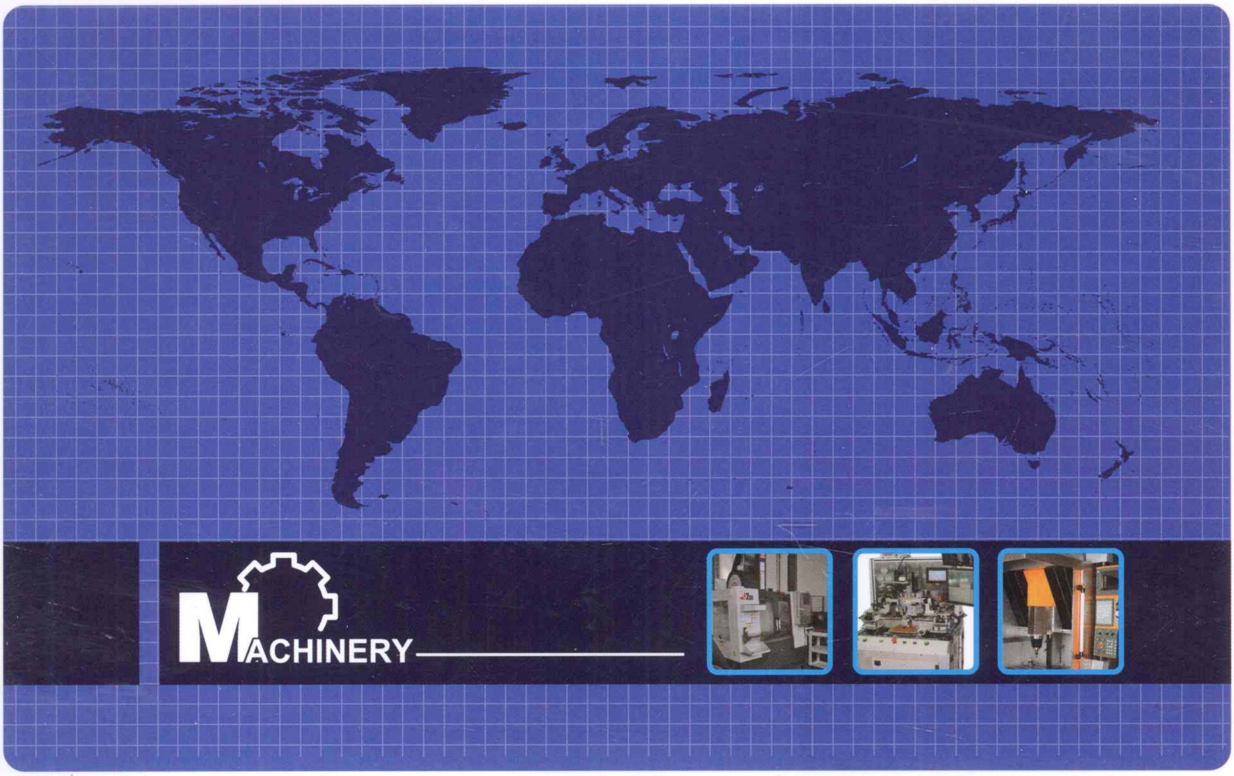
普通高等教育“十二五”机电类规划教材



新编机电工程专业英语

朱 林 杨春杰 主编

- 全部课文节选自欧美科技文献原著
- 资料新而全，反应学科的发展趋势
- 附科技英语翻译及写作的简单介绍

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朱　林　杨春杰　主　编
刘永斌　邰金华　副主编

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内 容 简 介

本书为机电工程专业英语课程配套教材，共分为 7 个单元，详细介绍了以下主要内容：机械设计理论及技术、金属材料及热加工、金属切削原理与机床、机械电子、液压传动、汽车构造和工作性能、几何公差与配合、CAD/CAE/CAPP/CAM 及 MEMS/NEMS 技术、生物力学、热管工程应用技术、机械工程文献介绍及英文写作等内容，力求使读者既能全面了解重要的专业知识，又能切实提高专业英语的阅读和应用水平。为了便于讲授和阅读，编者在每一章后都对一些疑难句子做了注释；最后还附有全书课文的相关译文。

本书可作为高等院校机械设计制造及自动化、车辆工程、机电一体化、工业工程、材料成形及控制工程等专业的高年级本科生和研究生学习机电工程专业英语的教材，也可以作为从事机电工程相关工作的技术人员或管理者的参考书。

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前　　言

本书为机电工程专业英语课程配套教材，全书共分为 7 个单元，每个单元包含 4～6 课，每课供 2 个学时使用。各专业可以适当节选内容，以满足各自不同的教学要求。本书内容主要涉及机械设计理论及技术、金属材料及热加工、金属切削原理与机床、机械电子、液压传动、汽车构造和工作性能、几何公差与配合、CAD/CAE/CAPP/CAM 及 MEMS/NEMS 技术、生物力学、热管工程应用技术、机械工程文献介绍及英文写作等。本书还附有每篇文章的中文译文。

本书资料新颖，内容涵盖面广，既可作为高等院校机械设计制造及自动化、车辆工程、机电一体化、工业工程、材料成形及控制工程等专业的研究生和本科生学习机电工程专业英语的教材，也可作为从事机电工程相关工作的技术人员和管理者的参考书。

本书课文全部节选自欧美文献原著。为保持原著的语言风格，编者对选材一般只作删节，不作改写；对原著中采用的各种计量单位及图样标注均不作改动。本书原稿曾作为“机电工程专业英语”选修课的校内讲义，供高年级本科生和工程硕士生使用了多年。在听取了有关老师和学生的意见和建议后，我们对书稿又作了较大的增删与修改，直至成书。

本书由朱林、杨春杰担任主编，刘永斌、郇金华老师任副主编。在原稿的录入和编辑、配图过程中得到了编者两位硕士研究生程曦、彭双双的协助，在此表示衷心的感谢。

尽管我们为编写本书付出了努力和心血，但书中难免有疏漏和不当之处，敬请各位专家学者批评指正。

编　者

2013 年 7 月于合肥

目　录

Unit One Mechanisms and Machine Theory

Lesson 1 Mechanisms

Part A Text

A mechanism is a member combination that more than two or two connections with the members realize the regulation motion made up by way of the activity. They are the component of machinery. Activity connections between two members that have the relative motion are called the motion pairs. All motion pairs contacts with planes are called lower pairs and all motion pairs contacts with points or lines are called high pairs. The motion specific property of mechanism chiefly depends on the relative size between the member, and the character of motion pairs, as well as the mutual disposition method etc[1]. The member that is used to support the member of motion in the mechanism is called the machine frame and used as the reference coordinate for the study of the motion system. The member that possesses the independence motion is called motivity member. The member except machine frame and motivity member being compelled to move in the mechanism is called driven member. The independent parameter (coordinate number) essential for description or definite mechanism motion is called the free degree of mechanism. For gaining the definite relative motion between the members of mechanism, it is necessary to make the number of motivity members of mechanism equal the number of free degrees.

Mechanisms may be categorized in several different ways to emphasize their similarities and differences. Mechanisms are generally divided into planar, spherical, and spatial categories. All three groups have many things in common; the criterion which distinguishes the groups, however, is to be found in the characteristics of the motions of the links[2].

A planar mechanism is one in which all particles describe plane curves in space and all these curves lie in parallel places ,i.e. the loci of all points are plane curves parallel to a single common plane. This characteristic makes it possible to represent the locus of any chosen point of a planar mechanism in its true size and shape on a single drawing or figure[3]. The motion transformation of any such mechanism is called coplanar. The plane four-bar linkage, the plate cam and driven parts, and the slider-crank mechanism are familiar examples of planar mechanism. The vast majority of mechanism in use today is planar. The following Fig.1.1 is cam mechanism.

A cam is a machine member that drives a follower through a specified motion. By the proper design of a cam, any desired motion to a machine member can be obtained. As such, cams are widely used in almost all machinery. They include internal combustion engines, a variety of machine tools, compressors and computers. In general, a cam can be designed in two ways.

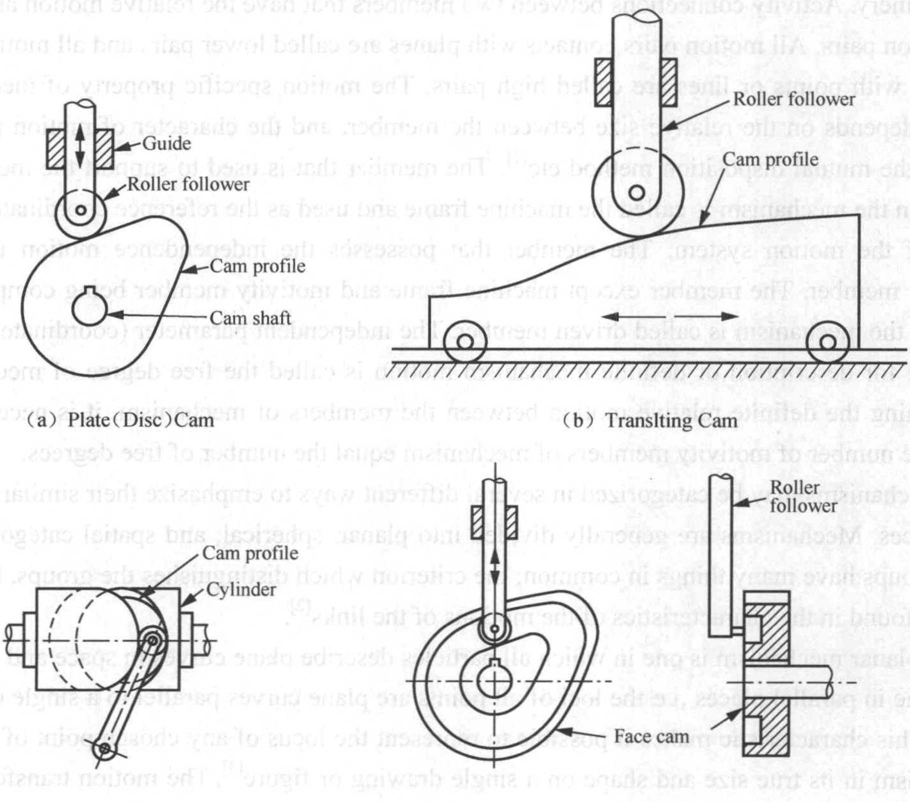
(1) To design an optimal profile of a cam to give a desired motion to the follower.

(2) To choose a suitable profile to ensure a satisfactory performance by the follower.

A rotary cam is a part of a machine, which changes cylindrical motion to straight-line motion. The purpose of a cam is to transmit various kinds of motion to other parts of a machine.

Practically every cam must be designed and manufactured to fit special requirements. Though each cam appears to be quite different from the other, all of them work in similar ways. In each case, as the cam is rotated or turned, another part is connected with the cam, called a follower, is moved either right or left, up and down, or in and out. The follower is usually connected to other parts on the machine to accomplish the desired action. If the follower loses contact with the cam, it will fail to work.

According to their basic shapes, cams are classified into four different types as illustrated in Fig.1.1.



(a) Plate(Disc)Cam (b) Transliting Cam

(c) Cylindrical Cam (d) Face Cam

Fig.1.1 Types of cam mechcanism

(1) Plate (Disc) Cam.

(2) Translation Cam.

(3) Cylindrical Cam.

(4) Face Cam.

Planar mechanisms utilizing only lower pairs are called planar linkages; they may include only revolute and prismatic pairs. Although a planar pair might theoretically be included, this would impose no constraint and thus be equivalent to an opening in the kinematics chain. Planar motion also requires that axes of all prismatic pairs and all revolute axes be normal to the plane motion.

Words and Expressions

motion pairs	运动副
disposition [dispə'ziʃən]	*n.* 配置；排列
machine frame	机座，机架
coordinate [kəu'ɔ:dinit]	*n.* 坐标
motivity member	原动件
parameter [pə'ræmitə]	*n.* 参变量
driven member	从动件
free degree	自由度
categorize ['kætigəraiz]	*v.* 分类
category ['kætigəri]	*n.* 种类，逻辑范畴
planar ['pleinə]	*adj.* 平面的，平坦的
spherical ['sferikəl]	*adj.* 球的，球形的
spatial ['speiʃəl]	*adj.* 空间的
loci ['ləusai]	*n.* [locus 的复数形式] 点的轨迹

Notes

[1] The motion specific property of mechanism chiefly depends on the relative size between the member, and the character of motion pairs, as well as the mutual disposition method etc.

① specific property：特性。

② as well as：不但……而且；和……一样；和；也，表示递进或并列关系。

[2] The criterion which distinguishes the groups，however，is to be found in the characteristics of the motions of the links.

全句翻译：然而，进行分类的标准在于连杆的运动特性。

① to be found 为不定式被动语态。

② links 译为“连杆装置”。

[3] This characteristic makes it possible to represent the locus of any chosen point of a planar mechanism in its true size and shape on a single drawing or figure.

① makes it possible：使……可能。

② represent：描绘，展现。

③ planar mechanism：平面机构。

④ in size and shape：在大小和形状方面。

Part B Reading Materials

A spherical mechanism is one in which each link has some point which remains stationary as the linkage moves and in which the stationary points of all links lie at a common location, i. e. the locus of each point is a curve contained in a spherical surface, and the spherical surfaces defined by several arbitrarily chosen points axes all concentric. The motions of all particles can therefore be completely described by their radial projections, or “shadows”, on the surface of a sphere with properly chosen center.

Spherical linkages are constituted entirely of revolute pairs. A spherical pair would produce no additional constraints and would thus be equivalent to an opening in the chain, while all other tower pairs have no spherical motion. In spherical linkages, the axes of all revolute pairs must intersect at a point.

Spatial mechanisms, on the other hand, include no restrictions on the relative motions of the particles. The motion transformation is not necessary coplanar, nor must it be concentric. A spatial mechanism may have particles with loci of double curvature. Any linkage which contains a screw pair, for example, is a spatial mechanism, since the relative motion within a screw pair is helical. To take an example, worm gear pairs transmit motion between two shafts. The shafts are usually at right angles to each other but do not lie in the same plane. The teeth on the worm slide against the teeth of the worm wheel, producing a rolling action. The worm turns the worm wheel.

Lesson 2 Movement Analysis

Part A Text

One of the simplest and most useful mechanisms is the four-bar linkage. Most of the following description will concentrate on this linkage, but the procedures are also applicable to more complex linkage.

We already know that a four-bar linkage has one degree of freedom. Are there any more that are useful to know about four-bar linkage? Indeed there are! These include the Grashof criteria, the concept of inversion, dead-center position (branch points), branching, transmission angle and their motion feature, including positions, velocities and accelerations.

The four-bar linkage may take form of a so-called crank-rocker or a double-rocker or a double-crank (drag-link) linkage, depending on the range of motion of the two links connected to the ground link. The input crank of a crank-rocker type can rotate continuously through 360, while the output link just "rocks" (or oscillates). As a particular case, in a parallelogram linkage, where the length of the input link equals that of the output link and the lengths of the coupler and the ground link are also the same, both the input and output link may rotate entirely around or switch into a crossed configuration called an anti-parallelogram linkage[1]. Grashof's criteria states that the sum of the shortest and longest links of a planar four-bar linkage cannot be greater than the sum of the remaining two links, if there is to be continuous relative rotation between any two links.

Notice that the same four-bar linkage can be a different type, depending on which link is specified as the frame (or ground). Kinematic inversion is the process of fixing different links of a chain to create different mechanisms. Note that the relative motion between links of a mechanism does not change in different inversions.

Besides having knowledge of the extent of the rotations of the links, it would be useful to have a measure of how well a mechanism might "run" before actually building it. Hartemberg mentions that "run" is a term that means effectiveness with which motion is imparted to the output link; it implies smooth operation, in which a maximum force component is available to produce a force or torque in an output member. Although the resulting output force or torque is not only a function of the geometry of the linkage, but it is generally the result of dynamic or inertia force, which are often several times as large as the static force. For the analysis of low-speed operations or for an easily obtainable index of how any mechanism might run, the concept of the transmission angle is extremely useful. During the motion of a mechanism, the transmission angle changes in value. A transmission angle of 0 degree may occur at a specific position, on which the output link will not move regardless of how large a force is applied to the input link. In fact, due to friction in the joints, the general rule of thumb is to design mechanisms with transmission angle of larger than a specified value. Matrix-based definitions have been developed which measure the ability of a linkage to transmit motion. The value of a determinant (which contains derivatives of output motion variables with respect to an input motion variable for a given linkage geometry [2]) is a measure of the movability of the linkage in a particular position.

If a mechanism has one degree of freedom (e.g. a four-bar linkage), then prescribing one position parameter, such as the angle of the input link, will completely specify the position of the rest of the mechanism (discounting the branching possibility). We can develop an analytical expression relating the absolute angular positions of the links of a four-bar linkage. This will be much more useful than a graphical analysis procedure when analyzing a number of positions and/or a number of different mechanisms, because the expressions will be easily programmed for automatic computation.

The relative velocity or velocity polygon method of performing a velocity analysis of a mechanism is one of several methods available. The pole represents all points on the mechanism having zero velocity. Lines drawn from the pole to points on the velocity polygon represent the absolute velocities of the corresponding points on the mechanism. A line connecting any two points on the velocity polygon represents the relative velocity for the two corresponding points on the mechanism.

Another method is the instantaneous center or instant center method, which is a very useful and often quicker in complex linkage analysis. An instantaneous center or instant center is a point at which there is no relative velocity between two links of a mechanism at that instant. In order to locate the locations of some instant centers of a given mechanism, the Knnedy's theorem of three centers is very useful. It states that the three instantaneous centers of three bodies moving relative to one another must be along a straight line.

The acceleration of links of a mechanism is of interest because of its effect on inertia force, which in turn influences the stress in the parts of a machine, bearing loads, vibration, and nose. Since the ultimate objective is inertia-force analysis of mechanism and machines, all acceleration components should be expressed in one and the same coordinate system: the inertia frame of reference of the fixed link of the mechanism.[3]

Notice that in general there are two components of acceleration of a point on a rigid body rotating about a ground pivot. One component has the direction tangent to the path of this point, pointed in the same sense of the angular acceleration of this body, and is called the tangential acceleration.[4] Its presence is due solely to the rate of change of the angular velocity. The other component, which always points toward the center of rotation of the body, is called the normal or centripetal acceleration. This component is present due to the changing direction of the velocity vector.

Words and Expressions

criterion (*pl.* criteria) [krai'tiəriən]	*n.* (判断)标准，判据，准则
branch [b'rʌntʃ]	*n.* & *v.* 分(部，支)
transmission angle	传动角
rock	*n.* 摆动；*v.* 摇动
rocker	*n.* 摇杆
oscillate ['ɔsə,leit]	*v.* 摆动，摇动
parallelogram [,pærə'leə,græm]	*n.* 平行四边形
antiparallelogram	*n.* 反平行四边形
frame	*n.* 机架，构架
impart	*v.* 给予，分给
to impart *M* to *N*	把 *M* 分给 *N*
torque [tɔːk]	*n.* 力矩，扭矩
dynamic [dai'næmik]	*adj.* 动力的，动力学的
inertia [i'nəːʃjə]	*n.* 惯性(物)，惯量
static ['stæti]	*adj.* 静力[学]的，静的
index ['indeks]	*n.* 指数，指标
friction ['frikʃən]	*n.* 摩擦
thumb [θʌm]	*n.* 拇指；*v.* 用拇指翻(书页等)
rule of thumb	凭感觉的方法，单凭经验的方法，经验法则，拇指法则
matrix [meitrik]	*n.* 矩阵
determinant [di'təːminənt]	*n.* 行列式
derivative [di'rivətiv]	*n.* 导数
derivative of *M* with respect to *N*	*M* 对于 *N* 的导数
movability [,muːvə'biliti]	*n.* 可动性，易动性
parameter [pə'ræmitə]	*n.* 参数
discount ['diskəunt]	*v.* 打折扣，忽视
absolute ['æbsəluːt]	*adj.* 绝对的
graphical [græfikl]	*adj.* 图形的，图解的
polygon ['pɔliː,gɔn]	*n.* 多边形
theorem ['θiərəm]	*n.* 定理
stress	*n.* 应力
bearing ['beəriŋ]	*n.* 轴承
centripetal [sen'tripitl]	*adj.* 向心力的

Notes

[1] As a particular case, in a parallelogram linkage, where the length of the input link equals that of the output link and the lengths of the coupler and the ground link are also the same, both the input and output link may rotate entirely around or switch into a crossed configuration called an anti-parallelogram linkage.

全句翻译：在平行四边形机构中有一种特殊情形，即机构中的输入杆长度等于输出杆长度，连杆长度也等于机架杆长度。这样，该机构的输入杆和输出杆均可以作圆周转动，也可以转换成一种被称为反平行四边形机构的交叉结构。

[2] …which contains derivatives of output motion variables with respect to an input motion variable for a given linkage geometry…

全句翻译：该行列式中包含某个给定机构的输出运动变量对输入运动变量的导数。

[3] …the inertia frame of reference of the fixed link of the mechanism.

全句翻译：机构固定构件的惯性坐标系。

[4] One component has the direction tangent to the path of this point, pointing in the same sense of the angular acceleration of this body, is called the normal or centripetal acceleration.

全句翻译：其中一个分量与该点轨迹相切，其方向与这个刚体角加速度方向相同，这一分量称为切向加速度。

Part B Reading Materials

Theoretical mechanics, is a subject of studying general principles of mechanical movement, belongs to common mechanics of classical mechanics. Theoretical mechanics falls into statics, kinematics and dynamics. Statics mainly studies the conditions of acting forces when the body under acting forces is equilibrium, also studies the analytic methods of forces acting on body, and the methods of simplifying force system,etc. Kinematics just studies the movements of body in view of geometry(e.g. track, velocity and acceleration, etc.), not the physical reasons causing the movements of body. Dynamics deals properly with motions under forces.

Lesson 3 Kinematic Synthesis

Part A Text

Mechanisms form the basic geometrical elements of many mechanical devices including automatic packaging machinery, typewriters, mechanical toys, textile machinery, and others. A mechanism typically is designed to create a desired motion of a rigid body relative to a reference member. Kinematic design, or kinematic syntheses, of mechanisms often is the first step in the design of a complete machine. When forces are considered, the additional problems of dynamics, bearing loads, stresses, and lubrication are introduced, and the larger problem becomes one of machine design.

A kinematician defined kinematics as "the study of the motion of mechanisms and methods of creating them". The first part of this definition deals with kinematics analysis. Given a certain mechanism, the motion characteristics of its components will be determined by kinematic analysis. The statement of the task of analysis contains all principal dimensions of the mechanism, the interconnections of its links, and the specification of the input motion or method of actuation. The objective is to find the displacements, velocities, accelerations, shock or jerk (second acceleration), and perhaps higher accelerations of the various members, as well as the paths described and motions performed by certain elements. In short, in kinematic analysis we determine the performance of a given mechanism. The second part of definition may be paraphrased in two ways:

(1) The study of methods of creating a given motion by means of mechanisms.

(2) The study of methods of creating mechanisms having a given motion.

In either version, the motion is given and the mechanism is to be found. This is the essence of kinematic synthesis. Thus kinematic synthesis deals with the systematic design of mechanisms for a given performance. The area of synthesis may be grouped into two categories.

(1) Type synthesis. Given the required performance, what type of mechanism will be suitable? (Gear trains? Linkages? Cam mechanisms?) Also, how many links should the mechanism have? How many degrees of freedom are required? What configuration is desirable? And so on, Deliberations involving the number of links and degrees of freedom are often referred to as the province of subcategory of type synthesis called number synthesis.[1]

(2) Dimensional synthesis. The second major category of kinematic synthesis is best defined by way of its objective: Dimensional synthesis seeks to determine the significant dimensions and

the starting position of a mechanism of a preconceived type for a specified task and prescribed performance.

Significant dimensions mean link lengths or distances on binary, ternary, and so on, links, angles between axis, cam-contour dimensions and cam-follower diameters, eccentricities, gear rations, and so forth. A mechanism of preconceived type may be a slider-crank linkage, a four-bar linkage, a cam with flat follower, or a more complex linkage of a certain configuration defined topologically but not dimensionally. There are three customary tasks for kinematic synthesis: function generation, path generation and motion generation.

In function generation mechanisms,[2] rotation or sliding motions of input and output links must be correlated. For an arbitrary function $y=f(x)$, a kinematic synthesis task may be to design a linkage to correlate input and output such that the input moves by x, the output moves by $y=f(x)$ for the range $x_0<x<x_{n+1}$[3]. In the case of rotary input and output, the angles of rotation φ and ϕ are the linear analogs of x and y respectively. When the input link is rotated to a value of the independent x, the mechanism in a "black box" causes the output link to turn to the corresponding value of the dependent variable $y=f(x)$. This may be regarded as a simple case of a mechanical analog computer. A variety of different mechanisms could be contained within the "black box". However, the four-bar linkage is not capable of error-free generation of an arbitrary function and can match the function at only a limited number of precision points. It is widely used in industry because the four-bar linkage is simple to construct and maintain.

In path generation mechanism a point on a "floating link" is to trace a path defined with respect to a fixed frame of reference [4]. If the path points are to be correlated with either time or input-link positions, the task is called path generation with prescribed timing. An example of path generation mechanisms is a four-bar linkage designed to pitch a baseball or tennis ball. In this case the trajectory of point p would be such as to pick up a ball at a prescribed location and to deliver the ball along a prescribed path with prescribed timing for researching a suitable throw-velocity and direction.

There are many situations in the design of mechanical devises in which it is necessary either to guide a rigid body through a series of specified, finitely separated positions or to impose constrains on the velocity and/or acceleration of the moving body at a reduced number of finitely separated positions. Motion-generation or rigid-body guidance mechanism[5] requires that an entire body be guided through a prescribed motion sequence. The body to be guided usually is a part of a floating link, of which not only is the path of a point p prescribed, but also the rotation of a line passing through the point and embedded in the body. For instance, the line might represent a carrier link in automatic machinery where a point located on the carrier link has a prescribed path while the carrier has a prescribed angular orientation. Prescribing the movement of the bucket for a bucket loader is another example of motion generation mechanism. The path of tip of the bucket is critical since the tip must perform a scooping trajectory followed by a lifting and a dumping trajectory. The angular orientation of the bucket is equally important to ensure that the load is dumped from the correct position.