Degrees of freedom (DOF)

- Number of __________________________ which are needed to __________ define the ________________ of all parts of a system at any instant of time.
- Number of __________________________ needed to give a predictable output if dimensions known

3 DOFs

Degrees of Freedom (DOF)

- DOF defines gross motions in a rigid body/link
- In the __________________________ stage, the kinematic bodies are assumed ______________ and ______________.
- In reality, elastic bodies have __________________ of DOFs, but we often approximate certain parts as massless elements.
  - ________________ analysis and reduces the number of effective DOFs.

Linkages (kinematic chains)

- Linkages = __________ + ______________ (kinematic pair connected to nodes).
- Provide a controlled output motion in response to input motion.
- Linkages are basic building blocks of mechanisms.

- __________ link - 2 nodes
- Ternary link - 3 nodes
- Quaternary link - 4 nodes

Joint - 6 basic lower pairs

- Revolute (R) __ DOF R
- Prismatic (P) __ DOF P
- Helical (H) __ DOF RP
- Cylindric (C) __ DOF RP
- Spherical (S) __ DOF RRR
- Planar (F) __ DOF RPP
Kinematic Pairs

Based on the nature of mechanical constraint
(a) _______ pair
(b) Unclosed or _________ pair

Physical closure

- Form-closed -- joint is closed by its geometry
  - preferred for ____________________________
- Force-closed -- an external force is needed to keep joint together
  - preferred for ____________________________
Force-Closed Mechanism

The spring is ______
a rigid body, _____
a link, and ______
contribute to the DOF equation

Courtesy:www.technologystudent.com

Locking out DOF

- Sometimes an applied force can ______________________ at a joint
- Example: automobile tire
  - Normal friction: ____________
  - Reduced friction: _________________
    (locked brakes)
  - Sudden start: _________________

DOF in ___________ Mechanisms

- Kutzbach-Gruebler’s equation (G=1)

Classification of Mechanisms

- If ______, the mechanism has M DOF
- If ______, the mechanism is a ________.
  All motion has been constrained.
- If M < 0, there are redundant constraints, and the mechanism is a ________
  ___________________________ or preloaded structure.
Planar Mechanisms

- When all the _______ of a mechanism move in a plane motion, it is called a ____________________.
- All the links in a planar mechanism move in planes __________________ to the reference plane.

Slider-crank mechanism


Slider-Crank

Slider – Crank DOF

\[ M = 3(L - 1) - 2J_1 - J_2 \]

- Number of links:
  - _________ = #1
  - _________ = #2
  - _________ = #3
  - _________ = #4
- \( L = \)
Slider – Crank DOF

\[ M = 3 (L - 1) - 2 J_1 - J_2 \]

- Number of joints:
  - #1
  - #2
  - #3
  - #4

- J_1 =

Slider-Crank Analysis

Typical “knowns” are

Typical “input” is

Typical “outputs” are

For the typical case where \( \theta_3 = 90^\circ \)
Engine Bore & Stroke

- Engine cylinders are described by the **bore** and **stroke**.
- Bore = diameter of piston
- Stroke = ____________