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Glossary

Engineering Mechanics II-Dynamics for bachelors study in 2nd year-clasis

Lecture 5: Part 1 of planar rigid-body kinematics.

Sections in lecture 5:

S1 Instantaneous slew centre (OSO) of a body. Replacement of a general planar motion of a part in the multibody system by rolling of centrodes

S2 Application of principle of mutually rolling centrodes in mechanisms.

S3 Dynamics of translational and rotational motion of a rigid-body.

S1 Instantaneous slew centre (OSO) of a body. Replacement of a general planar motion of a part in the multibody system by rolling of centrodes

Types of motions

In the slider crank mechanism on Fig.1 the PAR2 (crank) wrt PAR1 (ground) rotates 2/1, the PAR4 (piston) wrt PAR1 (ground) translates 4/1, and the PAR3 (coupler) moves wrt PAR1 (ground) via general planar motion 3/1 (it perform neither rotation, nor translation).

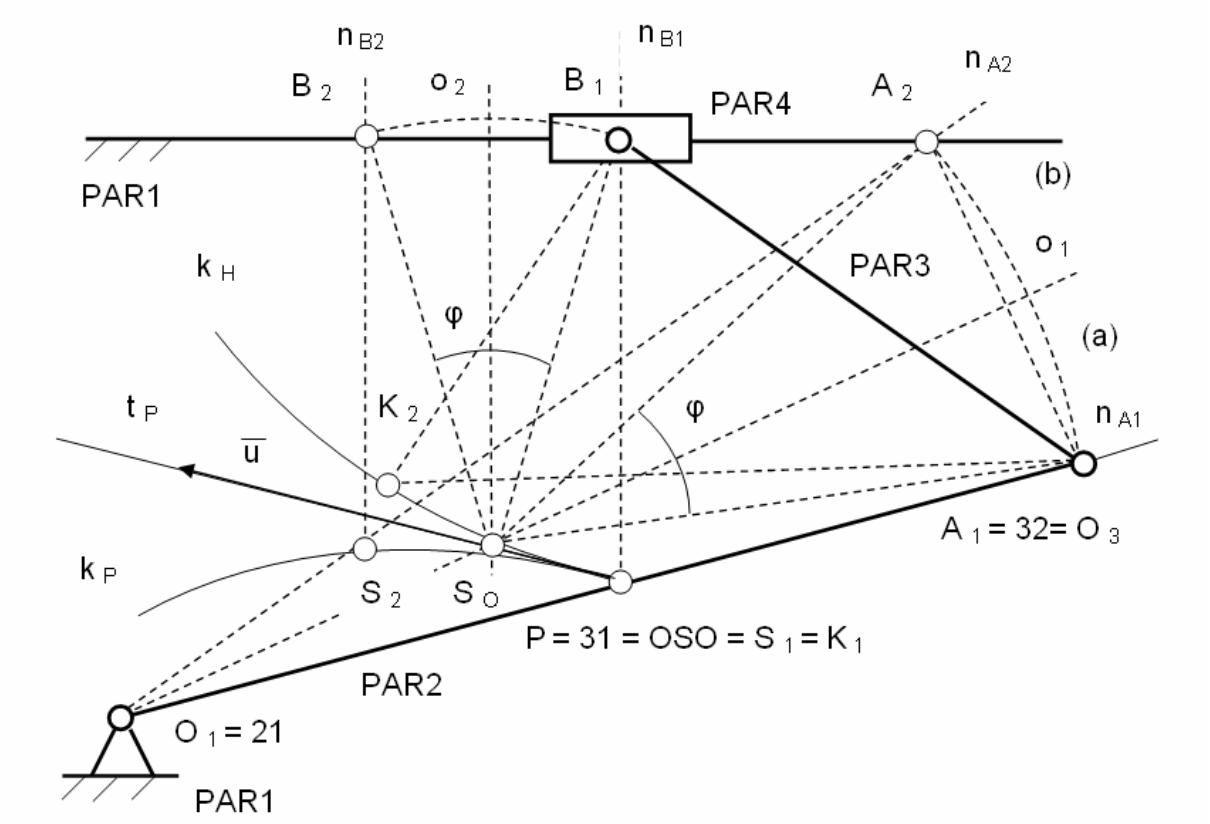

Fig.1 The slider crank mechanism in initial configuration ($O_1A_1B_1$) and final configuration ($O_1A_2B_2$).

Finite angle of slew

The lamina with coupler $\overrightarrow{AB}$ can be displaced from its initial position $\overrightarrow{A_1 B_1}$ to the final position $\overrightarrow{A_2 B_2}$ via slew about center $S_o = o_1 \times o_2$ (bisection of abscisses) with finite angle $j = \mathbf{S}(A_1 S_o A_2) = \mathbf{S}(B_1 S_o B_2)$.

Instantaneous centre

If the finite angle j of slew will be reduced to become infinite small, then the lamina with coupler $\overrightarrow{AB}$ will be displaced from its initial position $\overrightarrow{A_1 B_1}$ to the infinitesimal close position via slew about intersection point S_1 of normals n_{A1}, n_{B1} to the actual paths $(a),(b)$.

This intersection point S_1 is instantaneous slew center $S_1 = (OSO_{31})_1 = n_{A1} \times n_{B1} = P$ of zero velocity of coupler PAR3 wrt PAR1. For configuration of mechanism when coupler is in the position $\overrightarrow{A_2 B_2}$ the adjacent intersection point $S_2 = (OSO_{31})_2 = n_{A2} \times n_{B2}$ is new instantaneous slew centre S_2.

Fixed centrode

The locus of the instantaneous slew centres $\{S_i\}$ of zero velocity traced on the fixed lamina during general planar motion 3/1 of the coupler PAR3 wrt PAR1 is called the fixed centrode k_P.

Movable centrode

When the triangle $\Delta(A_2 B_2 S_2)$ will be returned to the initial position $\overrightarrow{A_1 B_1}$ the point K_2 from movable lamina of coupler PAR 3 will be obtained. After generalisation of this procedure $\Delta(A_i B_i S_i) \rightarrow \Delta(A_1 B_1 K_i)$ the locus of the instantaneous slew centres $\{K_i\}$ in the movable plane is called the movable centrode k_H.

Control curves

The general planar motion 3/1 of the coupler PAR3 wrt PAR1 can be replaced by pure rolling of movable centrode k_H against fixed centrode k_P (control curves).

Center of curvature

The center S_A of curvature of point A trajectory (a) is the center of osculating circle, by which is trajectory (a) replaced in the neighboroud of point A. When trajectory (a) is a circle then center S_A of curvature is coincident with center of this circle. When trajectory (a) is a straight line, then center S_A of curvature is a step point. During steady rotation or translation is center S_A of curvature identical with instantaneous slew centre OSO. In case of general plane motion center S_A of curvature and instantaneous slew center OSO are different points.

S2 Application of principle of mutually rolling centrodes in mechanisms.

Appliacation

Hypocyclic gear train on Fig.2 is one of well known apllication of control curves, where the movable centrode k_H is planetary wheel circle and the fixed centrode k_P is sun wheel circle. If the transmission ratio m_{PC} defined by ratio of pitch circles radii $m_{PC} = \frac{R_P}{R_C} = \frac{1}{3}$, then point C on the pitch circle of a planet generates trajectory named Steiner's hypocycloid which is approximately of circle's shape. The piston in dwell mechanism is required to be in the rest during phase of coupler BC revolution about point B, when point C is moving from C_1 to the C_2.

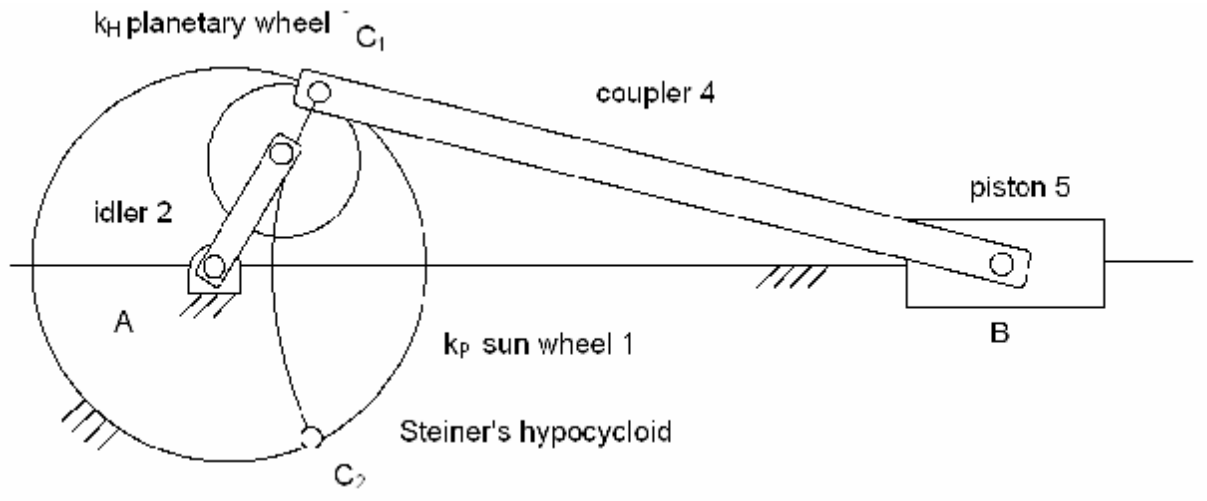

Fig 2. Dwell mechanism with hypocyclic gear train.