

## 2-5596 Mechanika viazaných mechanických systémov (VMS)

pre špecializáciu Aplikovaná mechanika, 4.roč. zimný sem.

Prednáša: doc.Ing.František Palčák, PhD., ÚAMM 02010

### Pojmy pre syntézu VMS

Syntéza VMS	Cieľom syntézy VMS je navrhnuť vhodný typ štruktúry a jej parametre (konfiguráciu a rozmery členov) tak, aby získaná VMS pre predpísaný pohyb vstupných hnacích členov generovala vyžadovaný priebeh pohybu výstupných hnaných členov.
Task categories	<p>A great variety of mechanisms are used in machines and devices. Even though these applications are quite different, all mechanisms can be classified into three categories depending on the task that mechanisms perform:</p> <ul style="list-style-type: none"> <li>• Function generation (positioning of output link LCS axes)</li> <li>• Path generation (positioning of output link LCS origin)</li> <li>• Motion generation (positioning of output link LCS origin and axes, too)</li> </ul>
Four-bar linkage	A large majority of mechanisms exhibit planar motion. A four-bar linkage (Fig.1) has the most basic chain of pin-connected links. It consist from input link (crank, or slider), coupler (floating link, crank, or slider) with path tracer points which generally trace out six-order algebraic coupler curves, and output link (follower, crank, or slider).

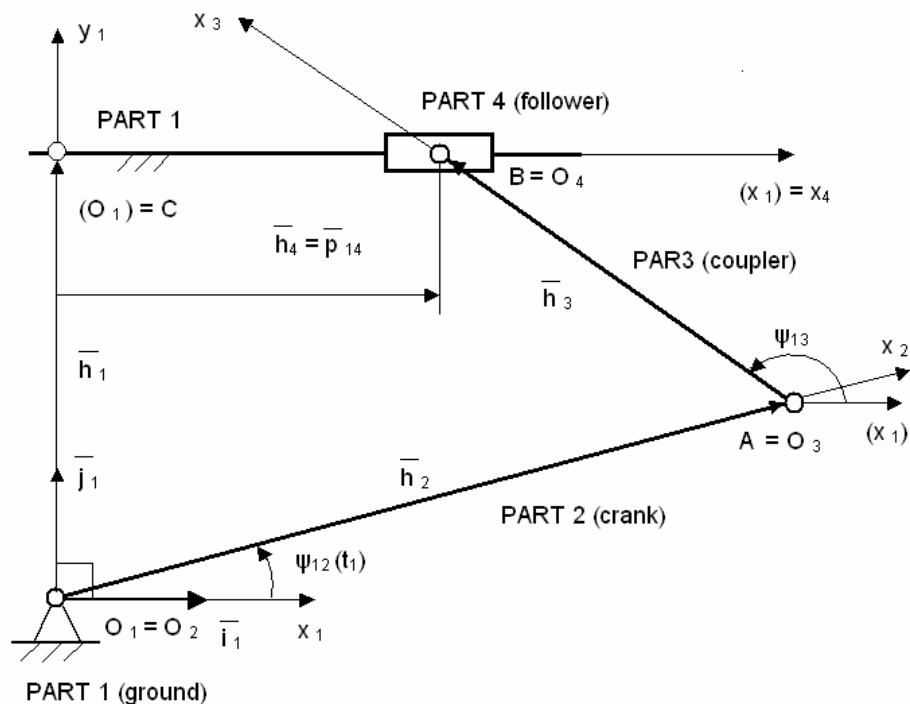


Fig.1 A four-bar planar linkage

Positioning

Under term positioning of the rigid body (PART2 on Fig.2) we understand the PART2 guidance through prescribed subsequent positions of its local coordinate system (LCS) origin  $O_2 \equiv A(x_2, y_2)$  as reference point and angular orientation (position) of axes  $x_2, y_2$  of its LCS wrt global coordinate system (GCS)  $O_1(x_1, y_1)$ . This description is according to Poisson's theorem of decomposition of rigid body general motion into translational motion of a body, represented by reference point (origin  $O_2$ ) displacement, and rotational displacement of rigid body about this reference point (origin  $O_2$ ).

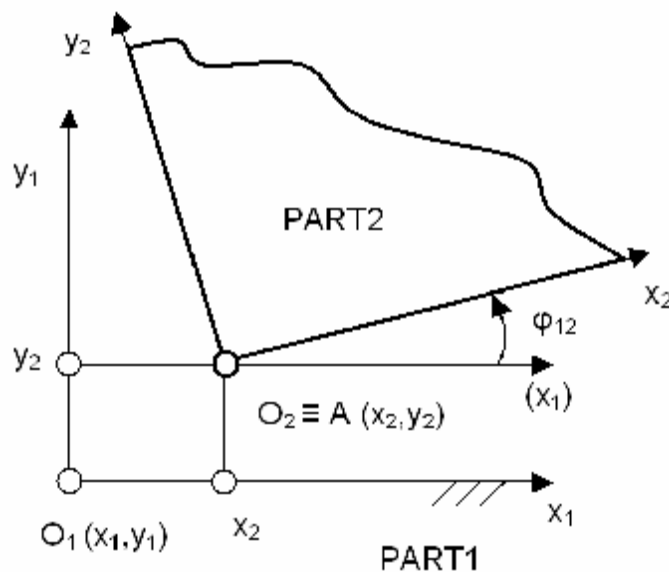


Fig.2 Position of PAR2 wrt PAR1 in plane

Position in plane

Unique position of PAR2 wrt PAR1 in plane (Fig.2) is given by two Cartesian position coordinates  $(x_2, y_2)$  of origin  $O_2 \equiv A(x_2, y_2)$  as reference point  $A(x_2, y_2)$  wrt origin  $O_1$  of GCS (global coordinate system) and by variable (floating) angle  $\phi_{12} = \mathbf{S}(x_1, x_2)$  for angular displacement of PAR2 LCS axis  $x_2$  wrt axis  $x_1$  of GCS, because free body (PAR2) has mobility  $n_v = 3$  in the plane.

Function generator

Function generator is a linkage (for example on Fig.3) in which a positioning of output link (PART4) LCS axes, or relative displacement of output link wrt ground to which is connected is of interest. Such mechanism should be designed to transform prescribed displacement  $q_{n12} = \phi_{12}$  or given forces from input link (PART2) to desired range  $\phi_{14} = f(\phi_{12})$  of the output link (PART4)

displacement  $\varphi_{14}$ . Present formula is called the first transform function (stroke function). This task does not require to control a path of tracer point on the coupler link.

#### Lawn sprinkler

Drive linkage on Fig.3 is used for a lawn sprinkler, which is adjustable by angle  $\varphi_v$ , to obtain desired range of oscillation of the sprinkler head. Mechanism is designed to transform displacement  $\varphi_{12}$  of input link (PART2) to desired range of the output link (PART4) angular displacement  $\varphi_{14} = f(\varphi_{12})$ , which is the sum of angles  $\varphi_{14} = \varphi_{14A} + \varphi_{14B}$ .

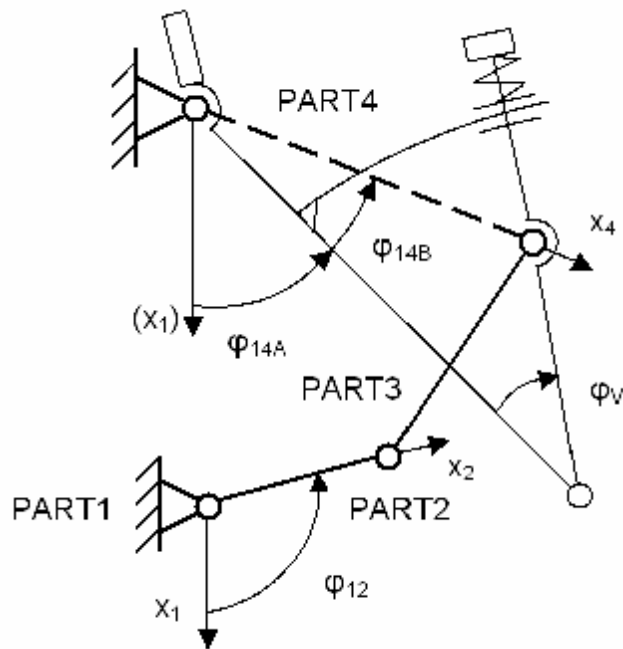


Fig.3 Drive linkage for a lawn sprinkler

#### Path generator

A path generator mechanism (for example on Fig.4) is positioning the proper selected path tracer point A (from output coupler link PART3) which should exhibit displacement along prescribed curve (path), while angular position of coupler link is arbitrary.

#### Level luffing crane

This level luffing crane on Fig.4 generates approximate straight-line trajectory (a) of the path tracer point A. Since a hook at the path tracer point A holds a wire rope which is always hanging vertically, the orientation (angular position) of the coupler link (PART3) can be arbitrary.

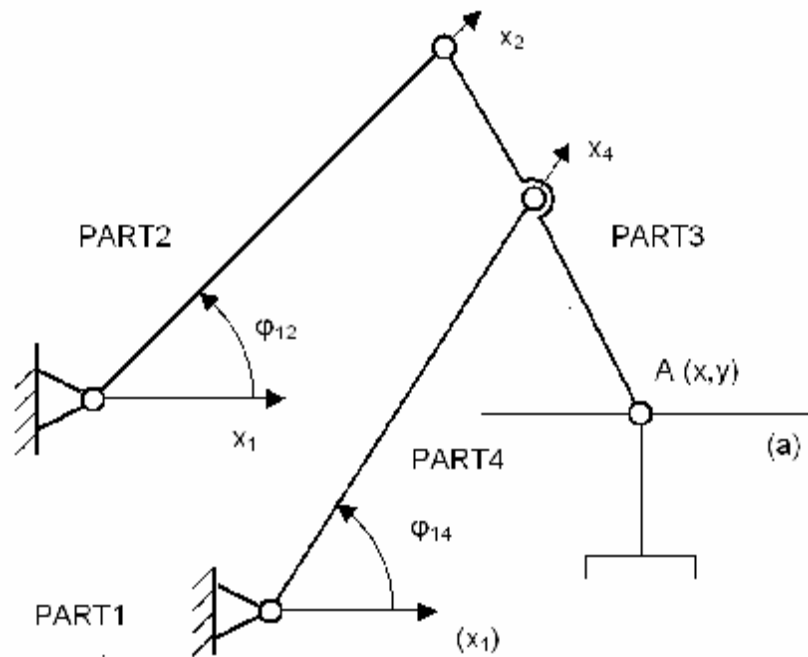


Fig.4 A level luffing crane.

#### Motion generator

Motion generator is a linkage (for example on Fig.5) in which a positioning of output link LCS origin and also its axes is of concern. So both, path tracer point  $A(x,y)$  coordinates and global angular position  $\psi_{13} = \mathbf{S}(x_1, x_3)$  of coupler link PART3 wrt GCS should vary according to prescribed requirements on the output link LCS displacement  $\psi_{13} = f(\psi_{12})$ .

#### In-line skater

A skater on Fig.5 with in-line wheels has braking mechanism which input link is boot cuff (PART2) joined with boot (PART1) by revolute ankle joint C. Output coupler link (PART3) with braking pad is designed to lengthen and adjust the response of the linkage as the brake pad wears down. The path tracer point A from braking pad should conduct its displacement along prescribed curve (a) and maintain parallel position wrt skating surface (PART1).

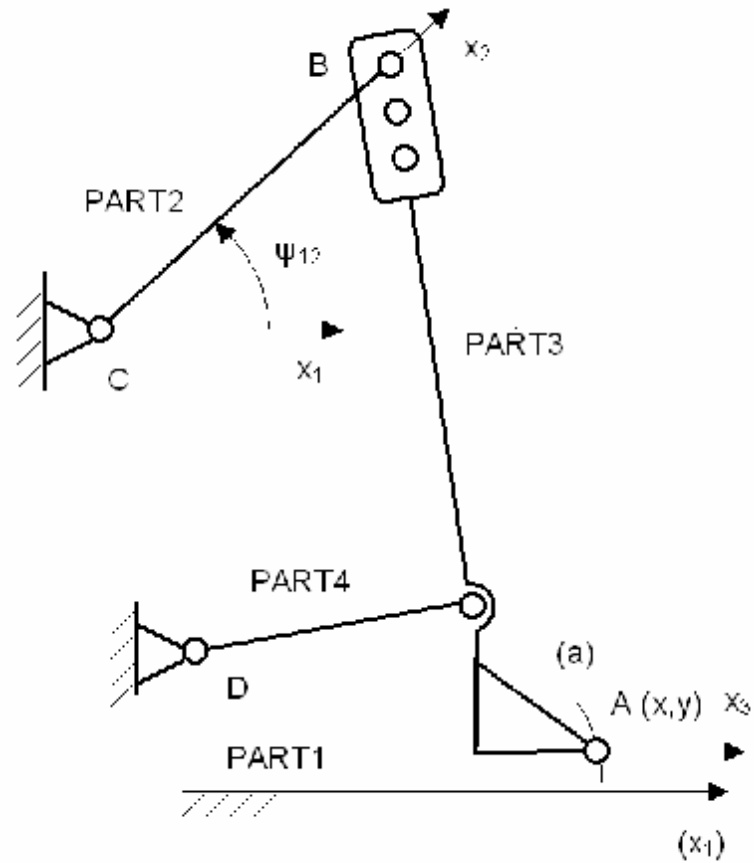


Fig.5 A braking mechanism for skater with in-line wheels

Six-bar linkages

Six-bar linkages with seven revolute joints and mobility  $n = 1$  are more suitable to meet requirements on type of performance like four-bar linkages, because there is more variables for process of optimisation and robust design. Such six-bar linkages can be classified according placement of ternary links in their structure. In a schemes of structures of a Watt six-bar chaines are ternary links adjacent, while Stephenson six-bar chaines have ternary links separated by binary links in corresponding schemes of structure.

Watt chain

In a scheme of structure on Fig.6 of a Watt six-bar chain W1 are ternary links PART3 and PART6 adjacent.

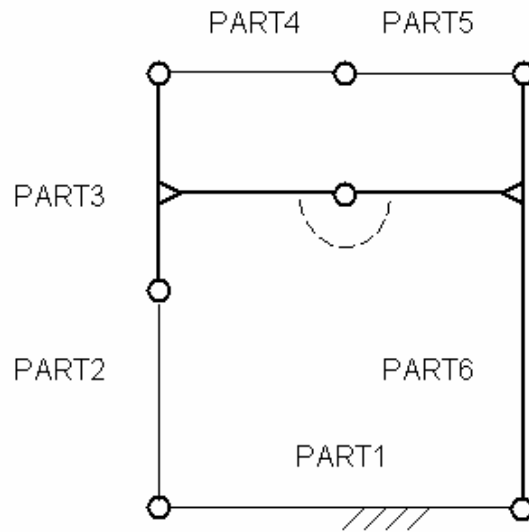


Fig.6 A Watt six-bar W1 scheme of structure.  
 In a scheme of structure of a Watt six-bar chain W2 on Fig.7 there are adjacent ternary links PART1 and PART4.

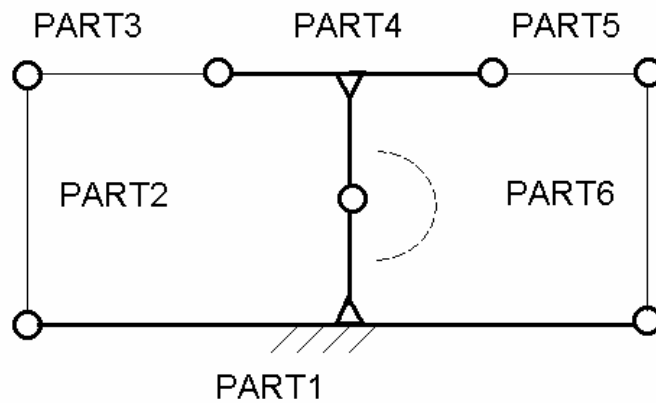


Fig.7 A Watt six-bar chain W2 scheme of structure.

### Stephenson chains

In a scheme of structure of Stephenson six-bar chain S1 on Fig.8 are ternary links PART2 and PART4 separated by binary link PART3.

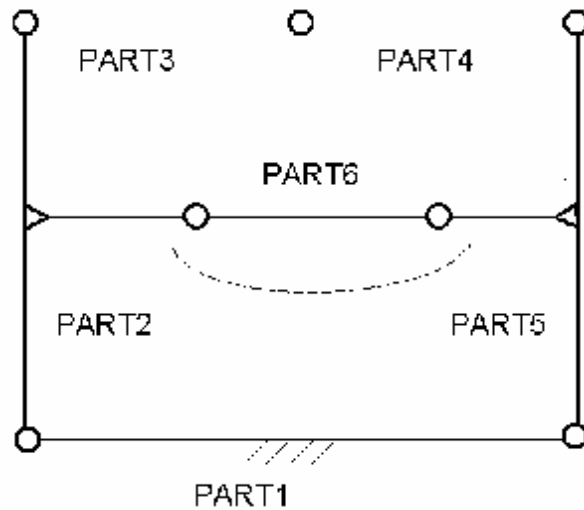


Fig.8 Stephenson six-bar chain S1 scheme of structure

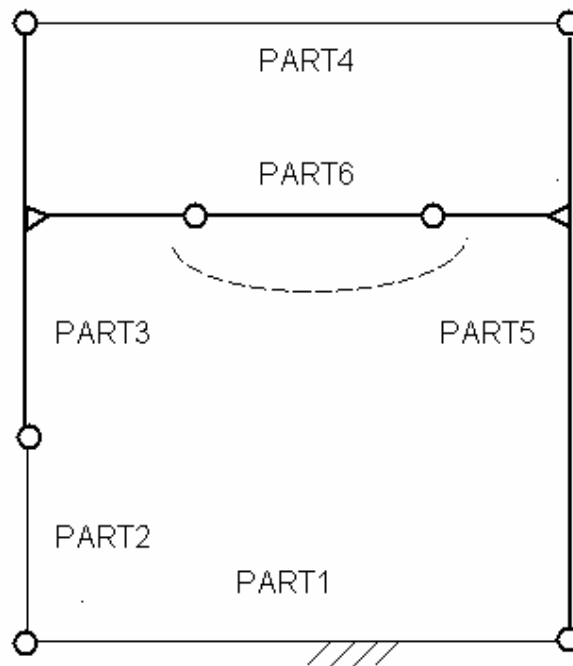


Fig.9 Stephenson six-bar chain S2 scheme of structure.

In a scheme of structure of Stephenson six-bar chain S2 on Fig.9 are ternary links PART3 and PART5 separated by binary link PART6.

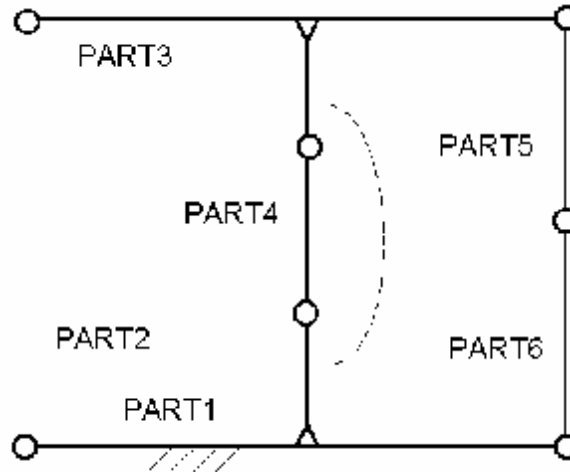


Fig.10 Stephenson six-bar chain S3 scheme of structure.

In a scheme of structure of Stephenson six-bar chain S3 on Fig.10 are ternary links PART1 and PART3 separated by binary link PART4.

Synthesis of MBS

The structural parameters are related by structural equations. Synthesis of MBS structure by types  $t$  of the joints is based on possibilities for combination of types  $t$  of the joints in all versions of structure satisfying prescribed requirements on structure parameters..

Type  $t$  of the joints

Synthesis of MBS structure by types  $t$  of the joints is based on possibilities for combination of types  $t$  of the joints.

Transformation chain

Method of transformation chain is based on mobility  $n_a$  of input link, mobility  $n_b$  of output link and mobility  $n_c$  of transformation chain. Mobility  $n$  of desired mechanism is then given by the sum

$$n = n_a + n_b + n_c .$$

Type  $g$  of the link

Synthesis of MBS structure by types  $g$  of the links is based on possibilities for combination of types  $g$  of the links.

Modular synthesis

Modular elements are members  $u_g$  of structure and also Assur's groups  $g_a$  of links.