

MECH-320 Kinematics of Mechanical Systems

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Course lectures Slides prepared by

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3 More on Machines and Mechanisms

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▶ 3.1 Planar and Spatial Mechanisms

- ▶ Mechanisms can be divided into **planar mechanisms** and **spatial mechanisms**, according to the relative motion of the rigid bodies.
- ▶ In a **planar mechanisms**, all of the relative motions of the rigid bodies are in one plane or in parallel planes.
- ▶ If there is any relative motion that is not in the same plane or in parallel planes, the mechanism is called the **spatial mechanism**. In other words, *planar mechanisms* are essentially two dimensional while *spatial mechanisms* are three dimensional. This tutorial only covers planar mechanisms.

3.2 Kinematics and Dynamics of Mechanisms

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- ▶ **Kinematics** of mechanisms is concerned with the motion of the parts without considering how the influencing factors (force and mass) affect the motion. Therefore, kinematics deals with the fundamental concepts of space and time and the quantities velocity and acceleration derived there from.
- ▶ **Kinetics** deals with action of forces on bodies. This is where the effects of gravity come into play.
- ▶
- ▶ **Dynamics** is the combination of *kinematics* and *kinetics*.
- ▶ **Dynamics of mechanisms** concerns the forces that act on the parts -- both balanced and unbalanced forces, taking into account the masses and accelerations of the parts as well as the external forces.

3.3 Links, Frames and Kinematic Chains

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- ▶ A **link** is defined as a rigid body having two or more pairing elements which connect it to other bodies for the purpose of transmitting force or motion.



- ▶ In every machine, at least one link either occupies a fixed position relative to the earth or carries the machine as a whole along with it during motion. This link is the **frame** of the machine and is called the **fixed link**.

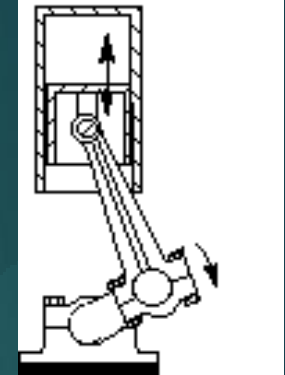
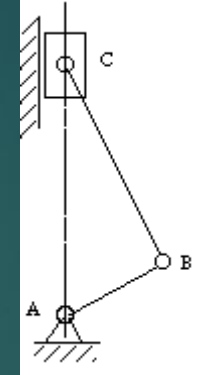


- ▶ The combination of links and pairs **without a fixed link is not a mechanism** but a **kinematic chain**.

3.4 Skeleton Outline

- ▶ **skeleton outline** of the mechanism.

The skeleton outline gives all the geometrical information necessary for determining the relative motions of the links.

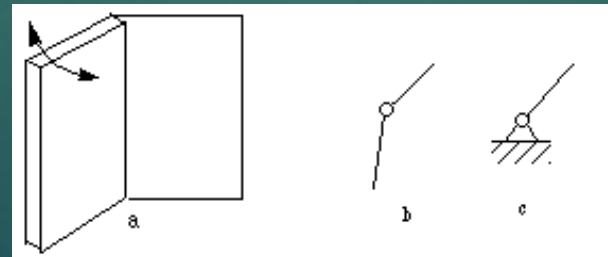


3.5 Pairs, Higher Pairs, Lower Pairs and Linkages

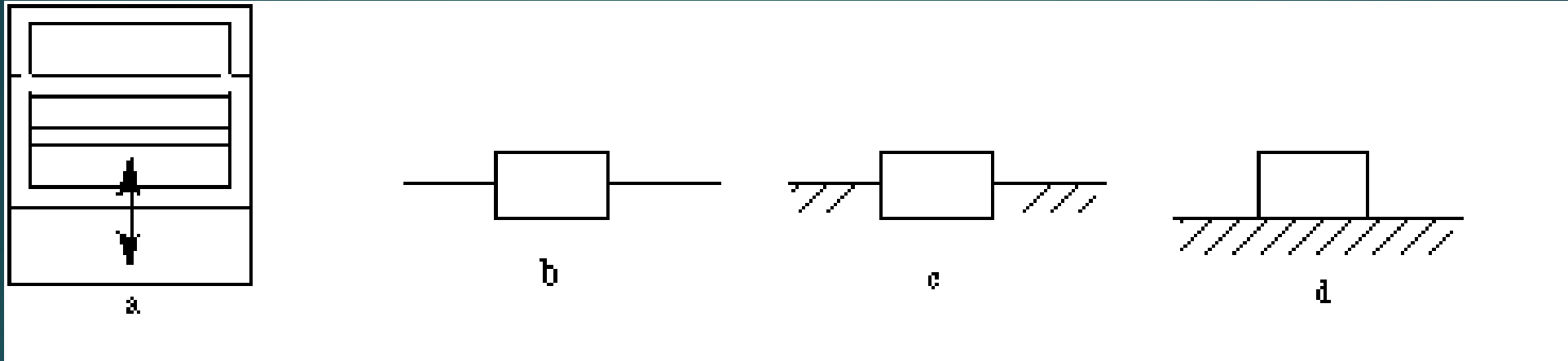
- ✓ A **pair** is a joint between the surfaces of two rigid bodies that keeps them in contact and relatively movable
- ✓ **revolute joint (pin joint)**, allowing the door to be turned around its axis.

✓

Revolute pair



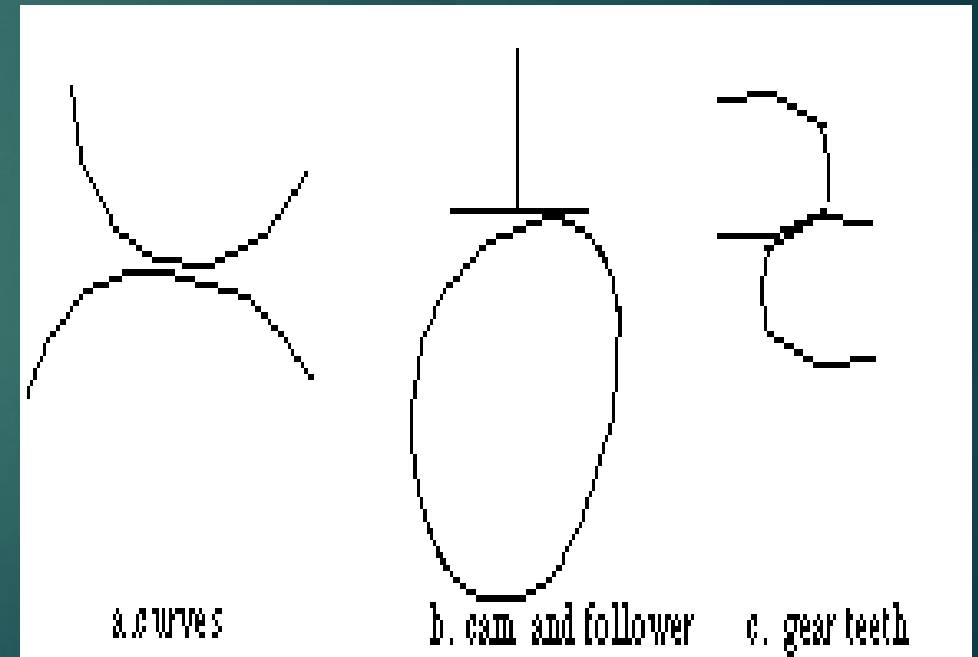
- **A prismatic pair:** a sash window can be translated relative to the sash.



- Its **skeleton** outlines are shown in **b, c** and **d**.
- **c and d** are used when one of the links is the frame.

lower pairs and higher pairs

- ▶ *the type of contact between the two bodies of the pair*
- ▶ **lower pairs is:** Surface-contact pairs.
- ▶ **In planar (2D) mechanisms:**
- ▶ there are two subcategories of:
- ▶ **lower pairs** -- *revolute pairs* and *prismatic pairs*
- ▶ **higher pairs: 1) Point - line contact pairs**
- ▶ **2) Point – curve contact pairs**
- ▶ The Figure shows some examples of *higher pairs*.
- ▶ Mechanisms composed of rigid bodies and lower and higher pairs are called **linkages**.



3.6 Kinematic Analysis and Synthesis

- ▶ In **kinematic analysis**, a particular given mechanism is investigated based on the mechanism geometry plus other known characteristics (such as input angular velocity, angular acceleration, etc.).
- ▶ **Kinematic synthesis**, on the other hand, is the process of designing a mechanism to accomplish a desired task. Here, both choosing the types as well as the dimensions of the new mechanism can be part of kinematic synthesis.