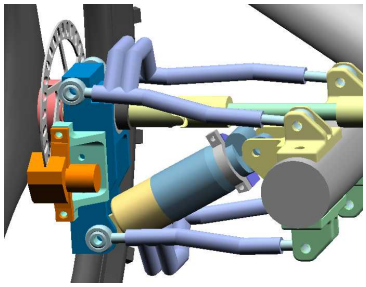
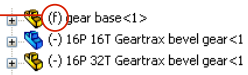
Assemblies
Mobility



CAD suspension model by Patrick Powers

SolidWorks Assembly Files

- An assembly file is a collection of *parts*
- The first part brought into an assembly file is *fixed*

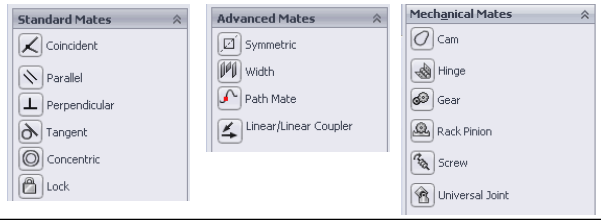


- Other parts are constrained relative to that part (or other parts) using *mating relations*

The Mating Game

- Mating features
  - Points (incl. vertices, sketch points)
  - Lines (incl. edges, axes, sketch lines)
  - Planes (incl. front, top, right, reference planes)
  - Cylindrical features (cylinders, holes)
  - Spheres

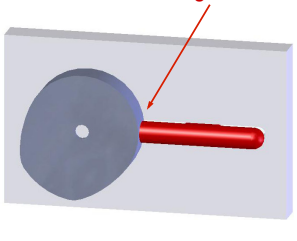
Esp. useful for parts with curved surfaces

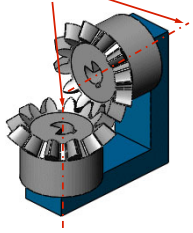


Mechanical Mates

Surfaces remain tangent

Relative rotation about axes



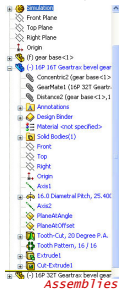


Cam Mate

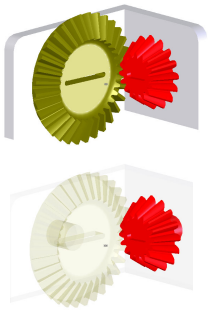
Gear Mate

Editing Parts in Assemblies

- In an open part document file
- Directly in assembly view

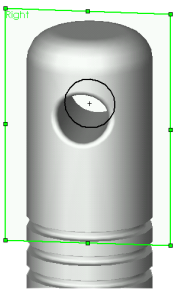


Feature manager tree turns blue

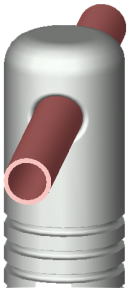


Rest of assembly becomes transparent

Inserting Component Directly in Assembly



1. Open sketch
2. Convert entitity

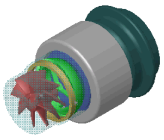


3. Extrude thin feature

Part is fixed in place (until mate suppressed)

Exploded Views

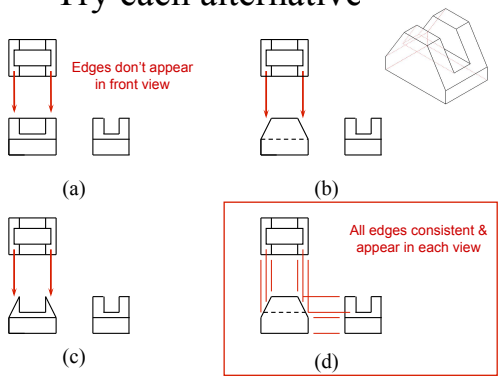
- Exploded views show how components relate to each other
- Useful in assembly drawings



Exercise
Choose the correct front view

(a) (b) (c) (d) None (e)

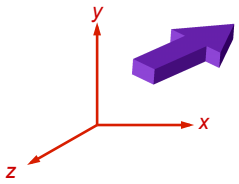
Try each alternative



Question

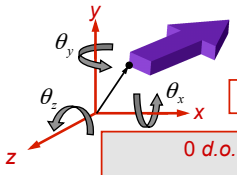
How many degrees of freedom does a rigid body floating in space have?

A. Zero
B. One
C. Two
D. Three
E. Six



Degrees of Freedom

- Number of variables needed to uniquely define the position of a rigid body in space, relative to a fixed frame of reference
- Consider a rigid body in space:



3 position coordinates: x, y, z

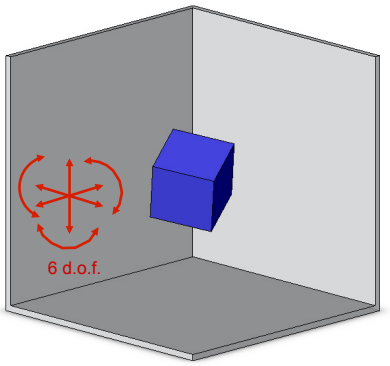
3 angles: $\theta_x, \theta_y, \theta_z$

This body has 6 degrees of freedom

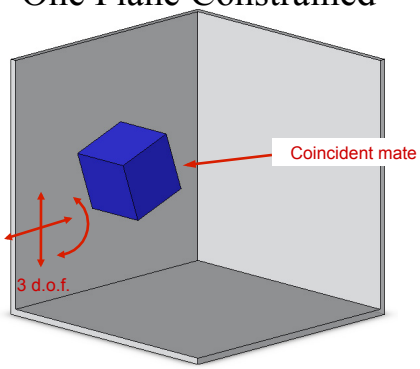
0 *d.o.f.* = structure or assembly

1 *d.o.f.* = moveable linkage or mechanism

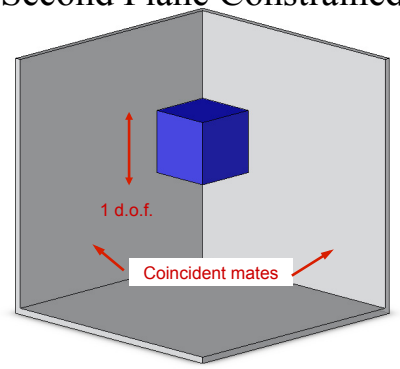
Unconstrained



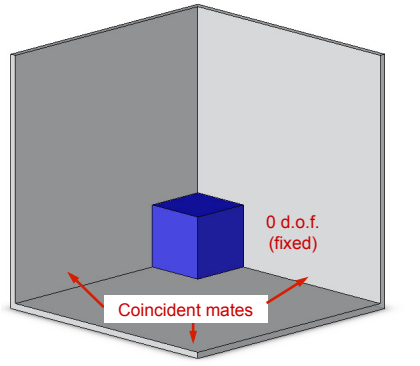
One Plane Constrained



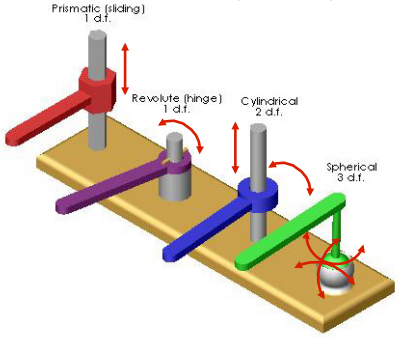
Second Plane Constrained



Third Plane Constrained



Kinematic Pairs (Joints)



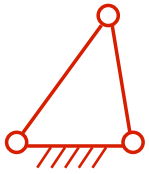
Kinematic Pairs (Joints)

Name	Symbol	D.O.F.	Notation	Comment
Revolute	R	1	p_1	e.g. Hinge
Prismatic	P	1	p_1	Linear slider w/o rotation
Cylindrical	C	2	p_2	Slide & rotate
Spherical	S	3	p_3	3 independent rotations

Question

How many degrees of freedom does this linkage have?

A. Zero
B. One
C. Two
D. Three
E. Six



Question

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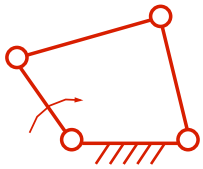

Question

How many degrees of freedom does this linkage have?

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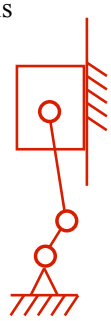


Linkage Mobility

Linkage = set of rigid links connected by joints

Kutzbach-Grübler criterion
for planar (2D mechanisms)

$$f = 3(n-1) - 2p_1 - p_2$$

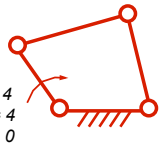
Where: n = number of links
p_1 = number of joints w/ 1 *d.o.f.*
p_2 = number of joints w/ 2 *d.o.f.*

Examples

$n = 3$
$p_1 = 3$
$p_2 = 0$

$$f = 3(n-1) - 2p_1 - p_2$$
$$f = 3(3-1) - 2(3) - 0 = 0$$

Truss
(fixed structure)



$n = 4$
$p_1 = 4$
$p_2 = 0$

$$f = 3(4-1) - 2(4) - 0 = 1$$

Four bar mechanism
(moveable linkage)

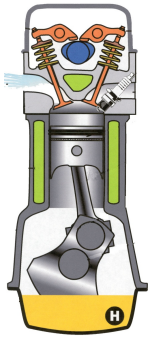
Truss Structures

Bridge

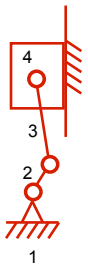
Roof Structure

Crane

Four Bar Mechanism



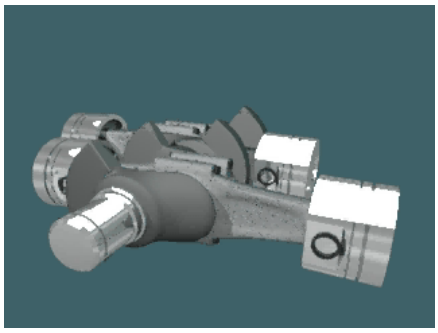
Internal combustion engine



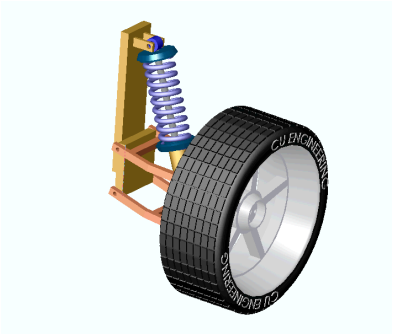
Slider-crank
linkage

$n = 4$ (count the engine block)
$p_1 = 4$
$p_2 = 0$
$f = 1$

4 Cylinder "Boxer" Engine



Automobile Suspension

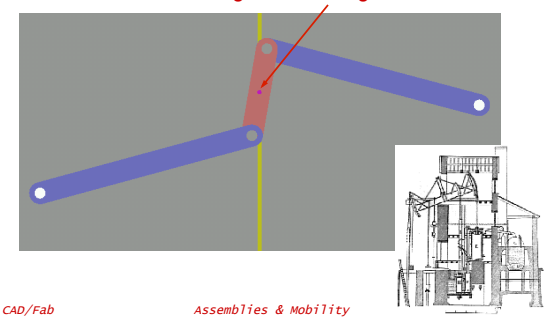


CAD model by Patrick Powers

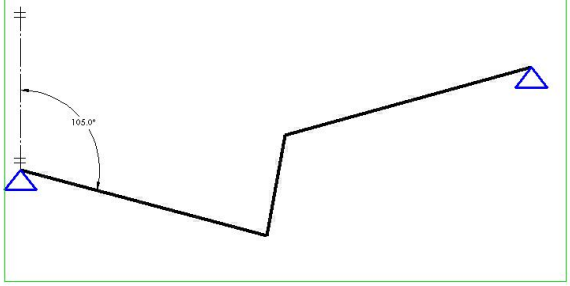
James Watt
1736-1819

Watt Linkage

Invented by James Watt in 1784 to guide the piston of his steam engine in a straight line

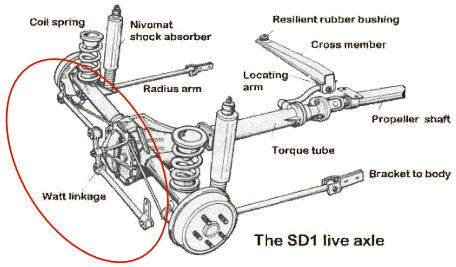


Using SolidWorks Drawings to Design Linkages



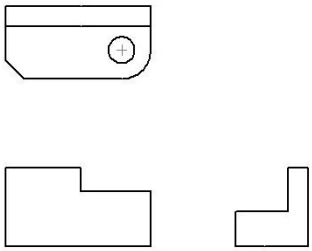
Watt Linkage

Still used in automobile suspensions

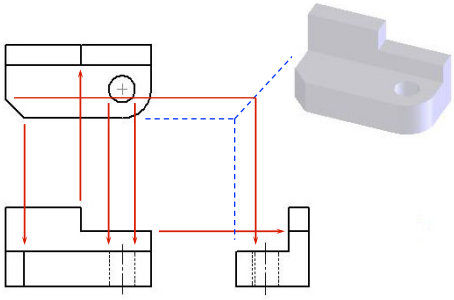


See http://www.brockeng.com/mechanism/Watt.htm for an animated demonstration

Complete the views

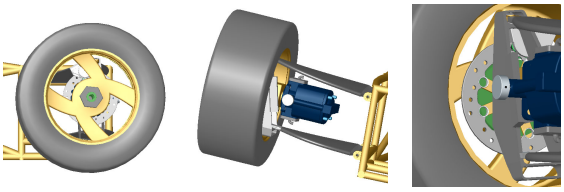


Solution



GDi Project

CU participated in the Global Design Initiative in 2002. Three university teams around the world designed a complete Formula SAE race car in just five 24-hour days. Each team worked on the car for eight hours, then shipped the SolidWorks CAD files to the next team.



CAD model courtesy of James Longino