SEM0104 - Aula 3

Tipos de Mecanismos: Simples e Complexos

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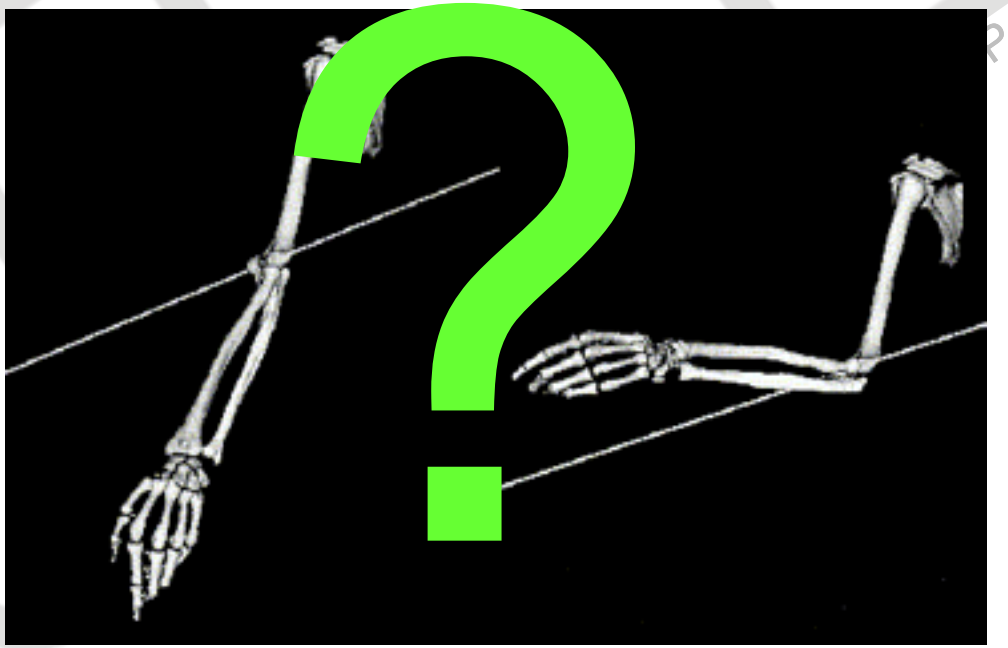
USP - EESC - SEM

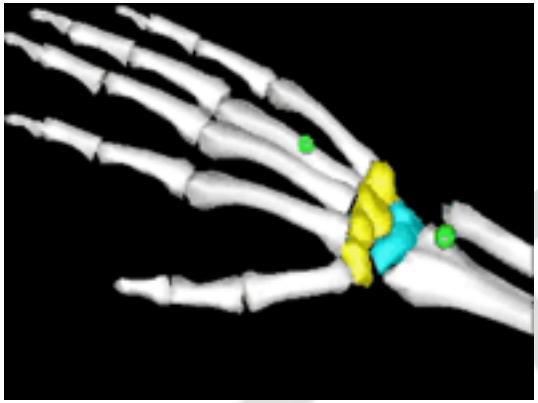
LabRoM

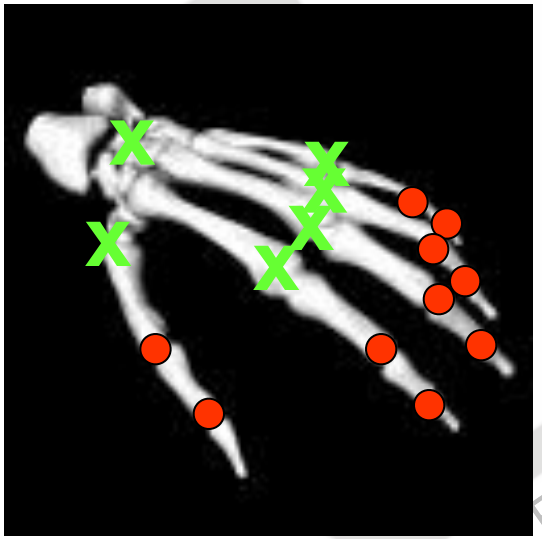
Pergunta da Aula Passada

Quantos GDLs possui o conjunto mão, ante-braço e braço?



Pergunta da Aula Passada

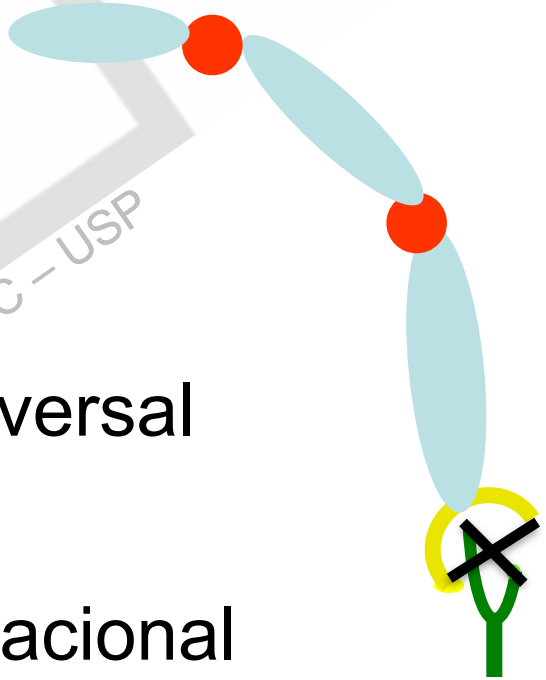




22 DoFs

x Junta Universal

Junta Rotacional



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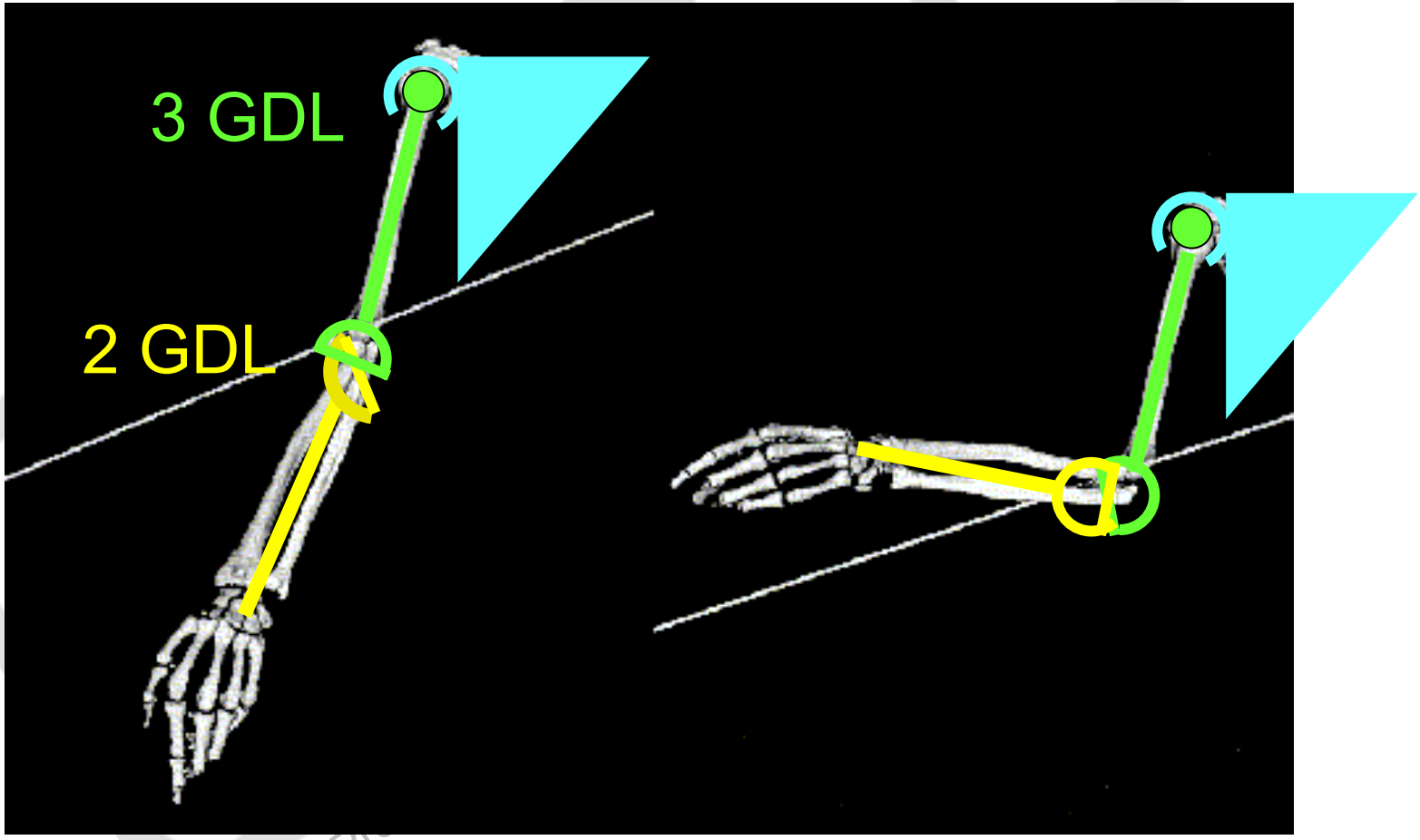
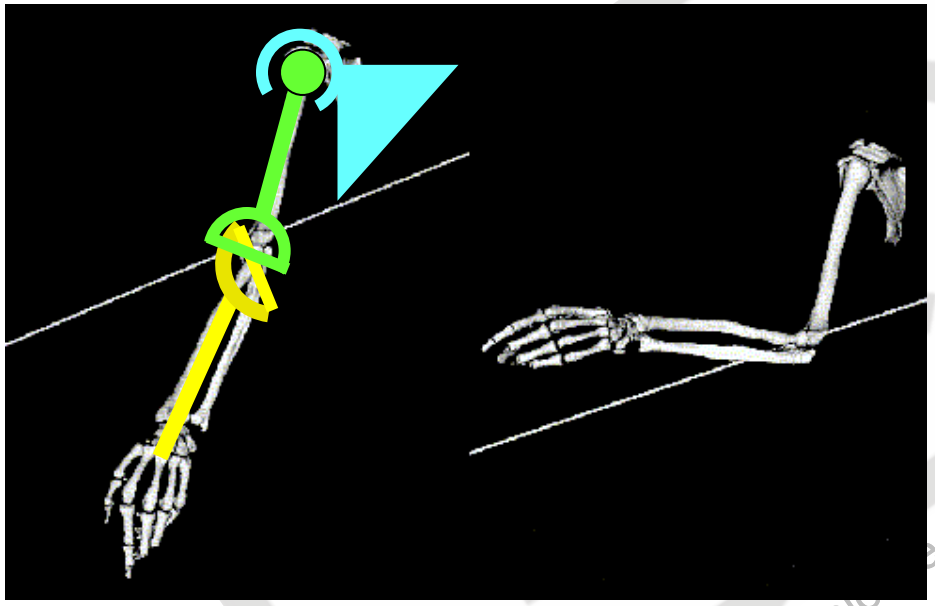


Pergunta da Aula Passada



No Total:

22 DoFs da mão
3 DoFs do braço
2 DoFs do ante-braço

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27 DoFs

Sumário da Aula

- **Classificação de Mecanismos**
- Mecanismos Simples
  - 4 Barras
    - Lei de Grashof
    - Lei de Reuleaux
  - Biela Manivela
- Mecanismos Complexos
- Bibliografia Recomendada

Classificação de Mecanismos

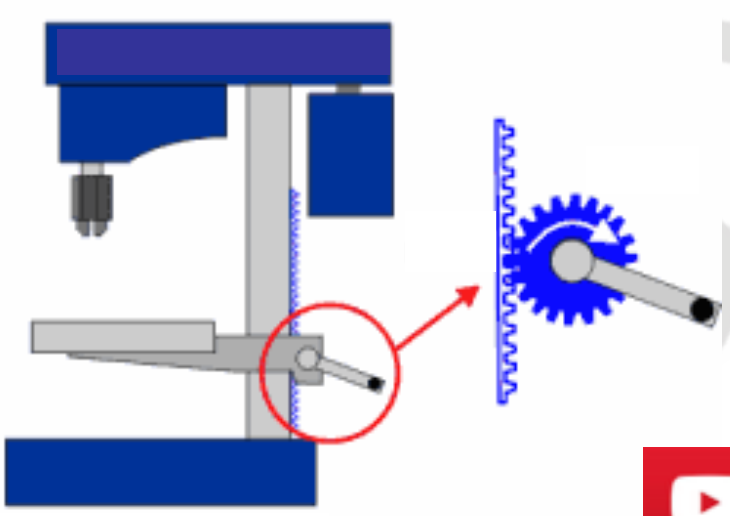
L. E. Torfason

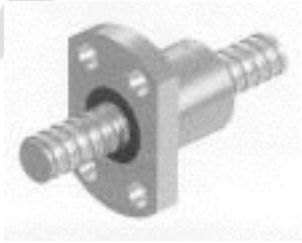
- Feita pelo tipo de transformação de movimento (262 Classes)
- 12 Classes Principais:
  - Atuadores Lineares
  - Ajuste Fino
  - Hesitação, Pausa e Parada
  - Posicionamento
  - Catraca
  - Contadores
  - Osciladores
  - Retorno Rápido
  - Reversíveis
  - Acoplamento
  - Geradores de Curvas
  - Geradores de Retas

Classificação de Mecanismos

L. E. Torfason – Atuadores Lineares

- Parafuso Fixo, Porca Fixa
- Cilindro Pneumático ou Hidráulico
- Pinhão - Cremalheira





https://www.youtube.com/watch?v=kl6qNn9-nkk

Classificação de Mecanismos

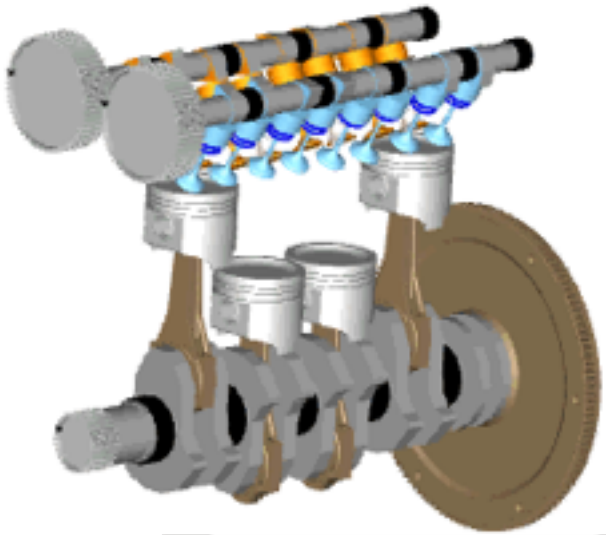
L. E. Torfason – Ajuste Fino

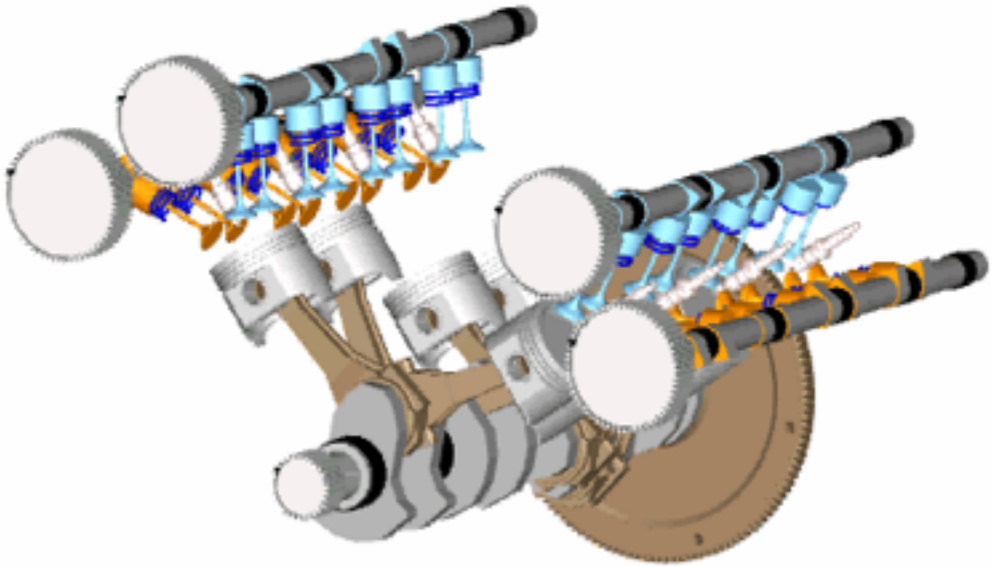
- Parafuso e Porca
- Engrenagens

Classificação de Mecanismos

L. E. Torfason – Hesitação, Pausa e Parada

- Came-Seguidor

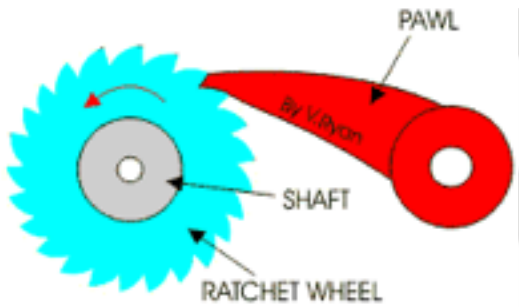


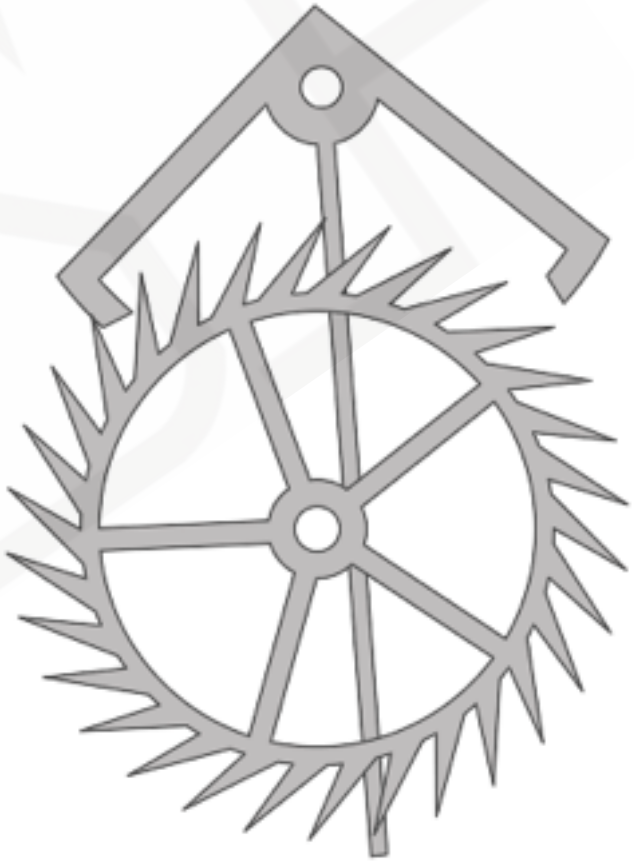


Classificação de Mecanismos

L. E. Torfason – Catraca

- Ratchet

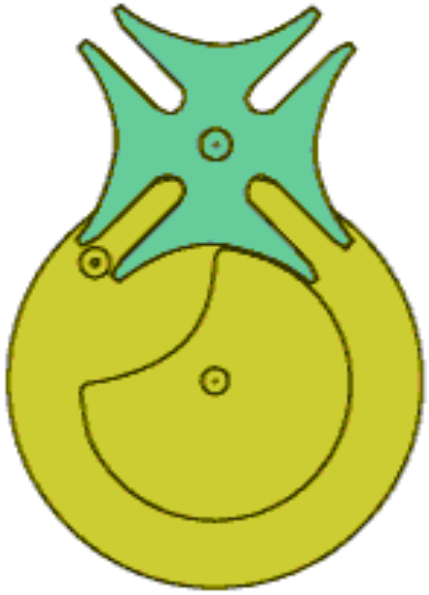




Classificação de Mecanismos

L. E. Torfason – Contadores

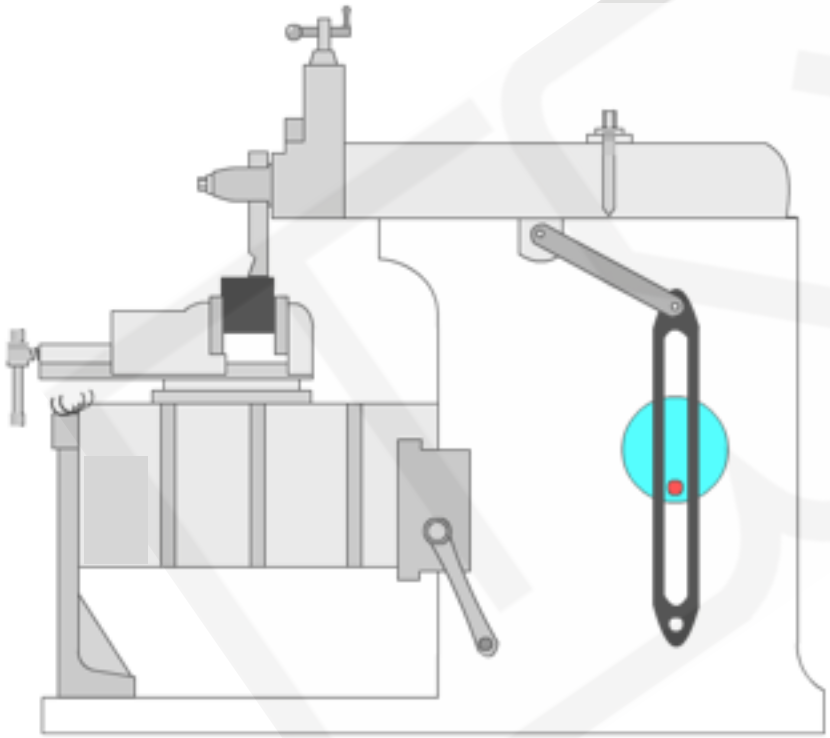
- Roda de Genebra
- Ratchet

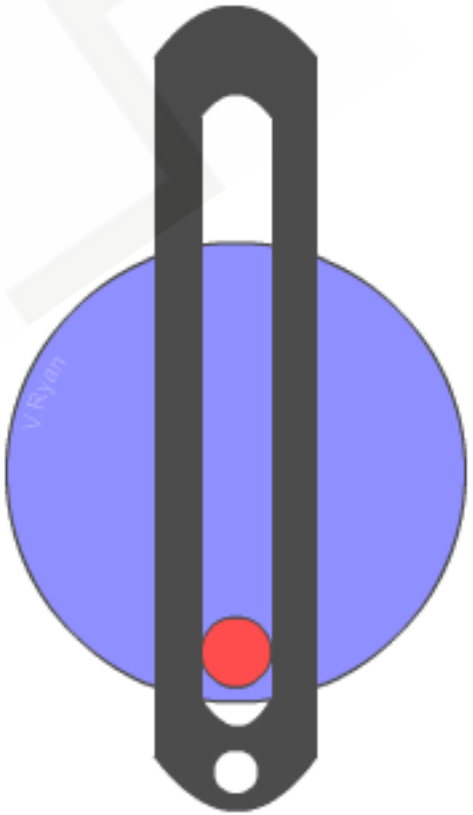


Classificação de Mecanismos

L. E. Torfason – Osciladores

- Bila-Manivela

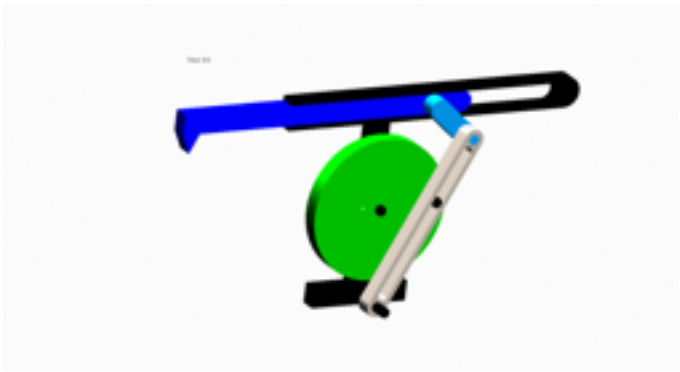




Classificação de Mecanismos

L. E. Torfason – Retorno Rápido

- Mecanismo de Retorno Rápido
  - Caracterizam-se por possuírem 2 fases de movimento para uma dada velocidade angular constante
  - Relação de tempo "ida-retorno"
  - Podem ser constituídos apenas por uma biela manivela ou por mecanismos mais complexos.



Classificação de Mecanismos

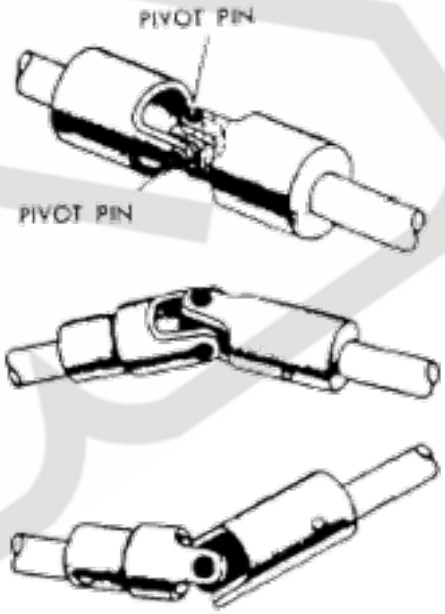
L. E. Torfason – Reversíveis

- Permitem que a direção de rotação possa ser alterada
  - Engrenagens
  - 4 Barras
  - Etc.

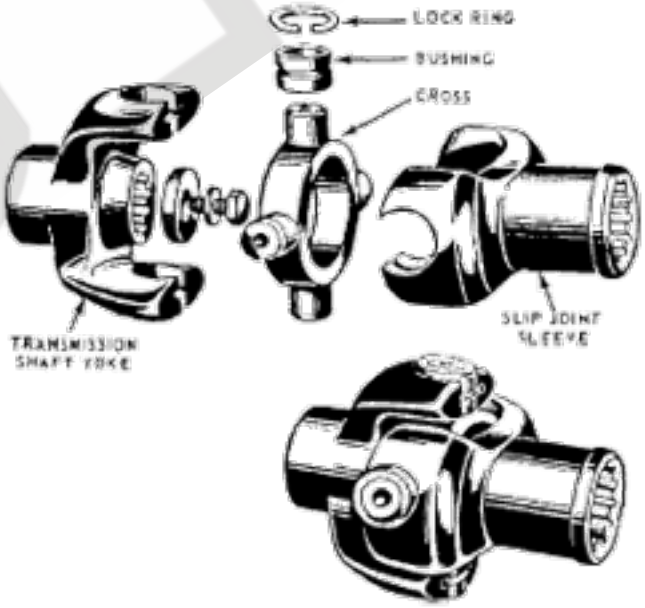
Classificação de Mecanismos

L. E. Torfason – Acoplamento

- Junta Universal
- Correia
- Corrente



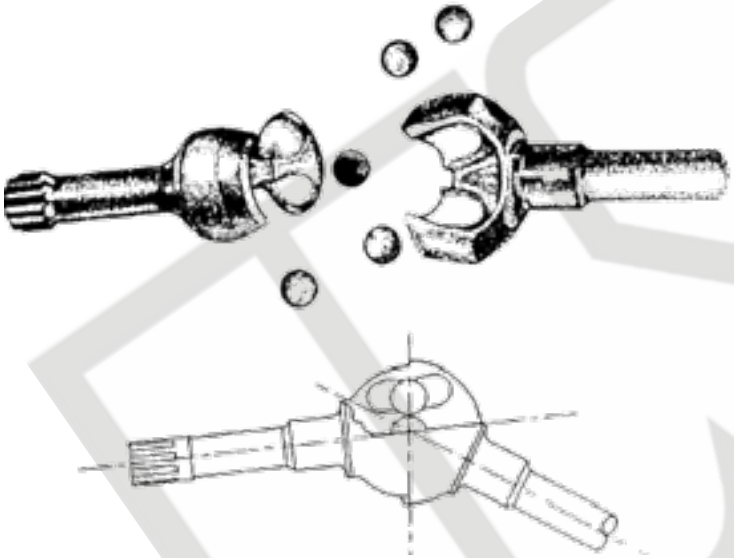
Hooke



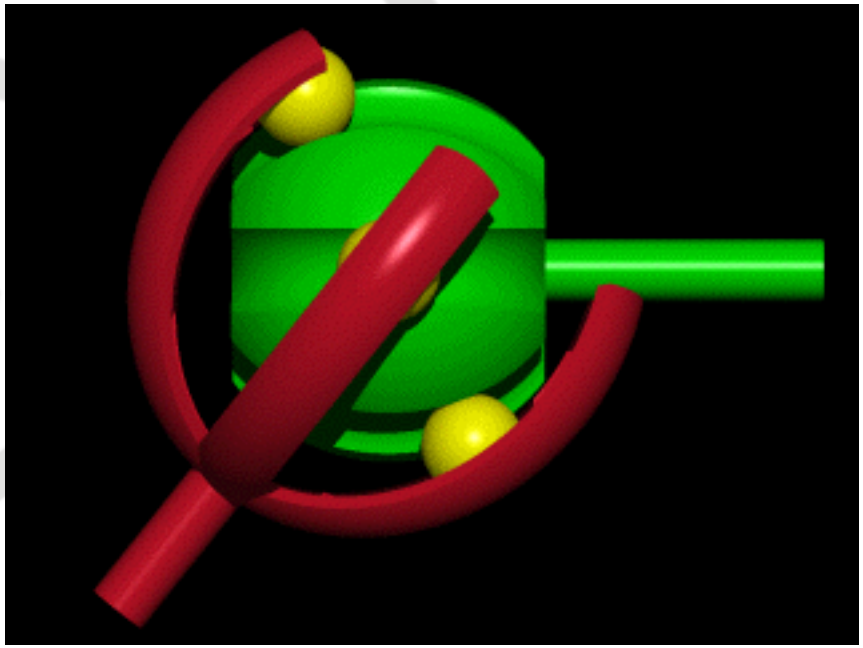
Ring and Trunnion

Classificação de Mecanismos

L. E. Torfason – Acoplamento



Bendix-Zeiss



Classificação de Mecanismos

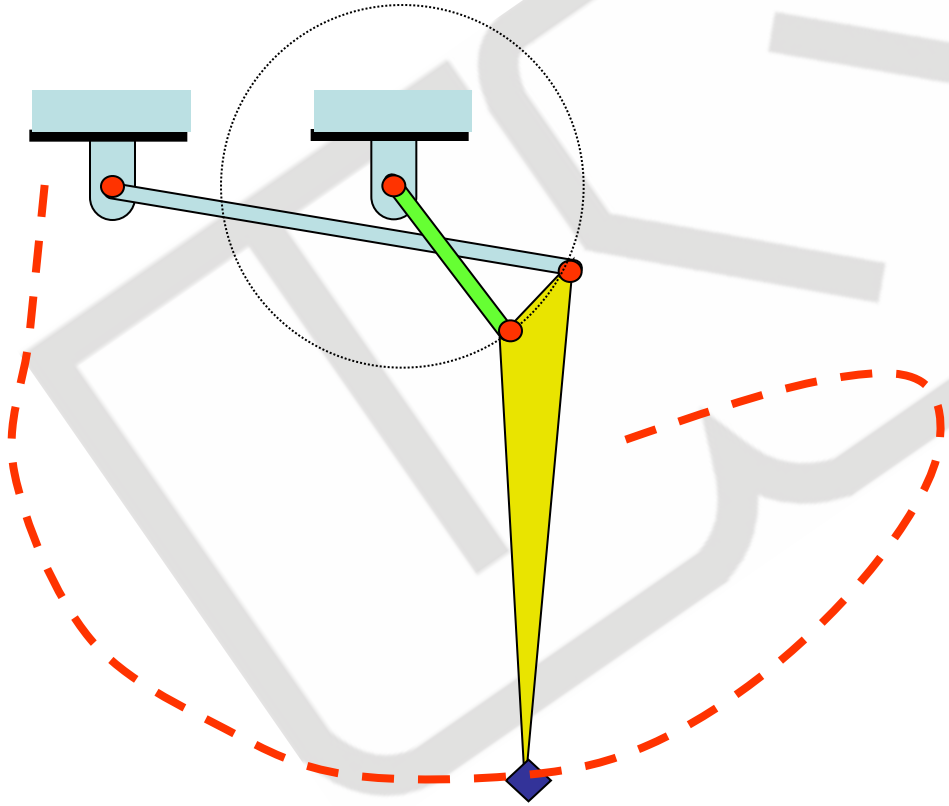
L. E. Torfason – Acoplamento

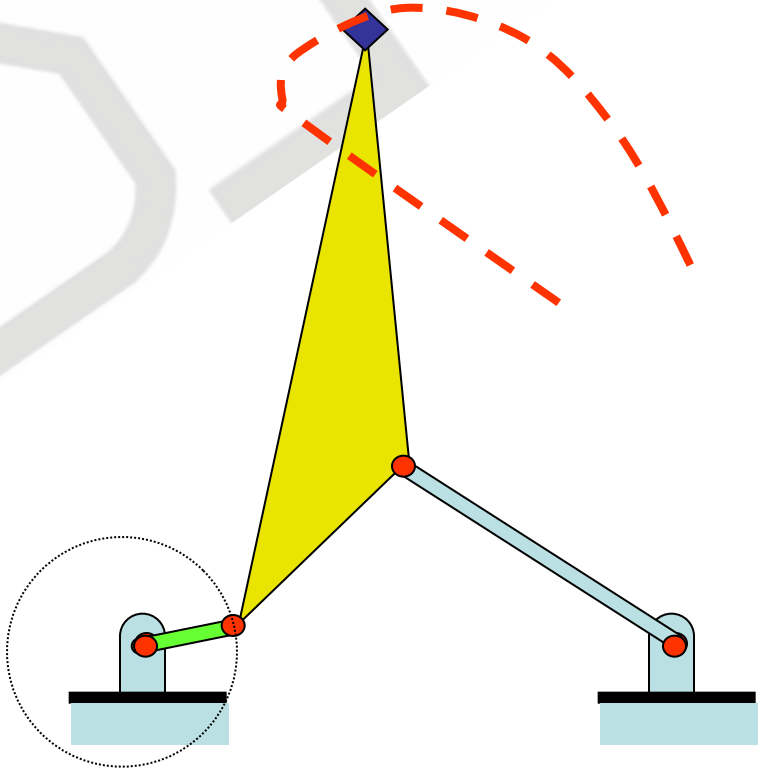
http://giphy.com/gifs/

Classificação de Mecanismos

L. E. Torfason – Geradores de Curvas

- 4 Barras

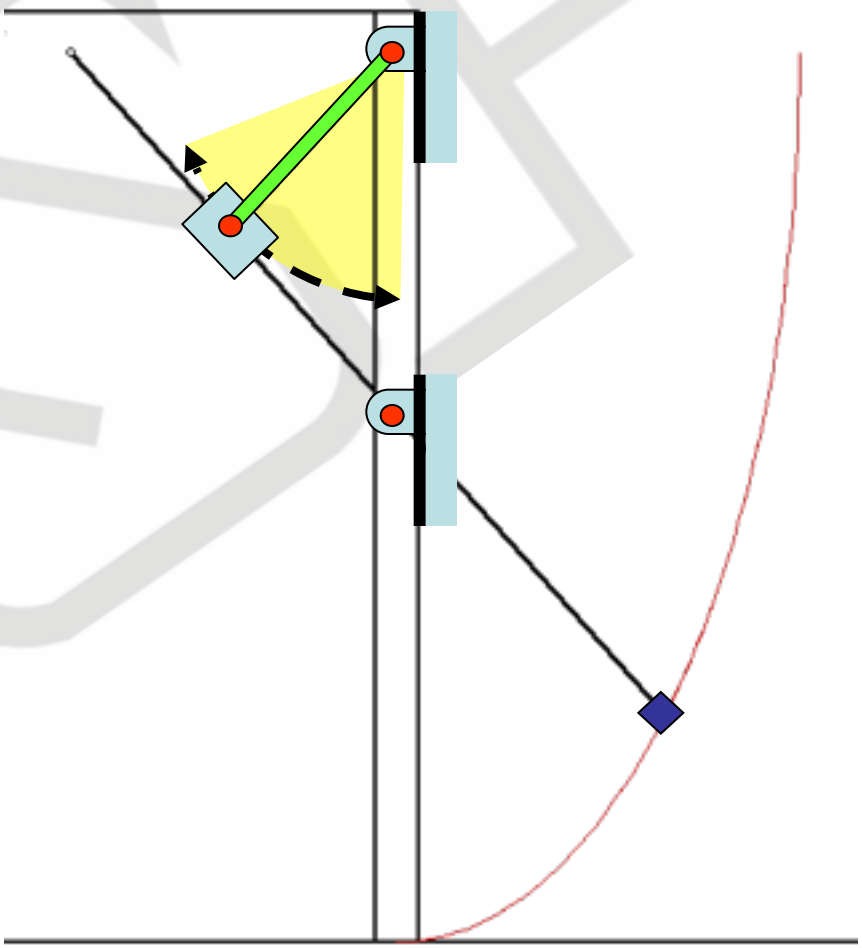




Classificação de Mecanismos

L. E. Torfason – Geradores de Curvas

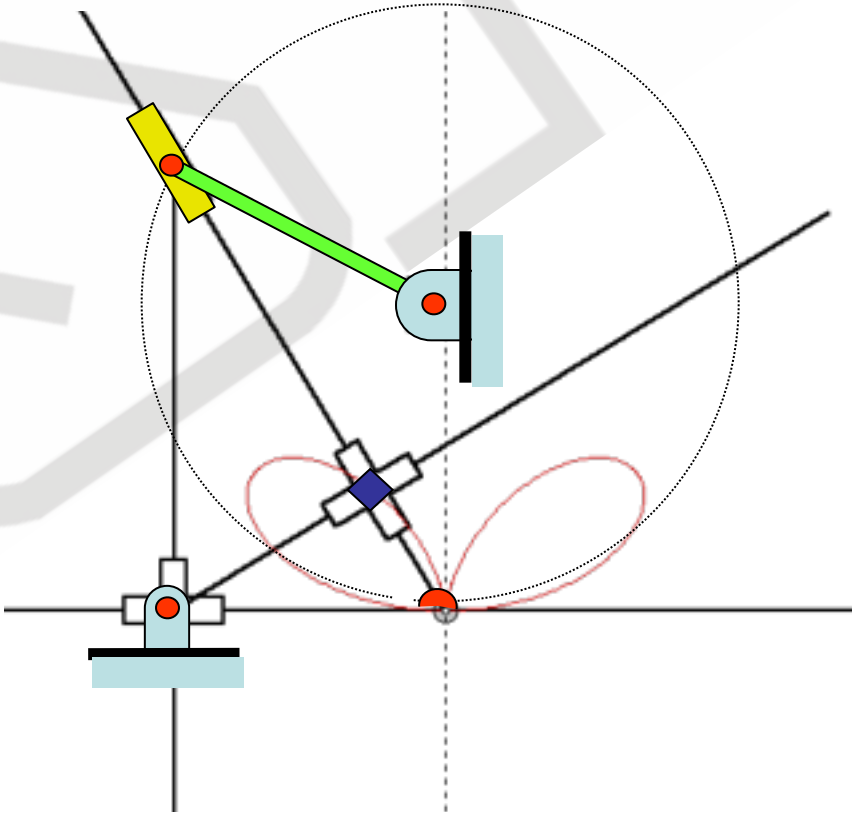
- Biela-Manivela



Classificação de Mecanismos

L. E. Torfason – Geradores de Curvas

- Biela-Manivela



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    - Lei de Reuleaux
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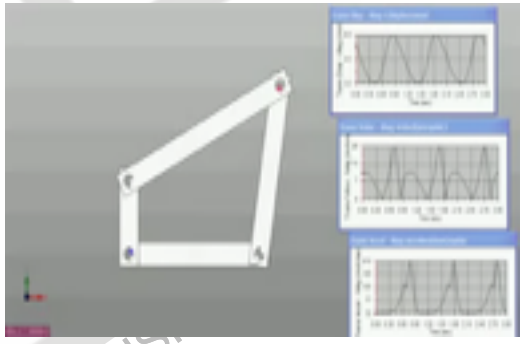
Mecanismos Simples
4 Barras

- Mecanismo Simples
  - Movimento oscilatório do link seguidor
  - Movimento do link acoplador



- 4 Barras Plano

- 4 Barras Espacial

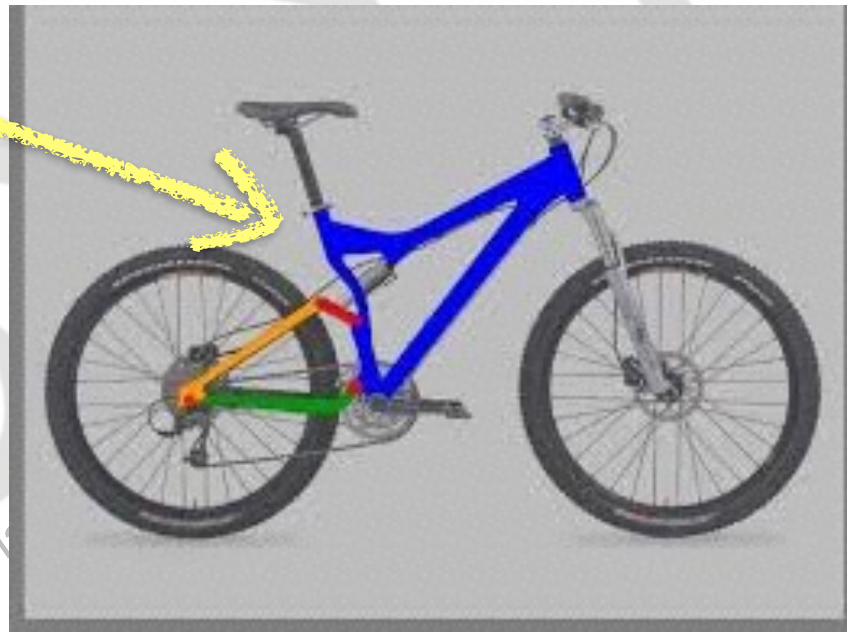
http://www.youtube.com/watch?v=-KYomnT8xSc

http://www.youtube.com/watch?v=c_PnjGARuNU

Mecanismos Simples
4 Barras

- Mecanismo Simples
  - Movimento oscilatório do link seguidor
  - Movimento do link acoplador

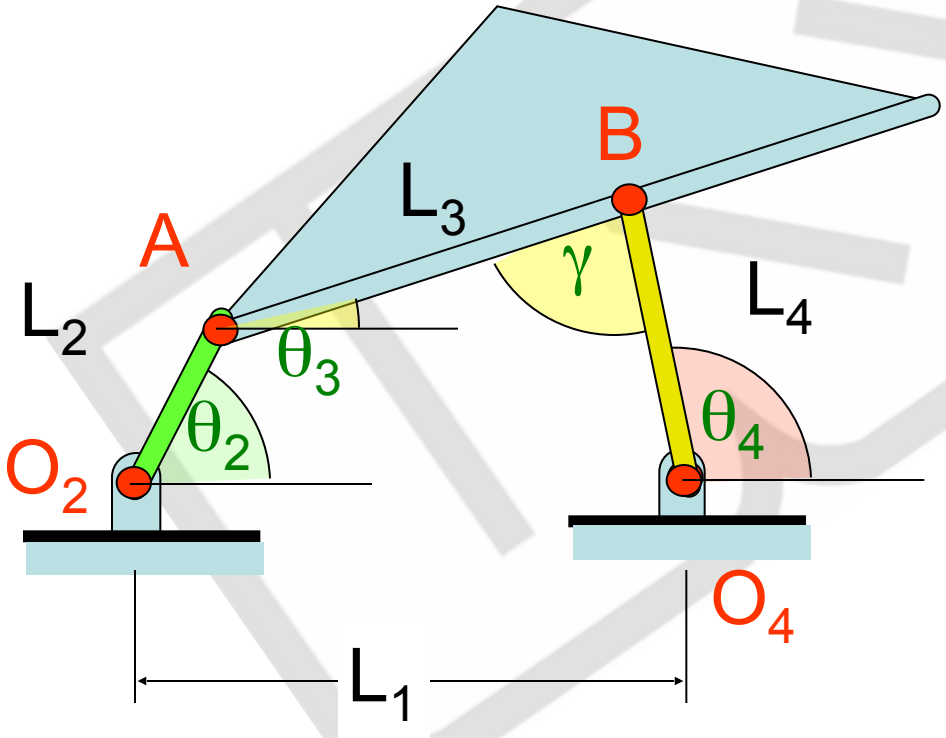
- 4 Barras Plano



https://en.wikipedia.org/wiki/Four-bar_linkage

Mecanismos Simples

4 Barras



L_2: link motor

L_1: solo

L_3: link acoplador

L_4: link seguidor

θ_2: âng. da barra motriz

θ_4: âng. da barra seguidora

θ_3: âng. da barra acopladora

γ: âng. de transmissão

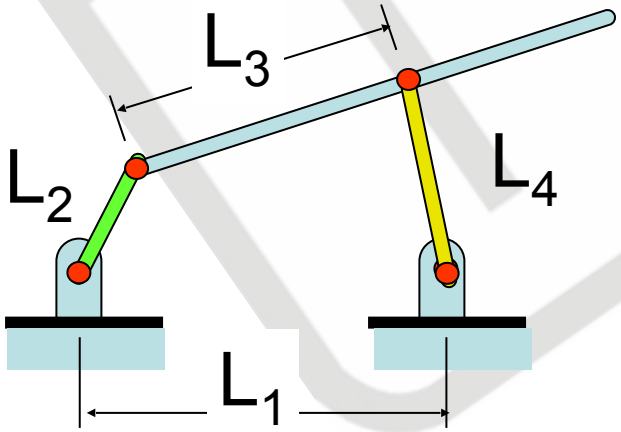
Lei de Grashof

- **Franz Grashof** - Prof. na Univ. de Karlsruhe

*1826 +1893

Condição para rotação completa barra motriz de mecanismo 4-barras

"A soma da menor e da maior barra de um mecanismo 4-barras **não** pode ser maior que a soma das 2 outras barras"

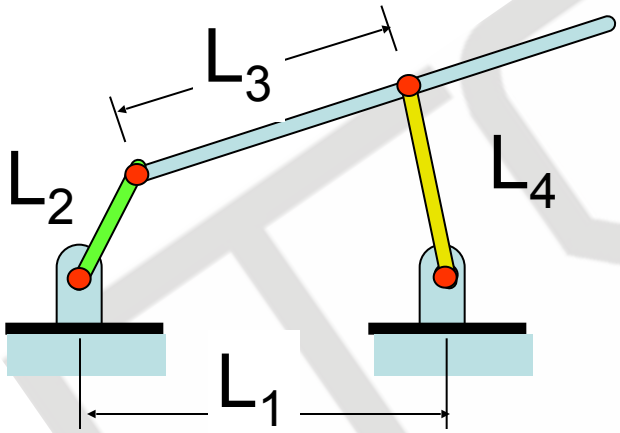


$Me = L_2$ $Ma = L_1$

$b_1 = L_3$ $b_2 = L_4$

Lei de Grashof

Equação



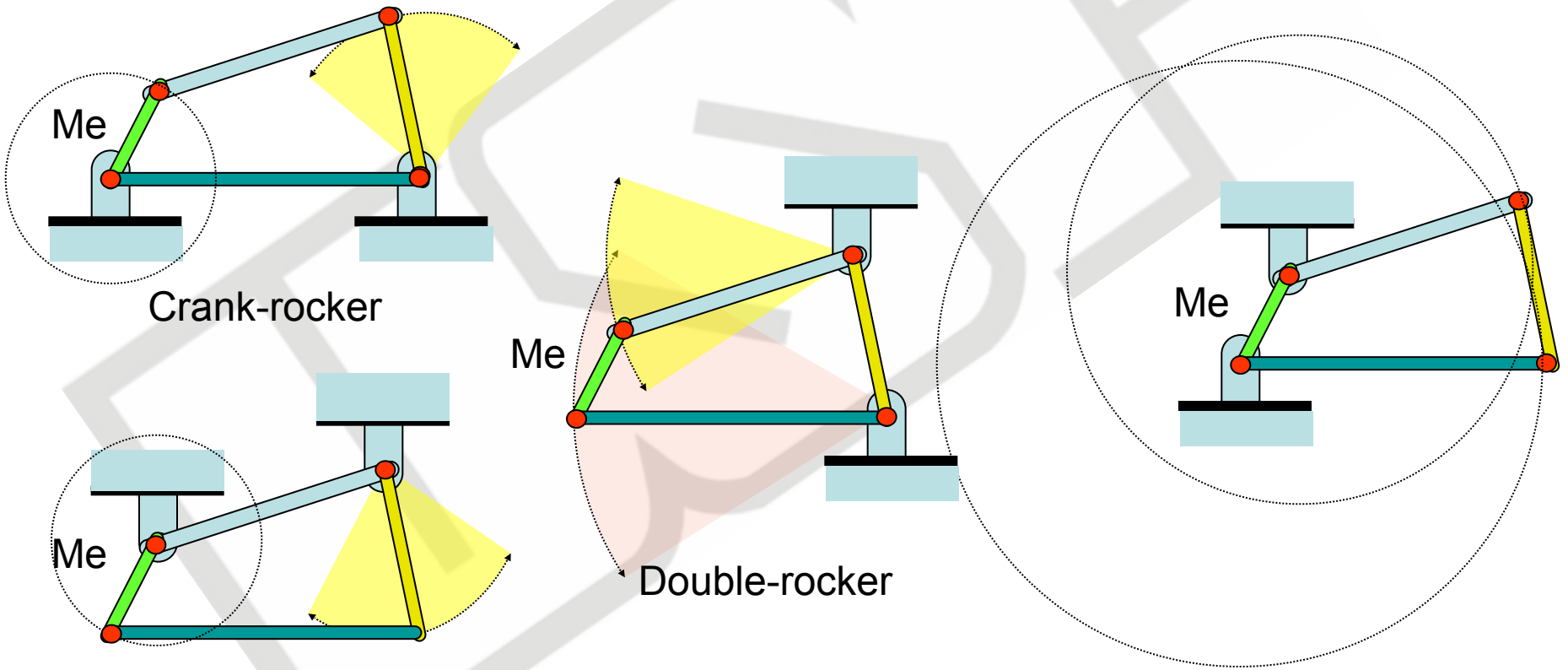
$$Me + Ma \leqslant b_1 + b_2$$

$Me = L_2$ $\quad$ $Ma = L_1$

$b_1 = L_3$ $\quad$ $b_2 = L_4$

Lei de Grashof

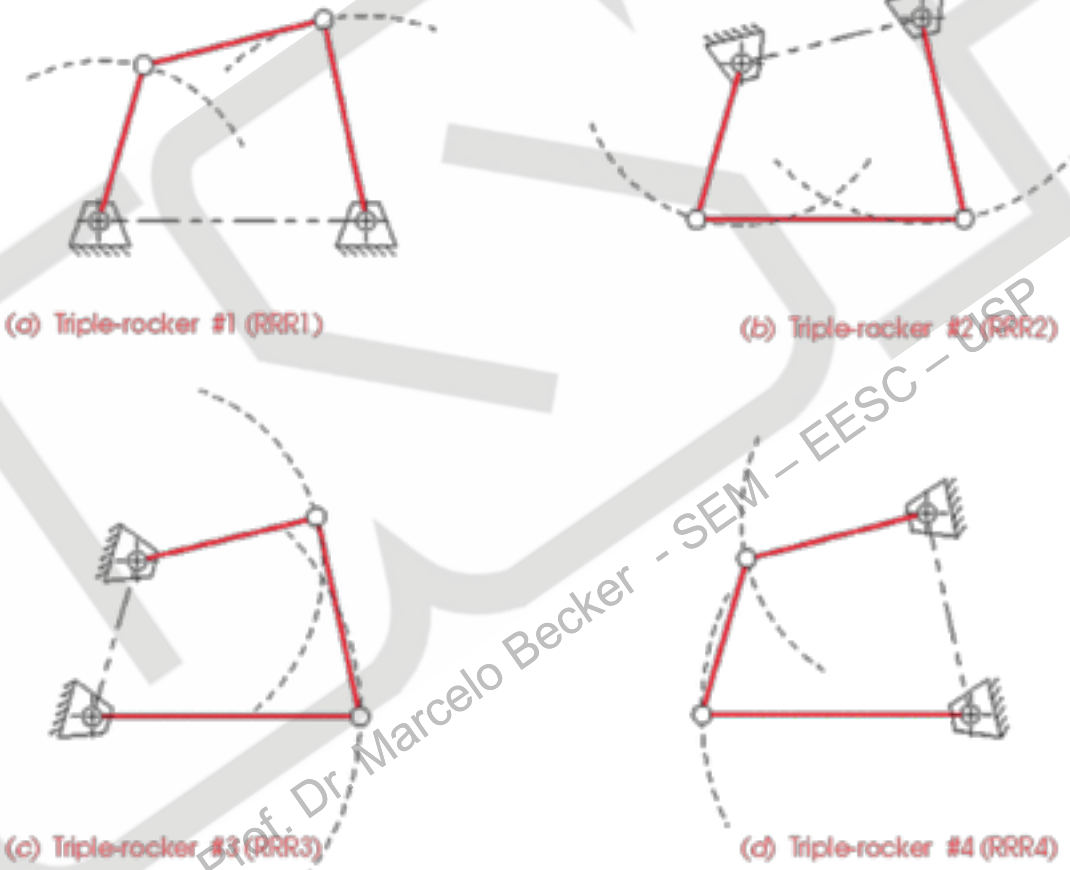
Inversões do Mecanismo 4-Barras



Me adjacente a Ma

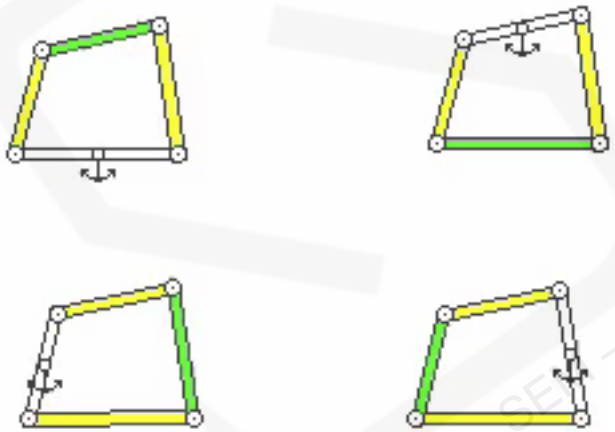
Lei de Grashof

- Inversões do mecanismo 4-barras



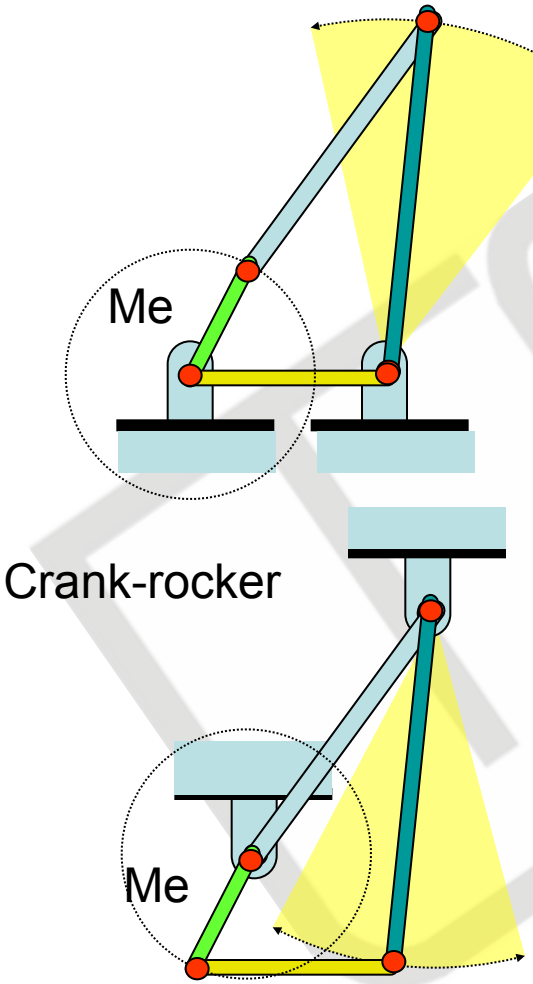
Lei de Grashof

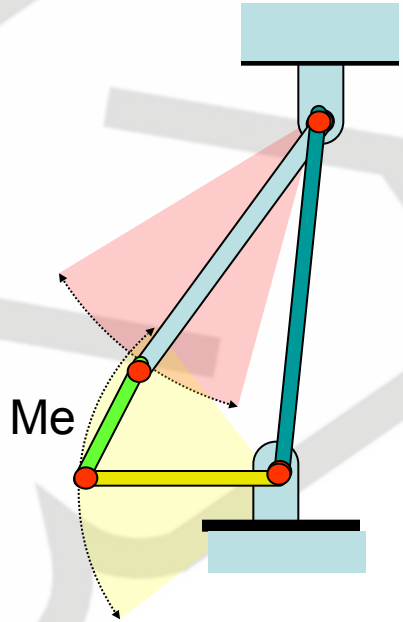
- Inversões do mecanismo 4-barras

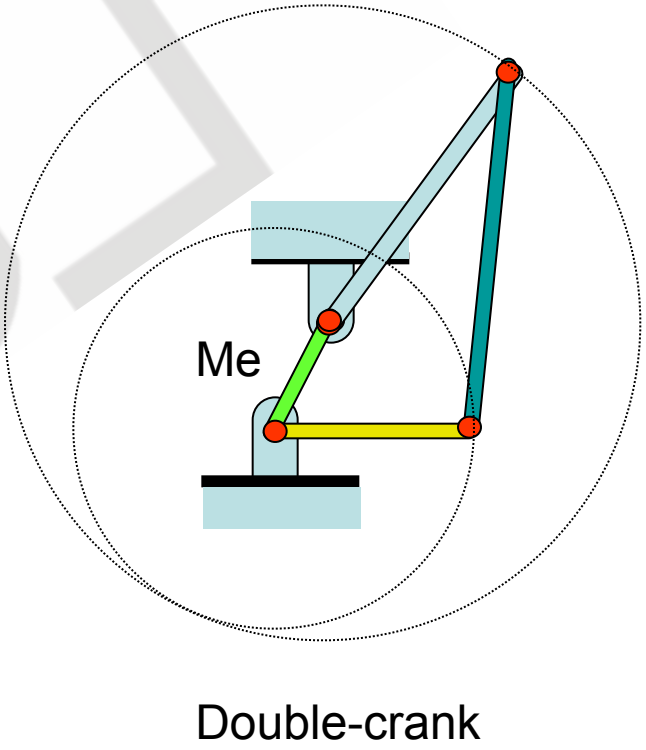


Lei de Grashof

Inversões do Mecanismo 4-Barras



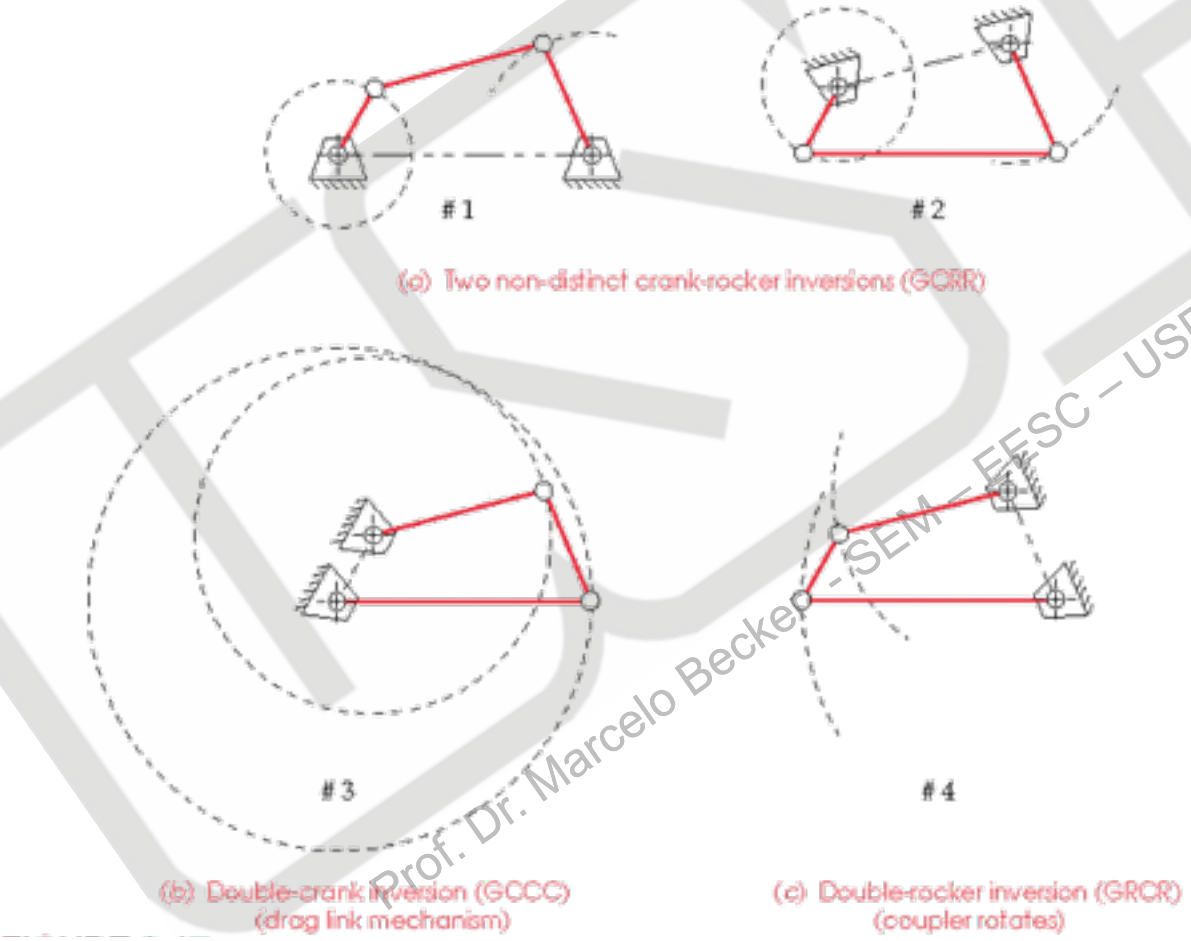




Me oposto a Ma

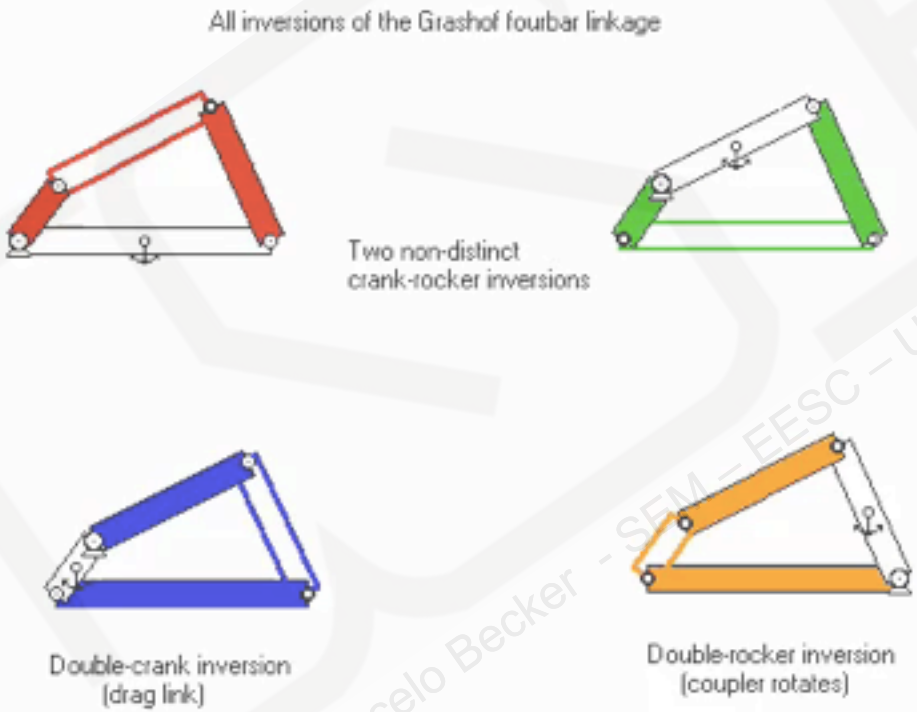
Lei de Grashof

- Inversões do mecanismo 4-barras



Lei de Grashof

- Inversões do mecanismo 4-barras



Lei de Grashof

- Classes de Grashof - Configurações Especiais

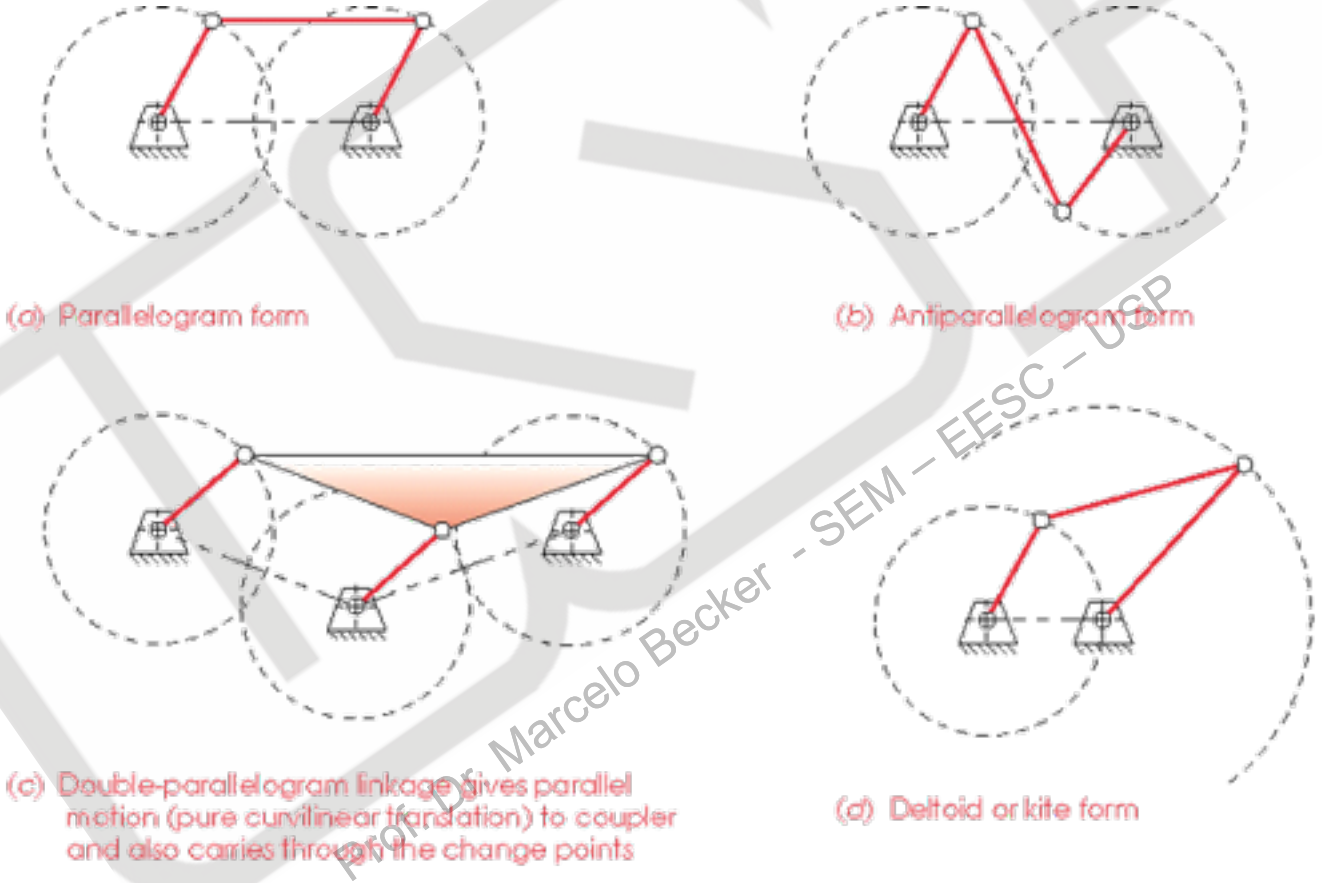


TABLE 2-4 Barker's Complete Classification of Planar Fourbar Mechanisms

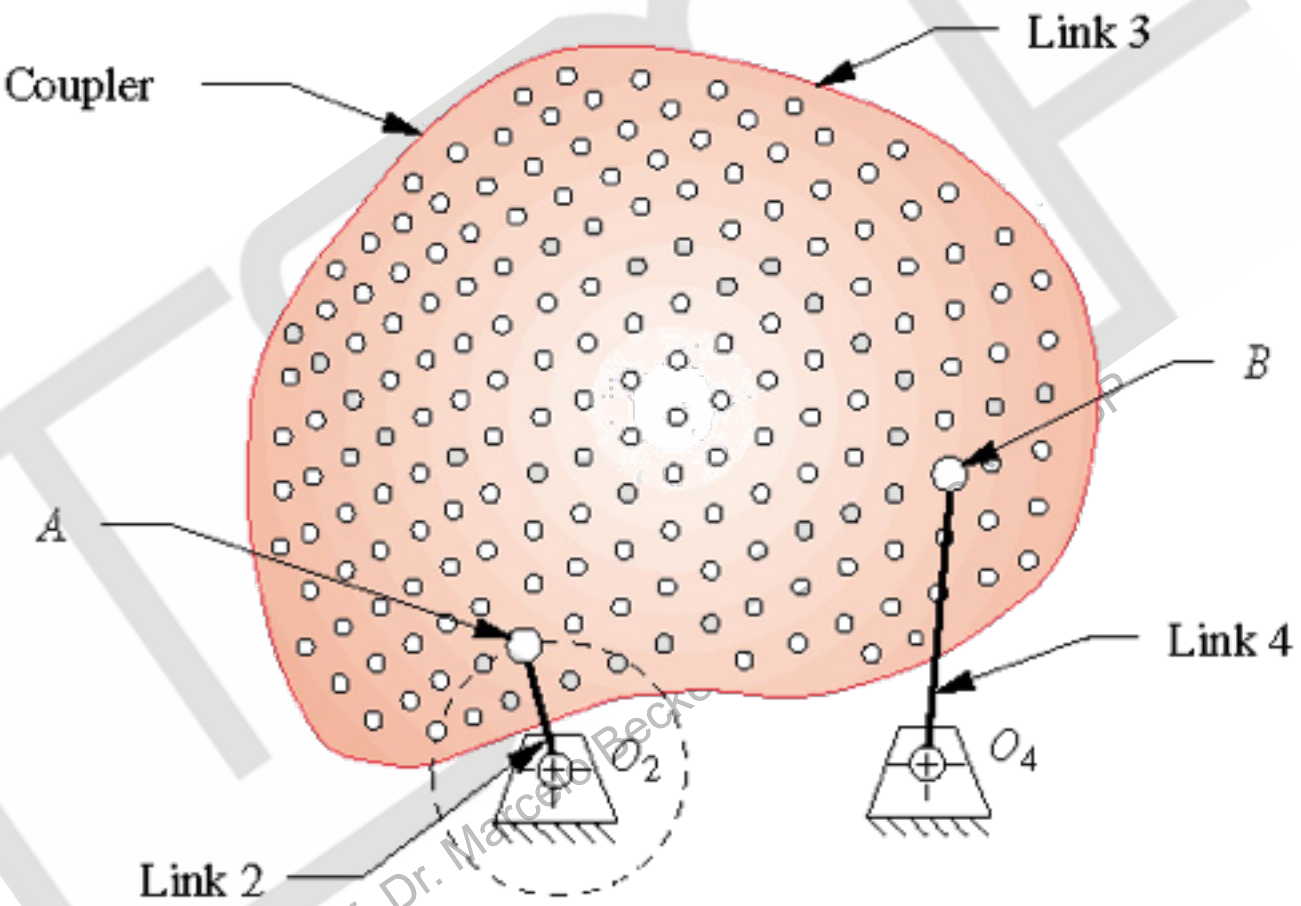
Adapted from ref. (10). s = shortest link, l = longest link, Gxxx = Grashof, RRRx = non-Grashof, Sxx = Special case

Type	$s + l$ vs. $p + q$	Inversion	Class	Barker's Designation	Code	Also Known As
1	<	$L_1 = s$ = ground	I-1	Grashof crank-crank-crank	GCCC	double-crank
2	<	$L_2 = s$ = input	I-2	Grashof crank-rocker-rocker	GCRR	crank-rocker
3	<	$L_3 = s$ = coupler	I-3	Grashof rocker-crank-rocker	GRCR	double-rocker
4	<	$L_4 = s$ = output	I-4	Grashof rocker-rocker-crank	GRRC	rocker-crank
5	>	$L_1 = l$ = ground	II-1	Class 1 rocker-rocker-rocker	RRR1	triple-rocker
6	>	$L_2 = l$ = input	II-2	Class 2 rocker-rocker-rocker	RRR2	triple-rocker
7	>	$L_3 = l$ = coupler	II-3	Class 3 rocker-rocker-rocker	RRR3	triple-rocker
8	>	$L_4 = l$ = output	II-4	Class 4 rocker-rocker-rocker	RRR4	triple-rocker
9	=	$L_1 = s$ = ground	III-1	change point crank-crank-crank	SCCC	SC* double -crank
10	=	$L_2 = s$ = input	III-2	change point crank-rocker-rocker	SCRR	SC crank-rocker
11	=	$L_3 = s$ = coupler	III-3	change point rocker-crank-rocker	SRCR	SC double-rocker
12	=	$L_4 = s$ = output	III-4	change point rocker-rocker-crank	SRRC	SC rocker-crank
13	=	two equal pairs	III-5	double change point	S2X	parallelogram or deltoid
14	=	$L_1 = L_2 = L_3 = L_4$	III-6	triple change point	S3X	square

* SC = special case.

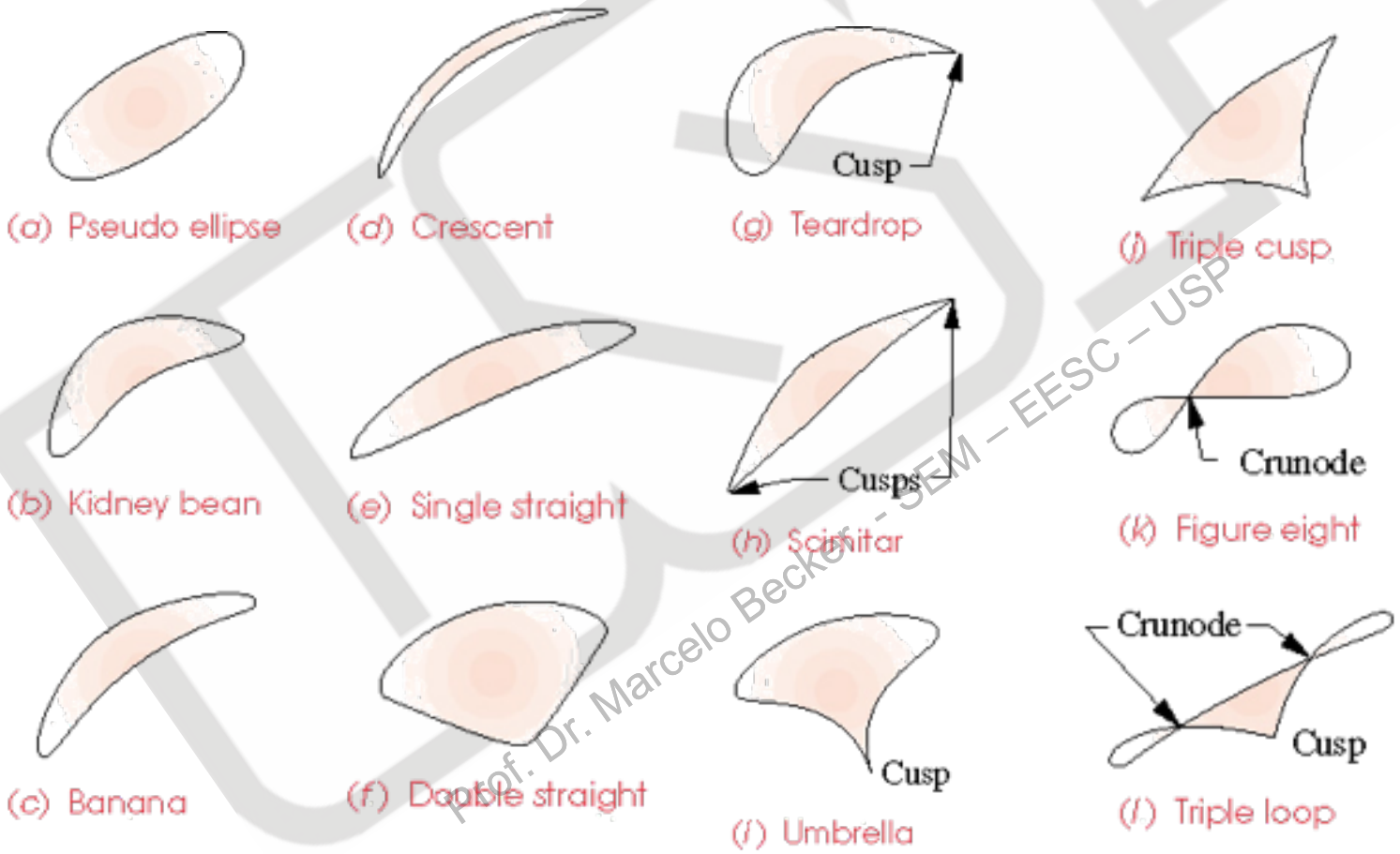
Mecanismos Simples

4 Barras



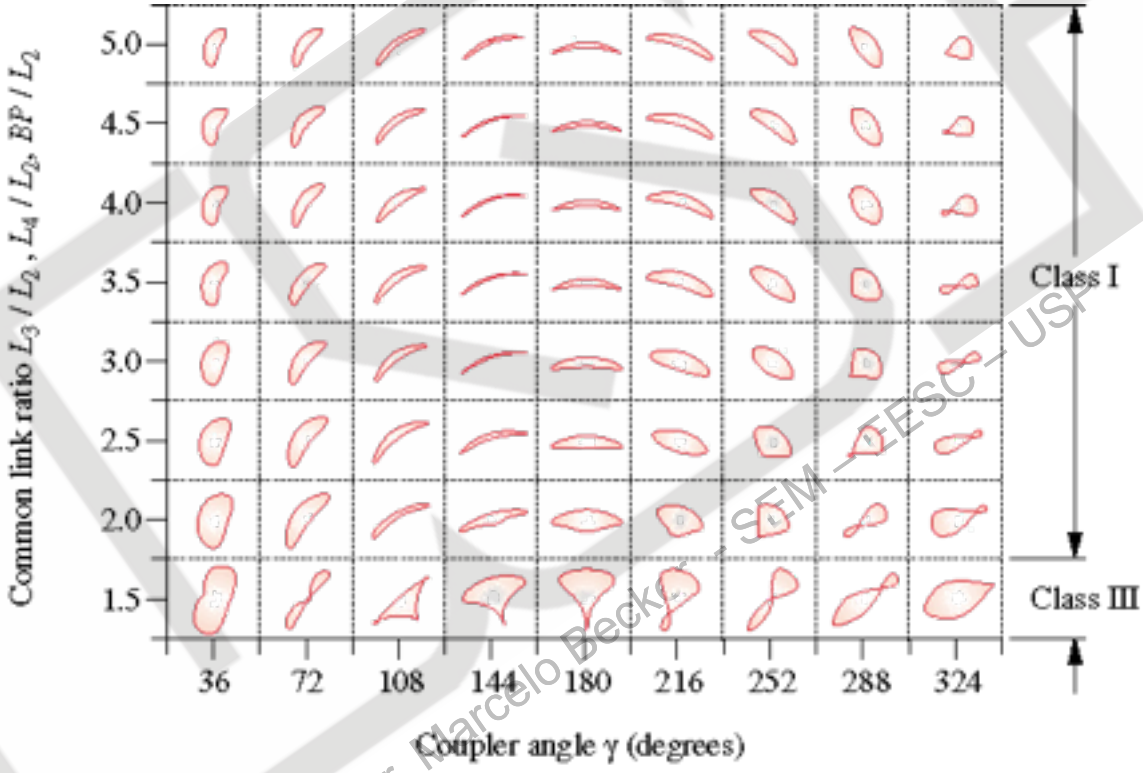
Mecanismos Simples
4 Barras

- Possíveis curvas geradas pelo link acoplador



Mecanismos Simples
4 Barras

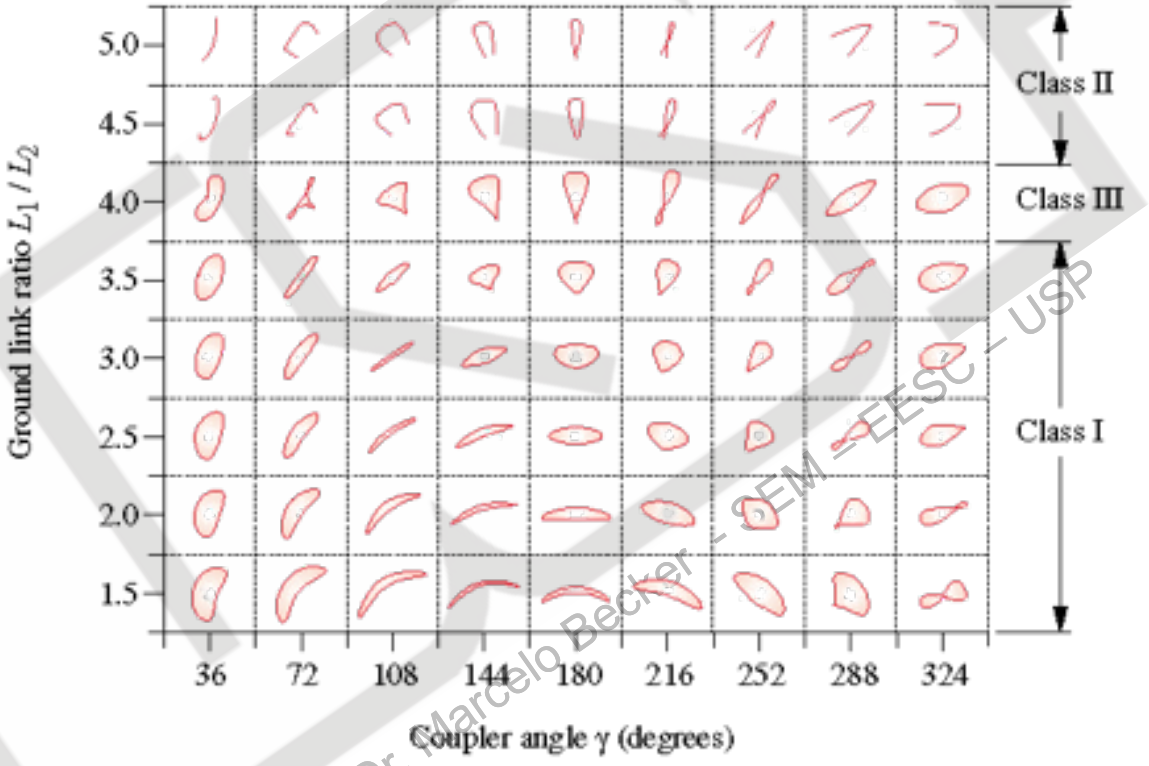
- Informações de Atlas



(a) Variation of coupler curve shape with common link ratio and coupler angle for a ground link ratio $L_1 / L_2 = 2.0$

Mecanismos Simples
4 Barras

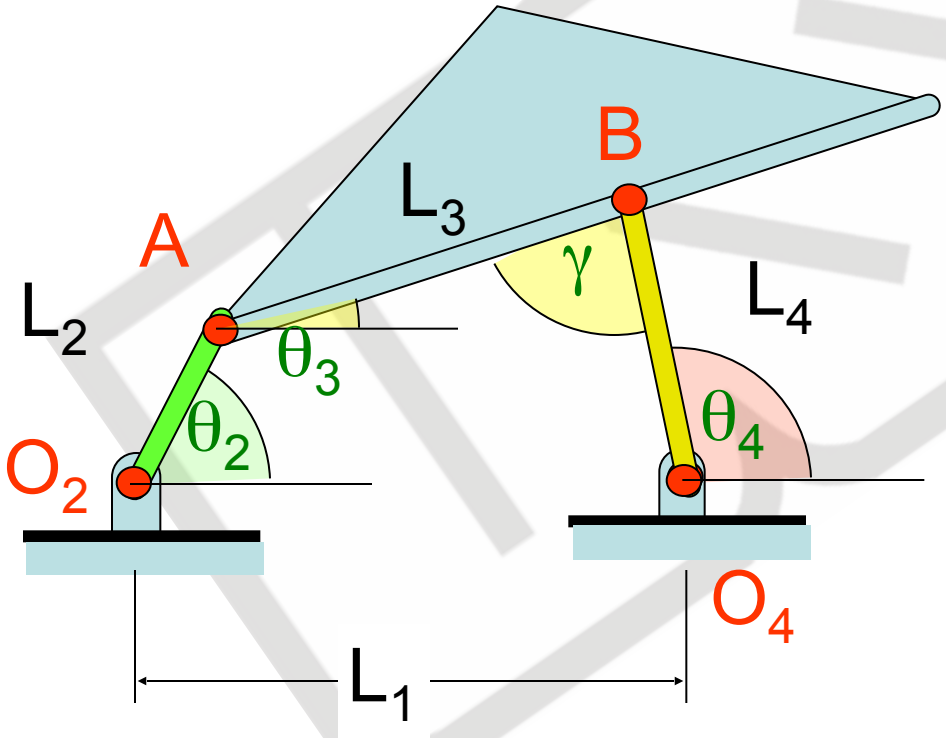
- Informações de Atlas



(b) Variation of coupler curve shape with ground link ratio and coupler angle for a common link ratio $L_3 / L_2 = L_4 / L_2 = BP / L_2 = 2.5$

Mecanismos Simples
4 Barras - Equacionamento

- Na Lousa



L_2: link motor

L_1: solo

L_3: link acoplador

L_4: link seguidor

θ_2: âng. da barra motriz

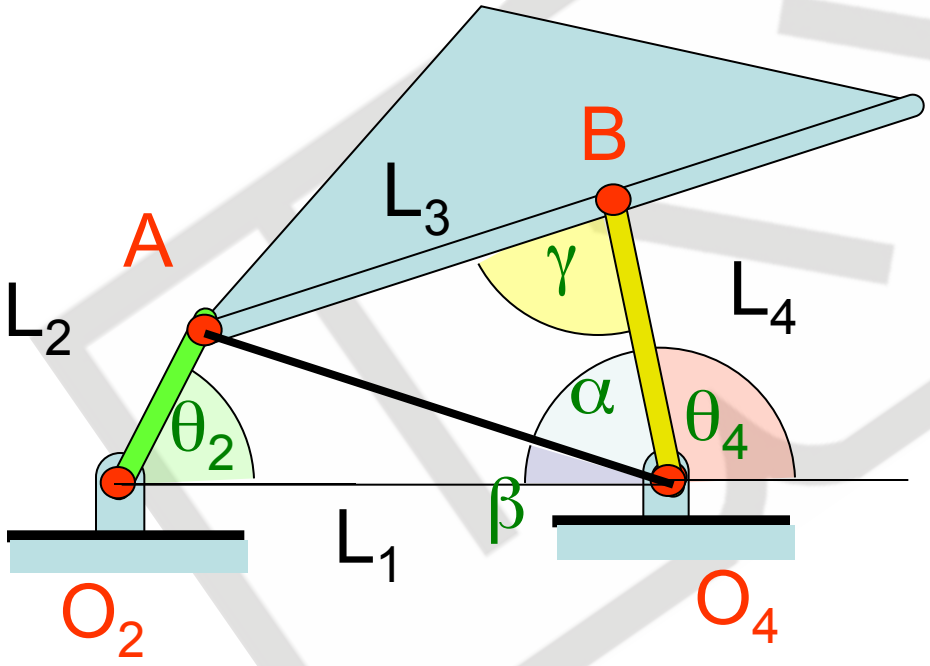
θ_4: âng. da barra seguidora

θ_3: âng. da barra acopladora

γ: âng. de transmissão

Mecanismos Simples
4 Barras - Equacionamento

- Na Lousa



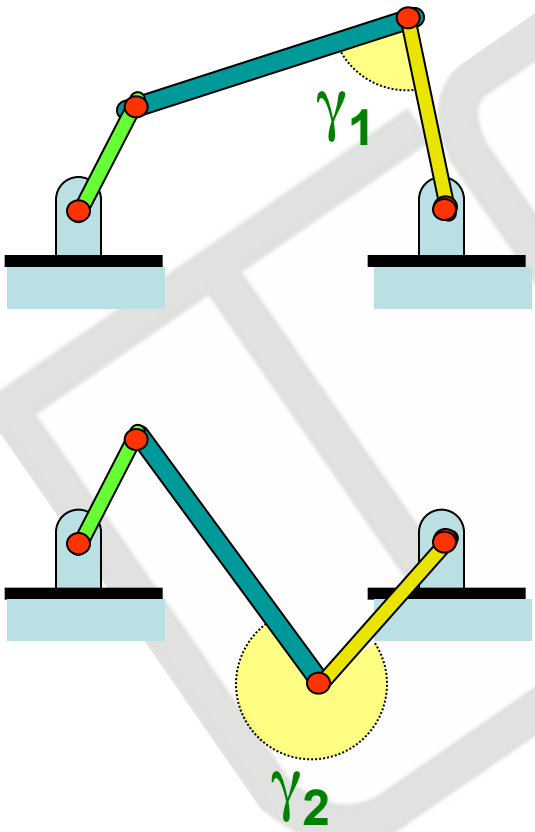
Na Lousa...

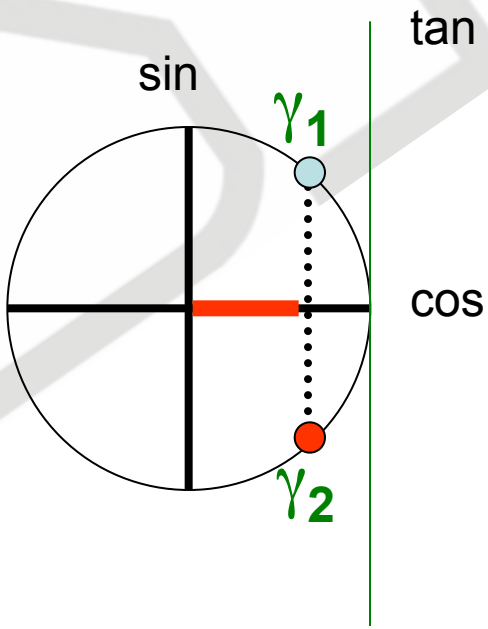
ΔABO_4

ΔAO_2O_4

Mecanismos Simples
4 Barras

- Significado físico dos 2 valores de γ





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  - Biela Manivela
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- Bibliografia Recomendada

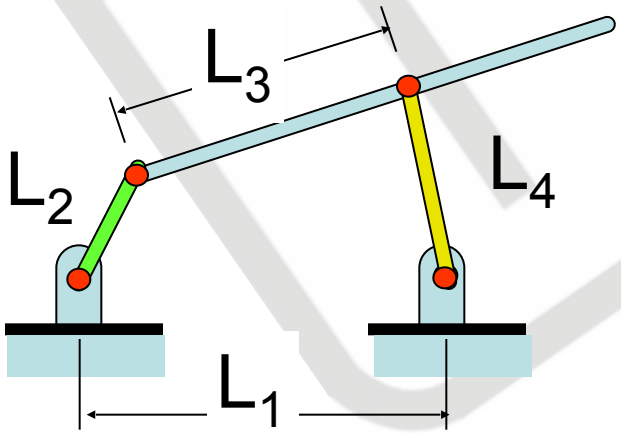
Lei de Reuleaux

Montagem do Mecanismo 4-Barras

- **Franz Reuleaux** - "Pai da Cinemática"

*1829 +1905

Condição para a montagem mecanismos 4-barras



L_2: link motor

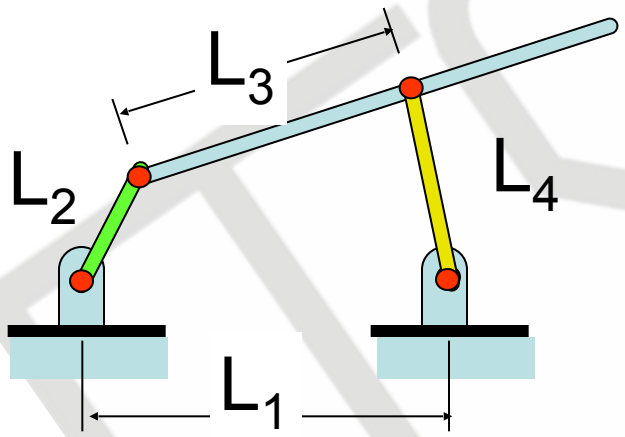
L_1: solo

L_3: link acoplador

L_4: link seguidor

Lei de Reuleaux

Montagem do Mecanismo 4-Barras



$$L_2 + L_3 + L_4 \geqslant L_1$$

$$L_2 + L_3 - L_4 \leqslant L_1$$

$$L_2 + L_1 + L_4 \geqslant L_3$$

$$L_2 + L_1 - L_4 \leqslant L_3$$

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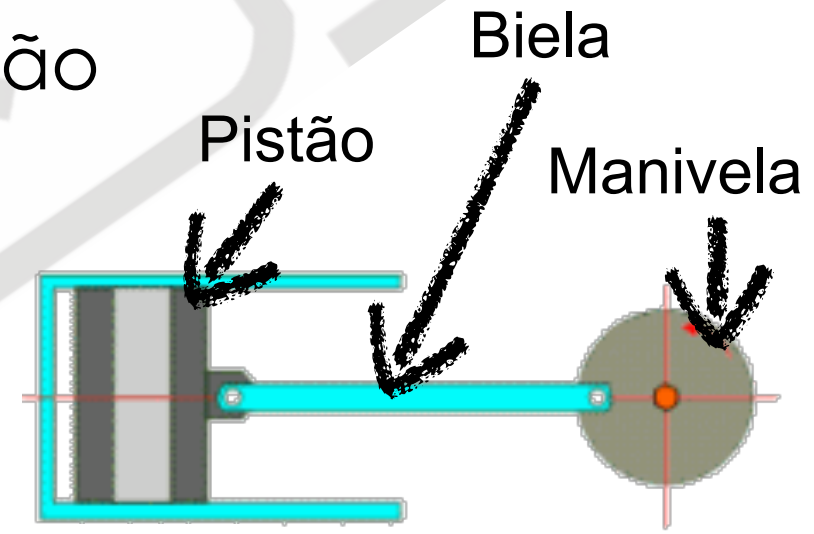
Mecanismos Simples
Biela-Manivela

- Exemplos de Aplicação: Motores de Combustão Interna, Máquinas Ferramenta, Compressores, etc.

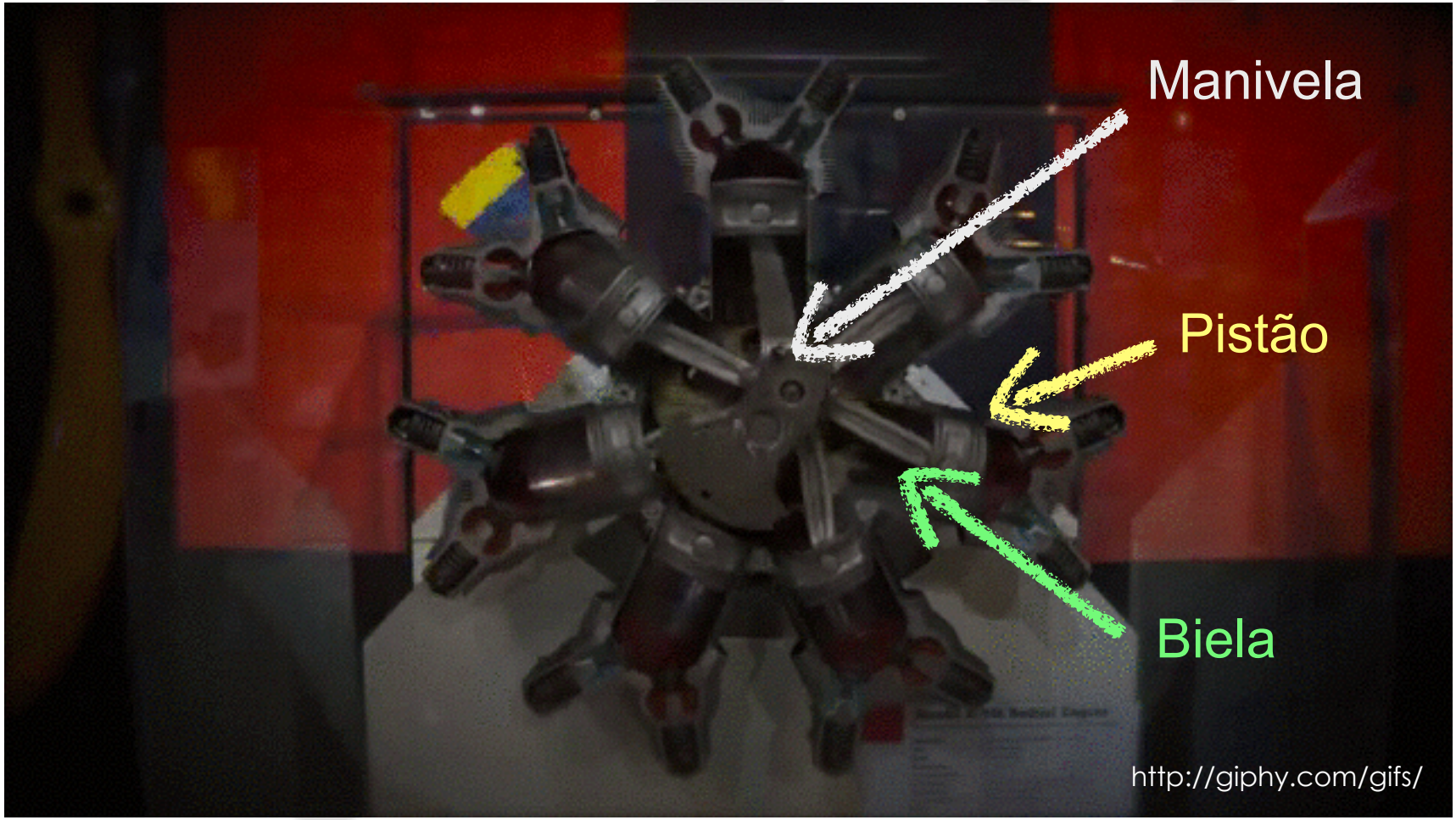
- Deslocamento do Pistão

- Velocidades

- Aceleração

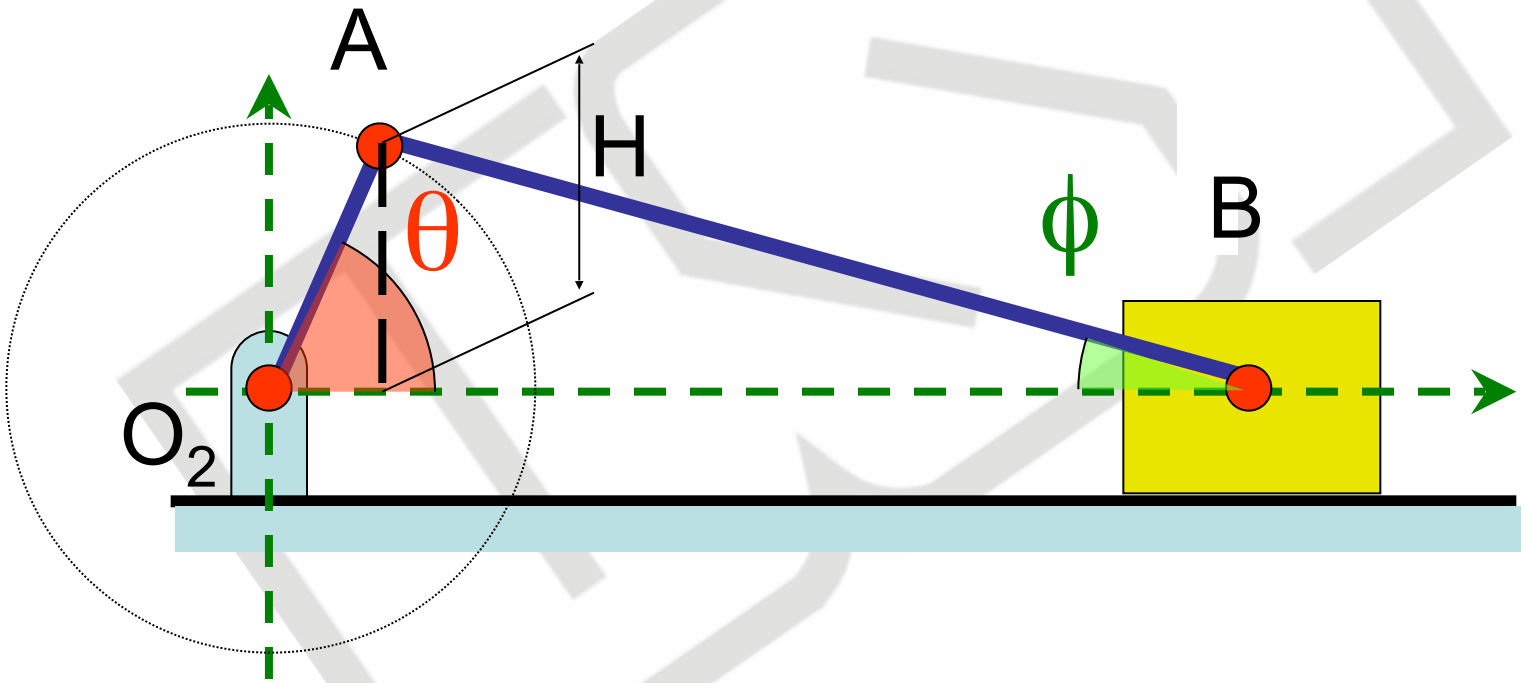


Mecanismos Simples
Biela-Manivela



Mecanismos Simples
Biela-Manivela

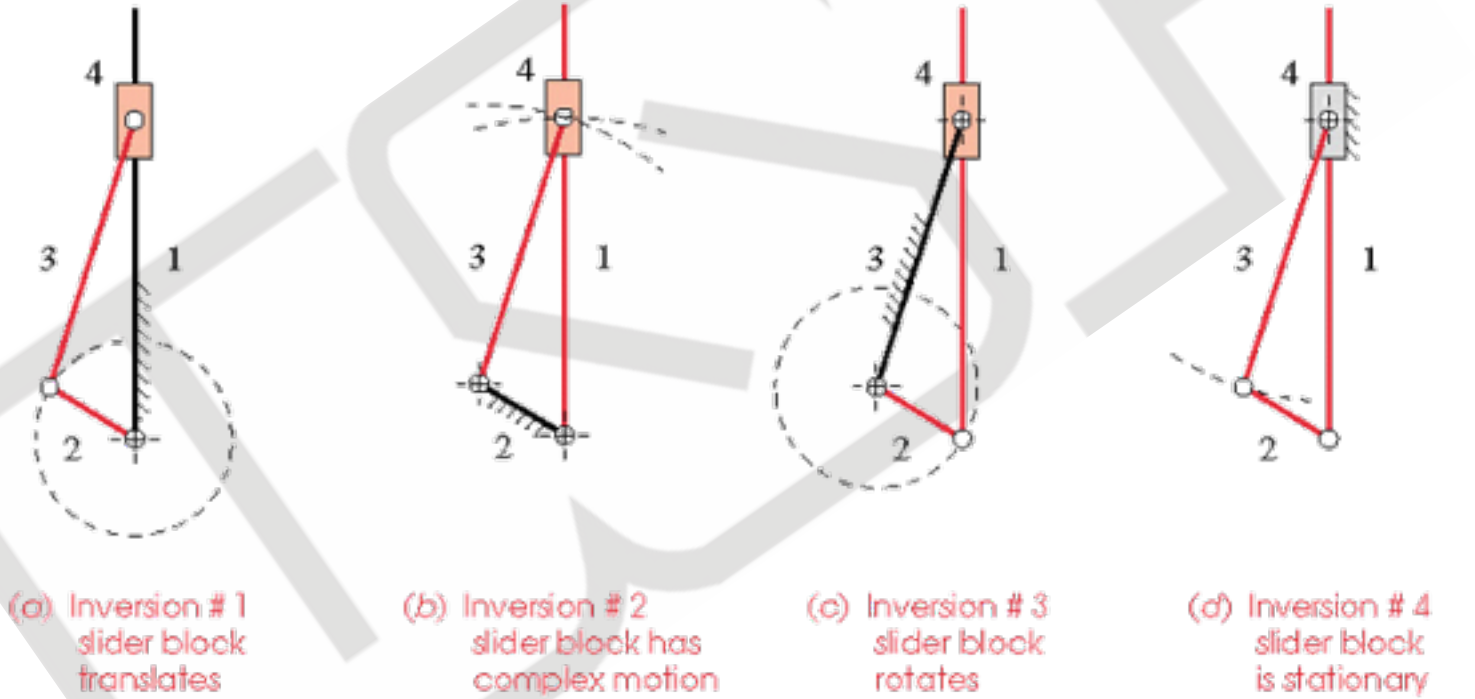
- Diagrama de Corpo Livre e Equacionamento



Na Lousa...

Mecanismos Simples
Biela-Manivela

- Outras Configurações para o Biela-Manivela



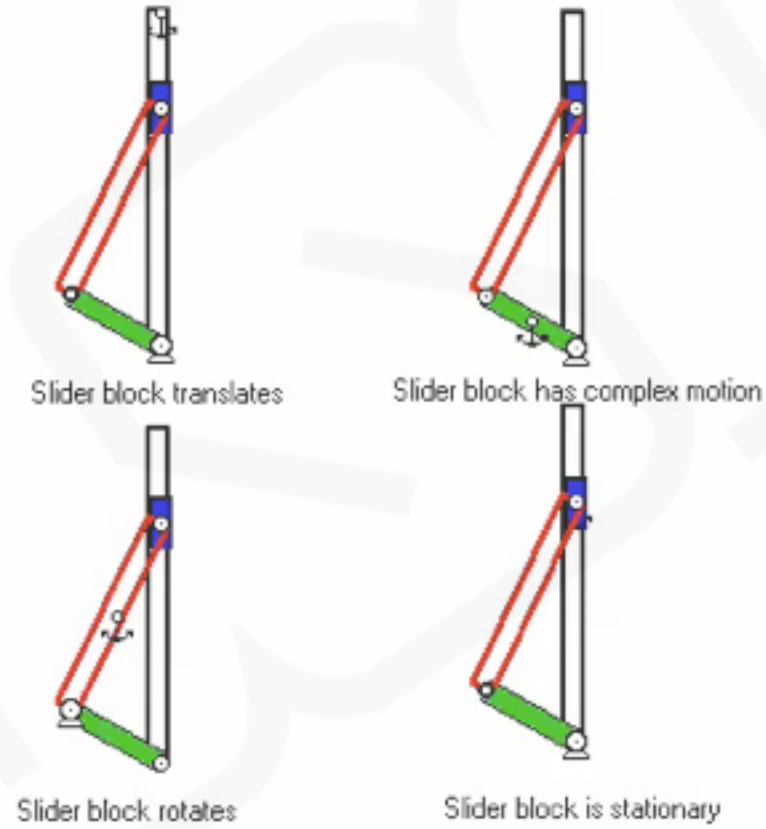
Compressores
Motores

Mecanismo de Whitworth

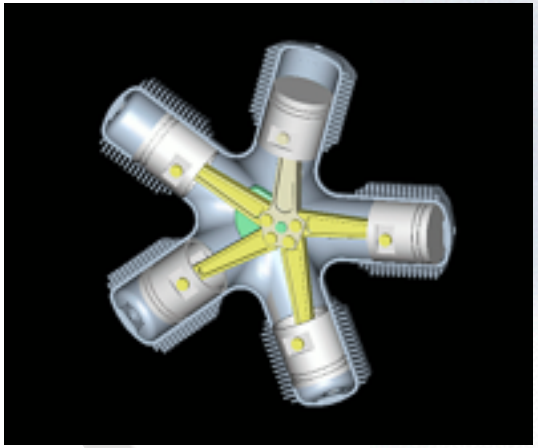
Bomba de água
Manual

Mecanismos Simples

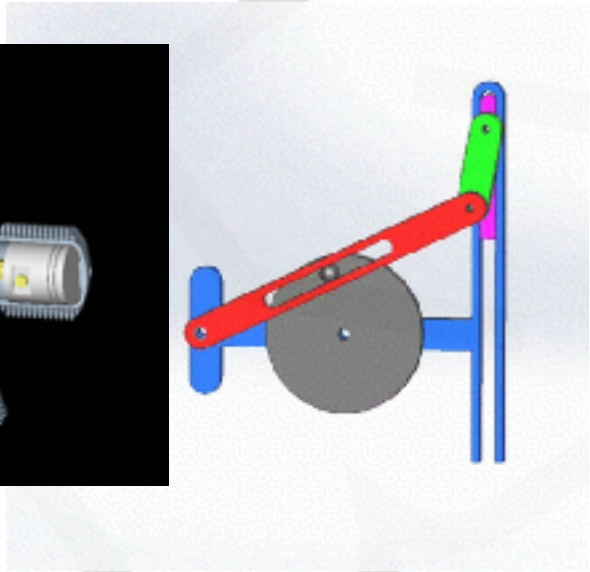
Biela-Manivela



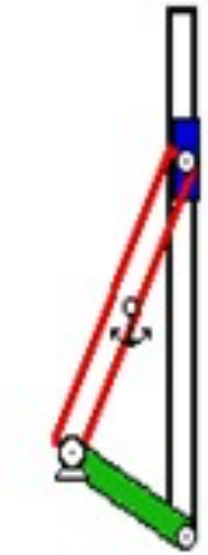
Mecanismos Simples
Biela-Manivela



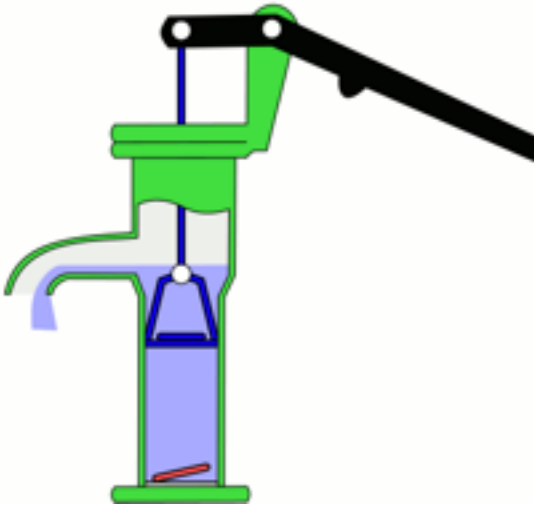
Compressores
Motores



Mecanismo de
Whitworth



Portão de Garagem



Bomba de água
Manual

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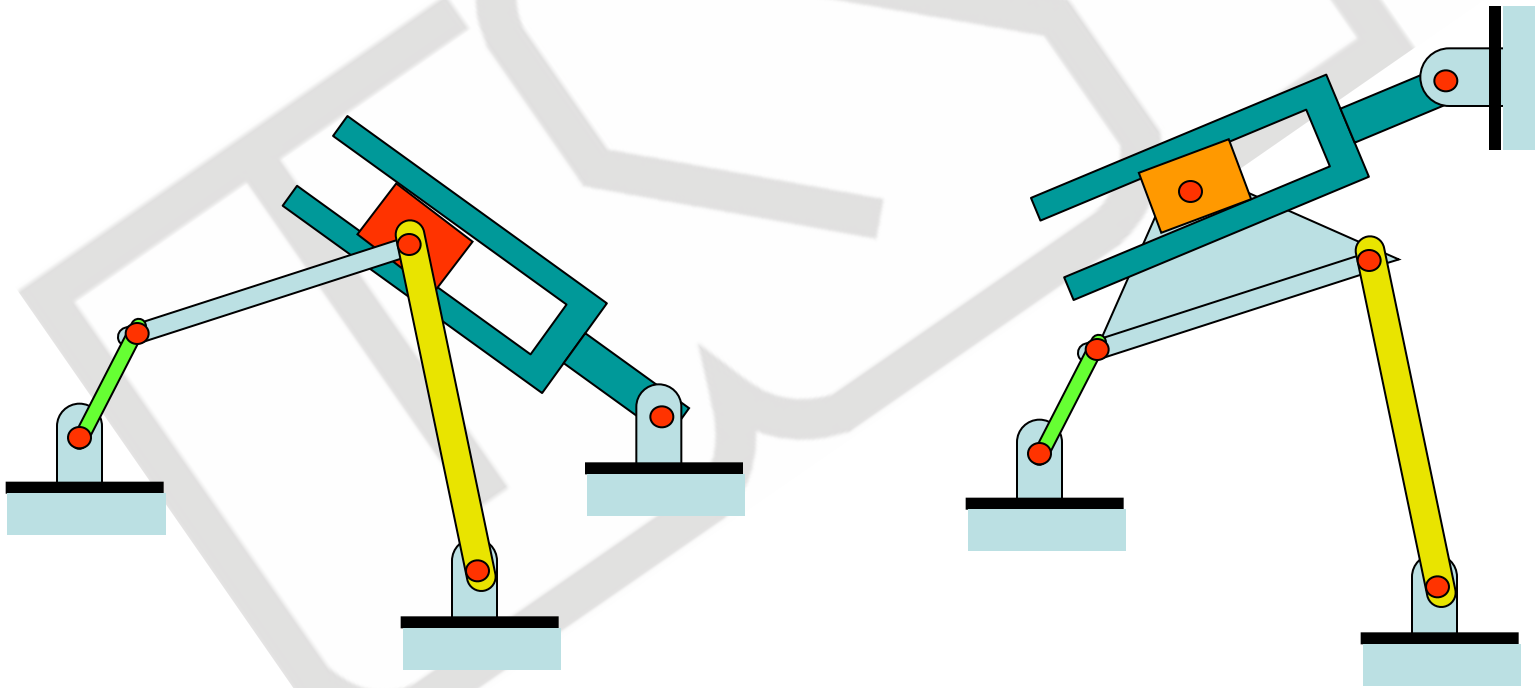
Mecanismos Complexos

- União de 2 ou mais mecanismos simples

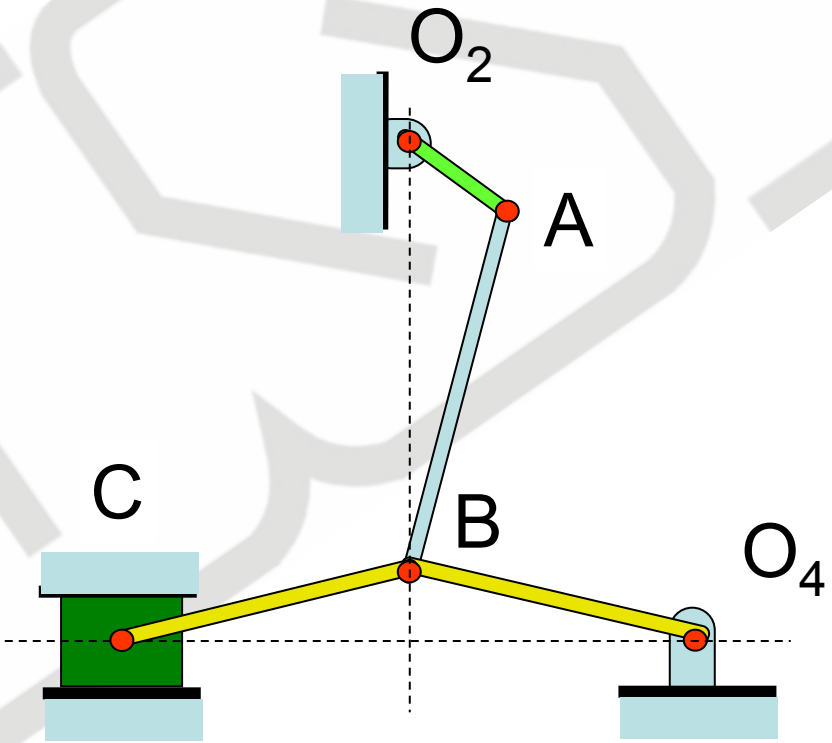
  4 Barras + Biela-Manivela



Mecanismos Complexos
Mecanismo Toggle

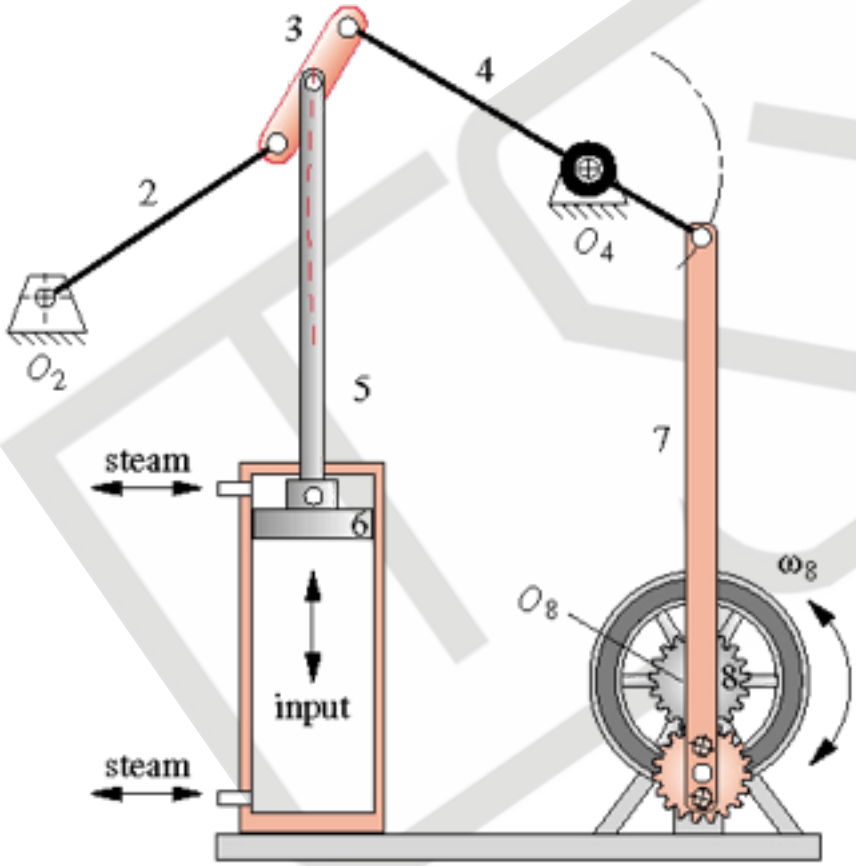
- Barras CB e BO_4 com mesmo comprimento

https://www.youtube.com/watch?v=dCfYlvcfS0k



Mecanismos Complexos

– Máquina a vapor de James Watt



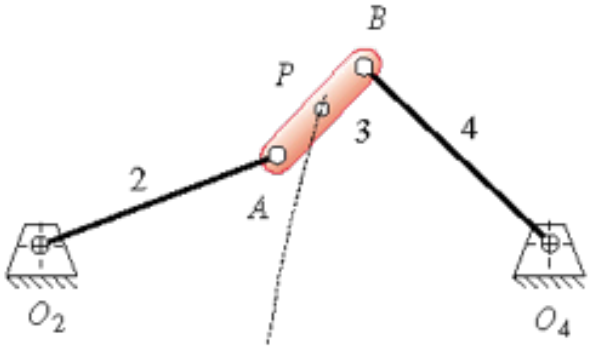
$L_1 = 4$

$L_2 = 2$

$L_3 = 1$

$L_4 = 2$

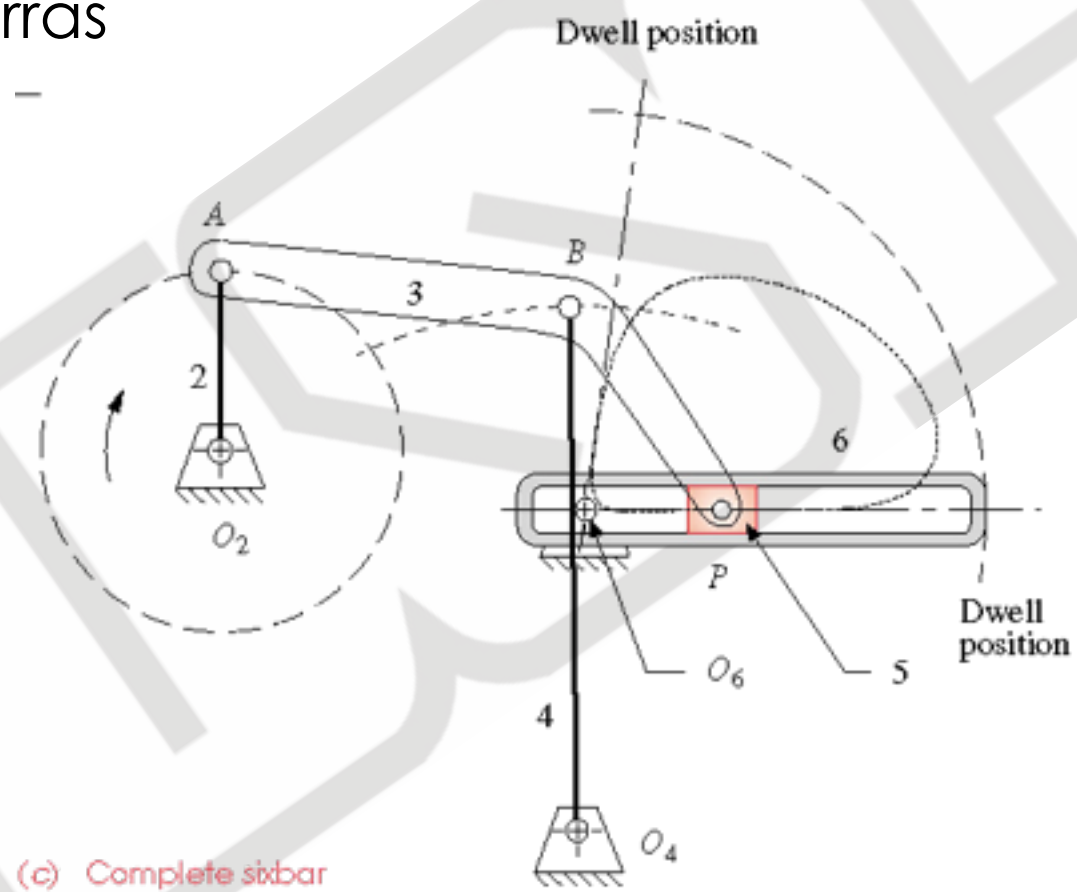
$AP = 0.5$



(a) A Watt straight-line linkage

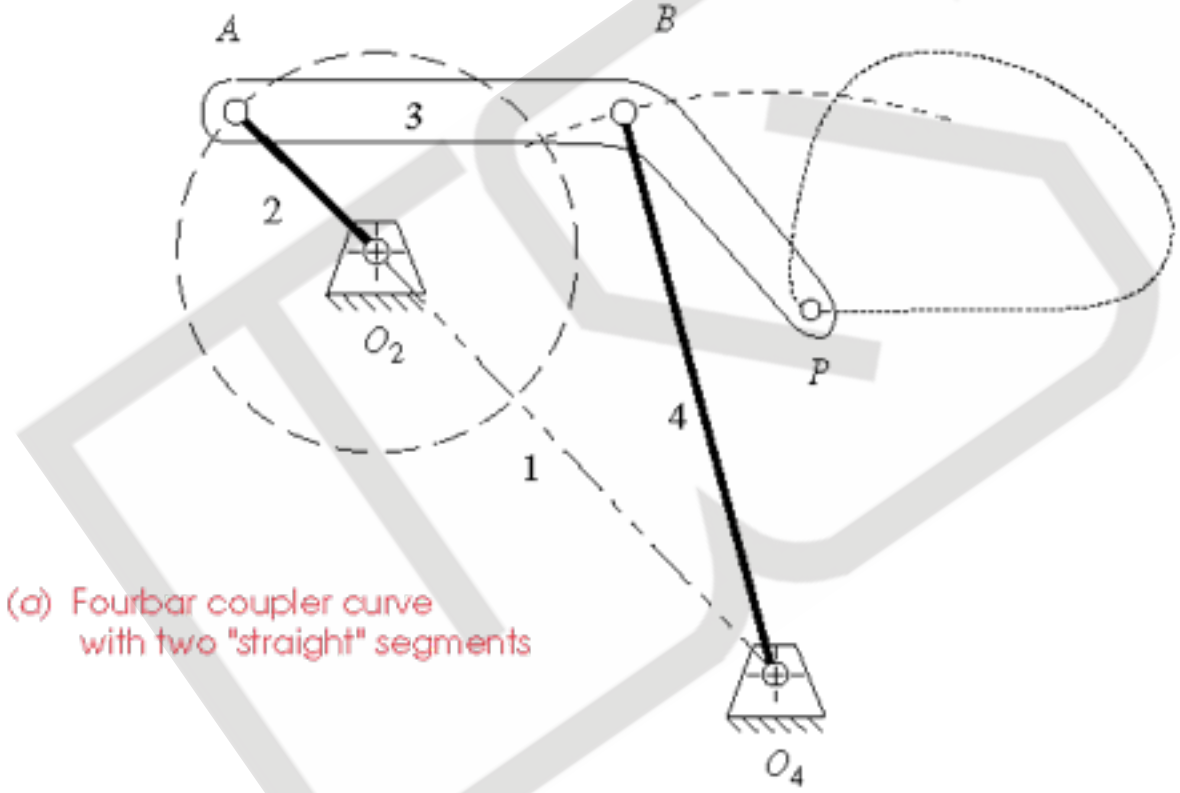
Mecanismos Complexos

- 6 barras

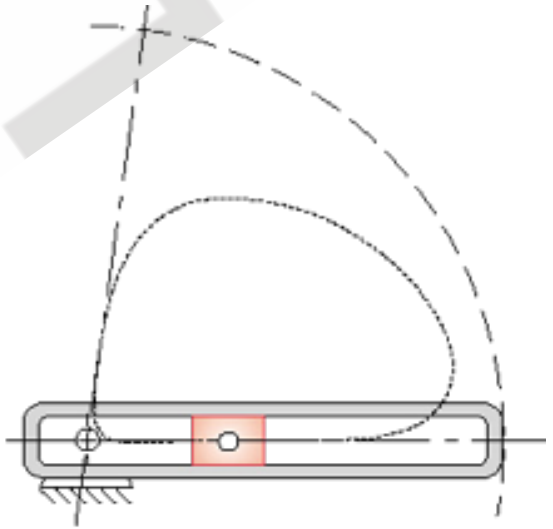


Mecanismos Complexos

– 6 barras



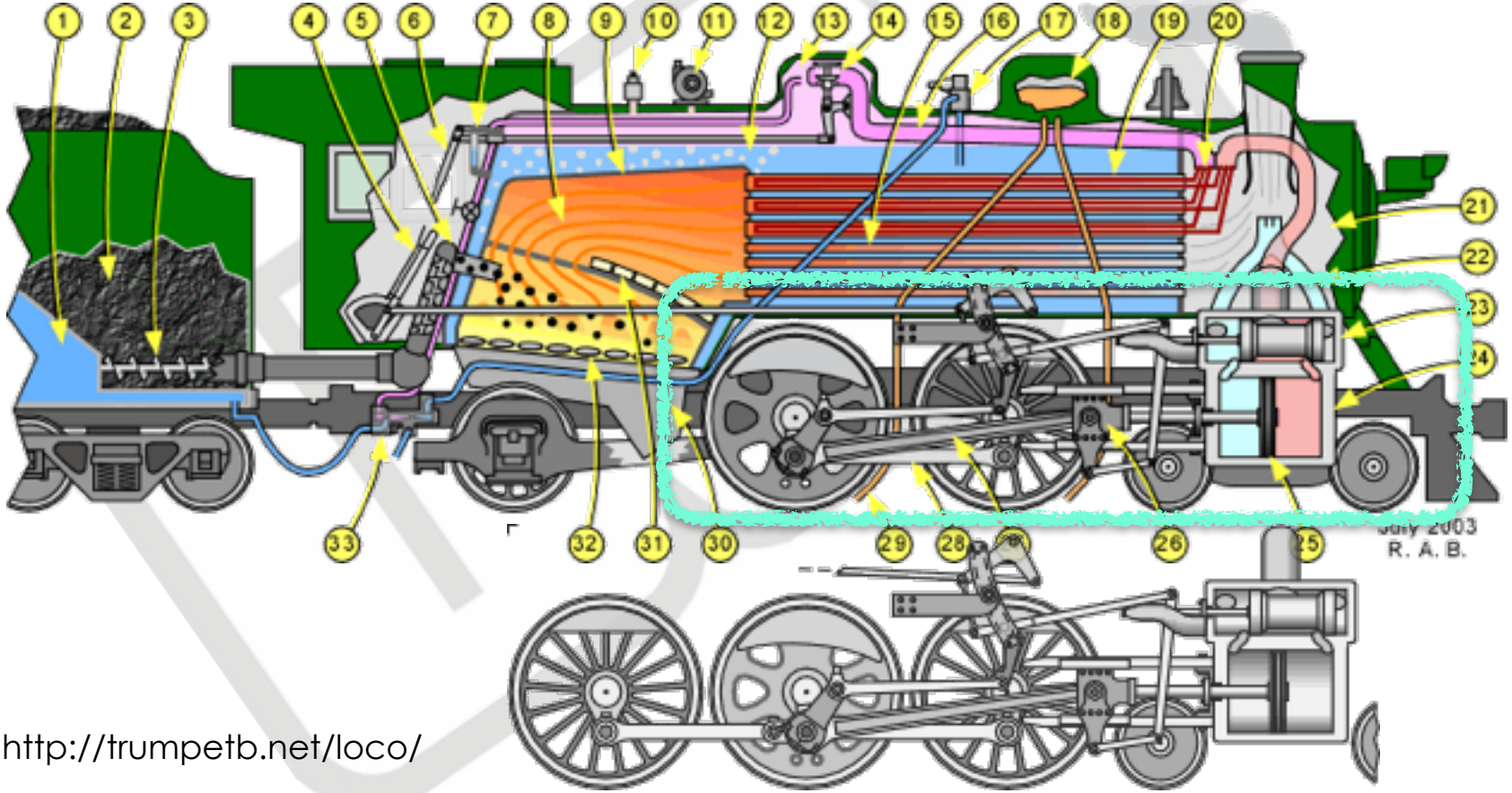
(a) Fourbar coupler curve with two "straight" segments



(b) Slider dyad for double-dwell

Mecanismos Complexos

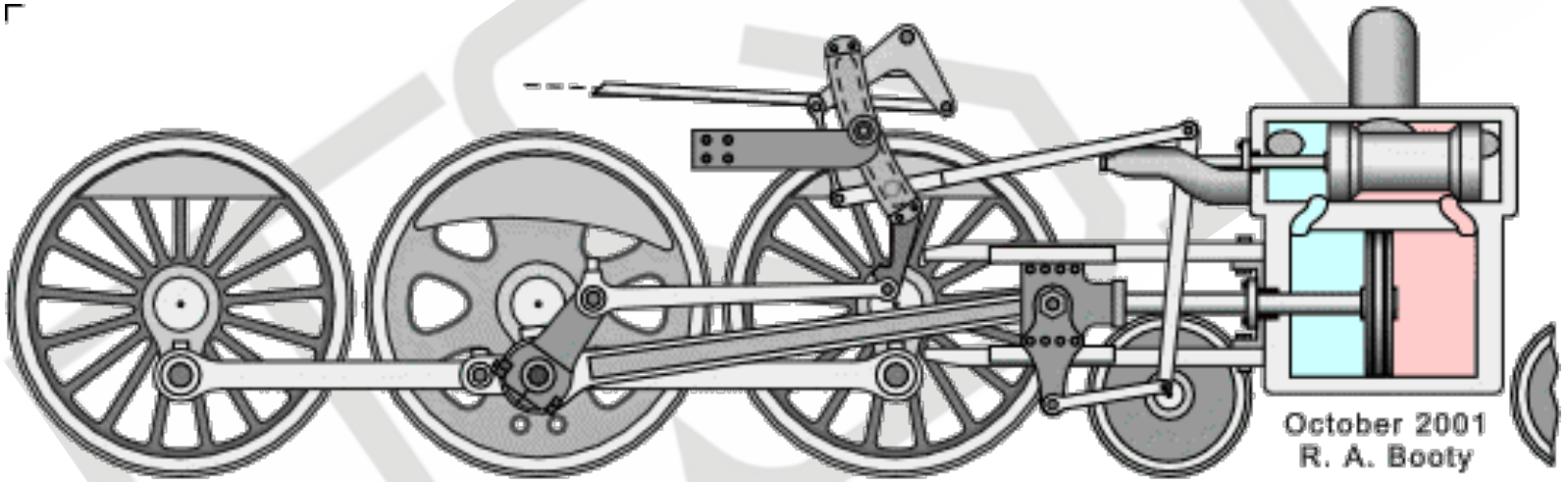
– Locomotiva a Vapor



http://trumpetb.net/loco/

Mecanismos Complexos

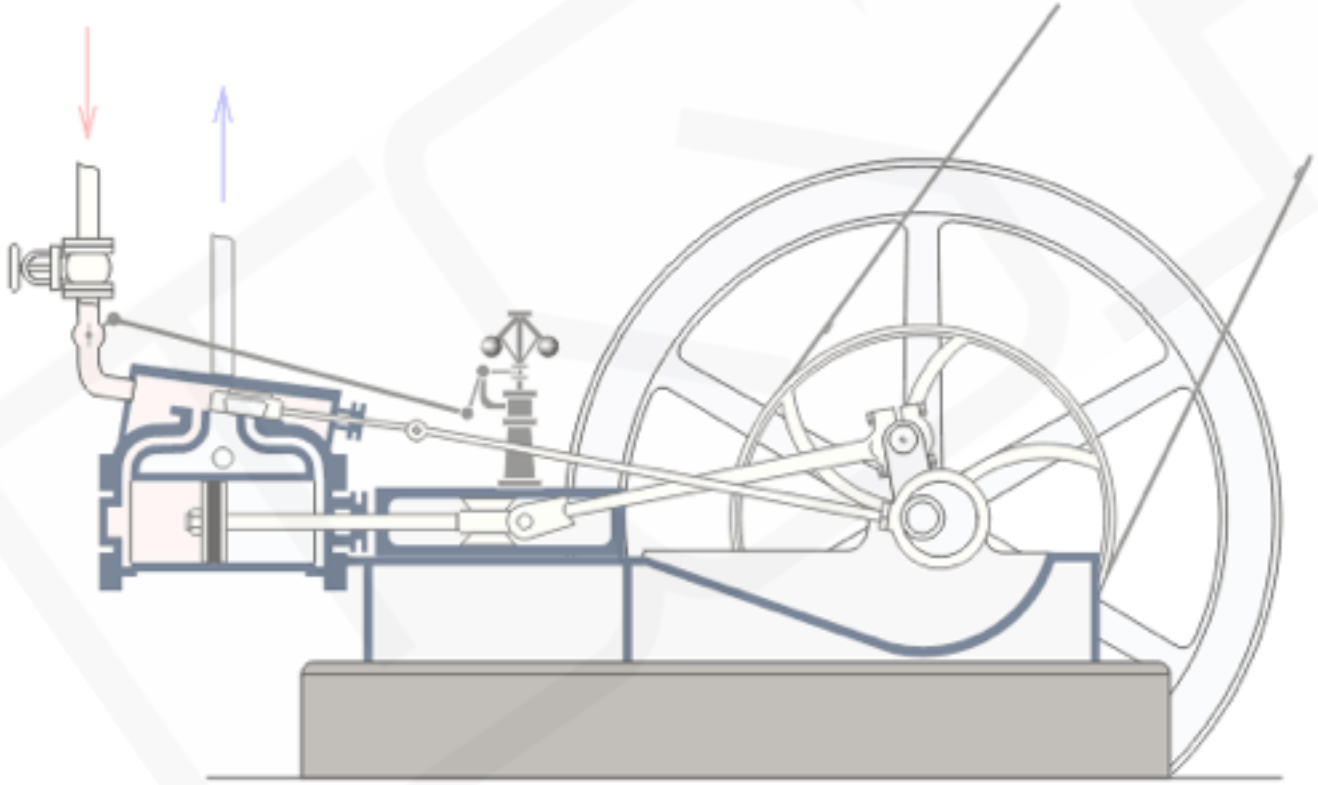
– Locomotiva a Vapor



http://trumpetb.net/loco/

Mecanismos Complexos

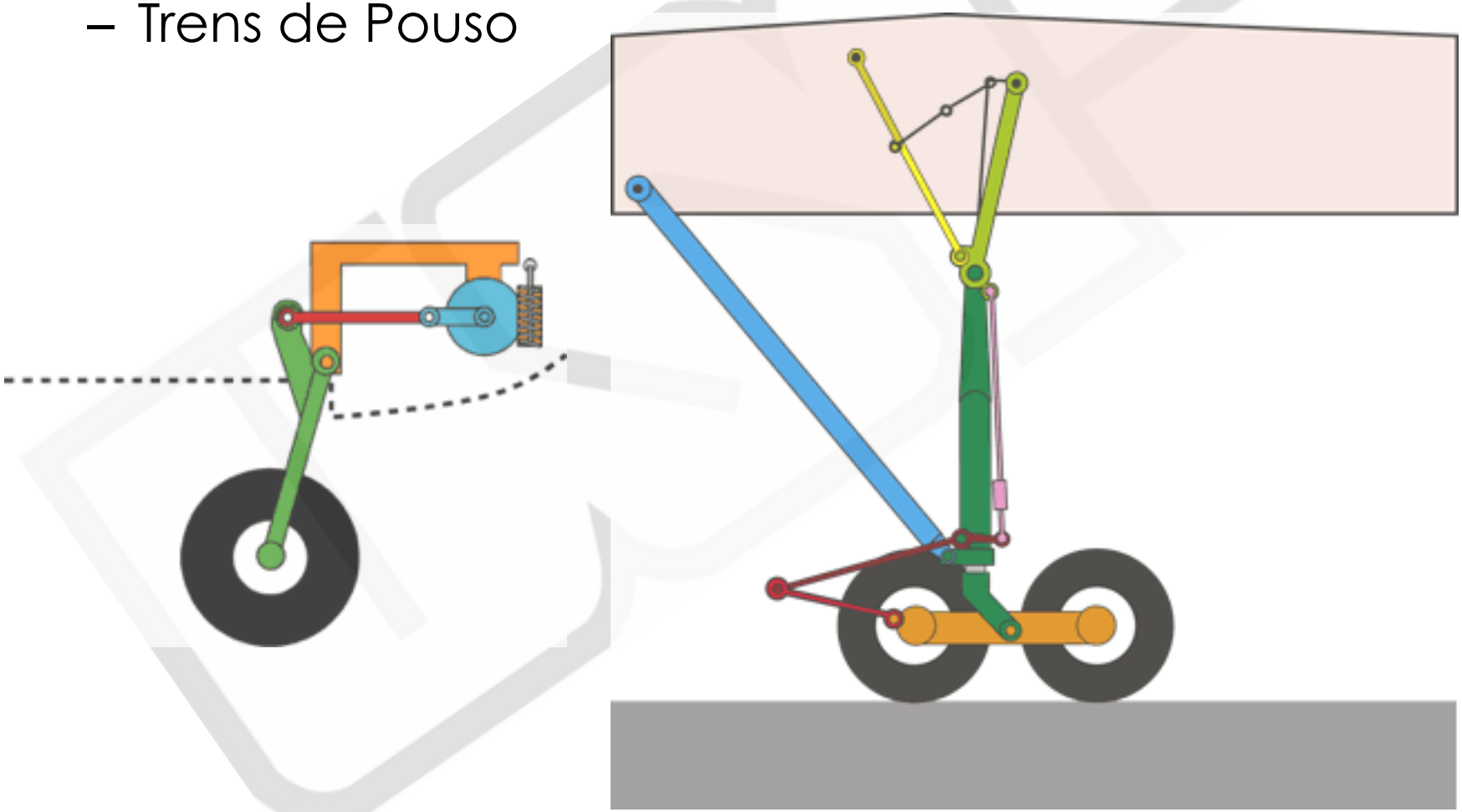
- Motor a Vapor



http://giphy.com/gifs/

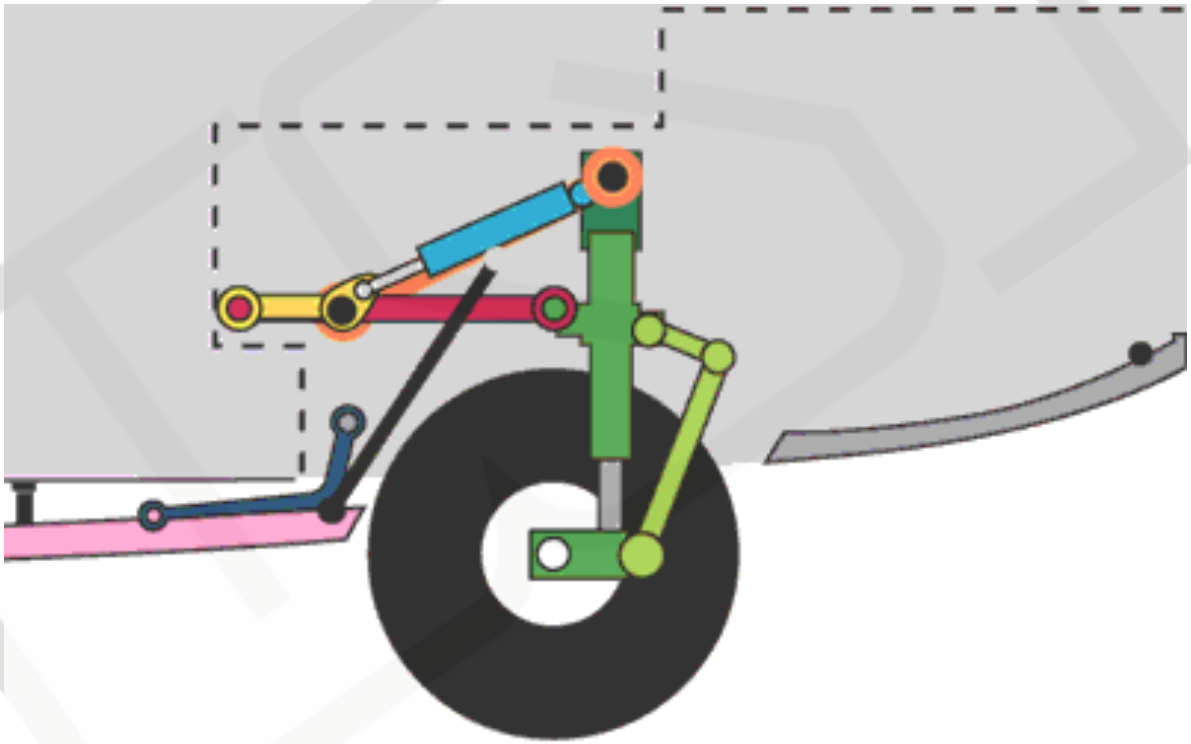
Mecanismos Complexos

– Trens de Pouso



Mecanismos Complexos

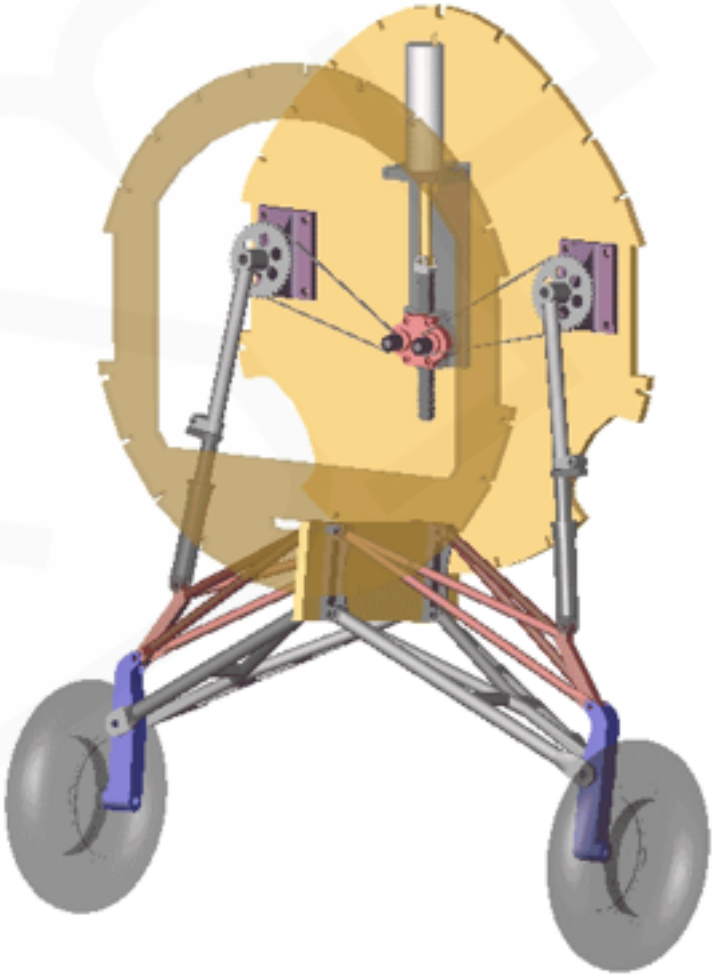
– Trens de Pouso



Mecanismos Complexos

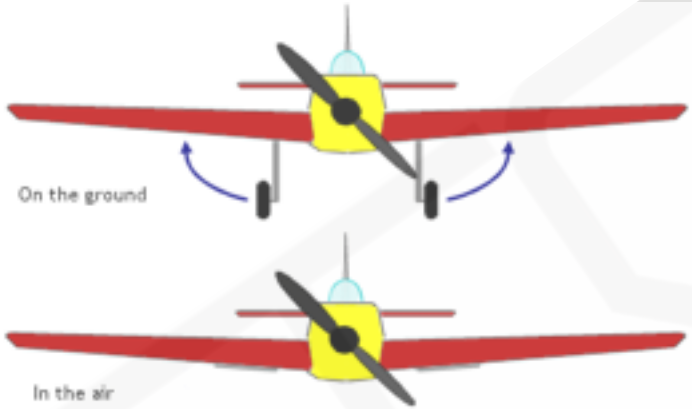
– Trens de Pouso

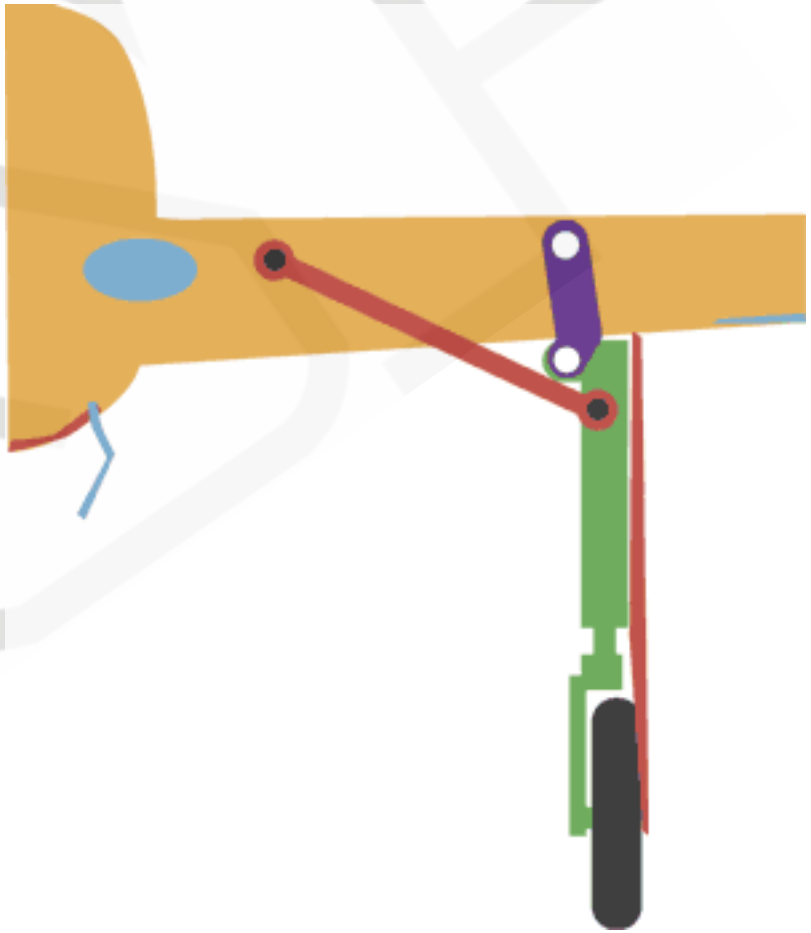
Grumman F4F Wildcat
WWII, 1940



Mecanismos Complexos

– Trens de Pouso





Mecanismos Complexos

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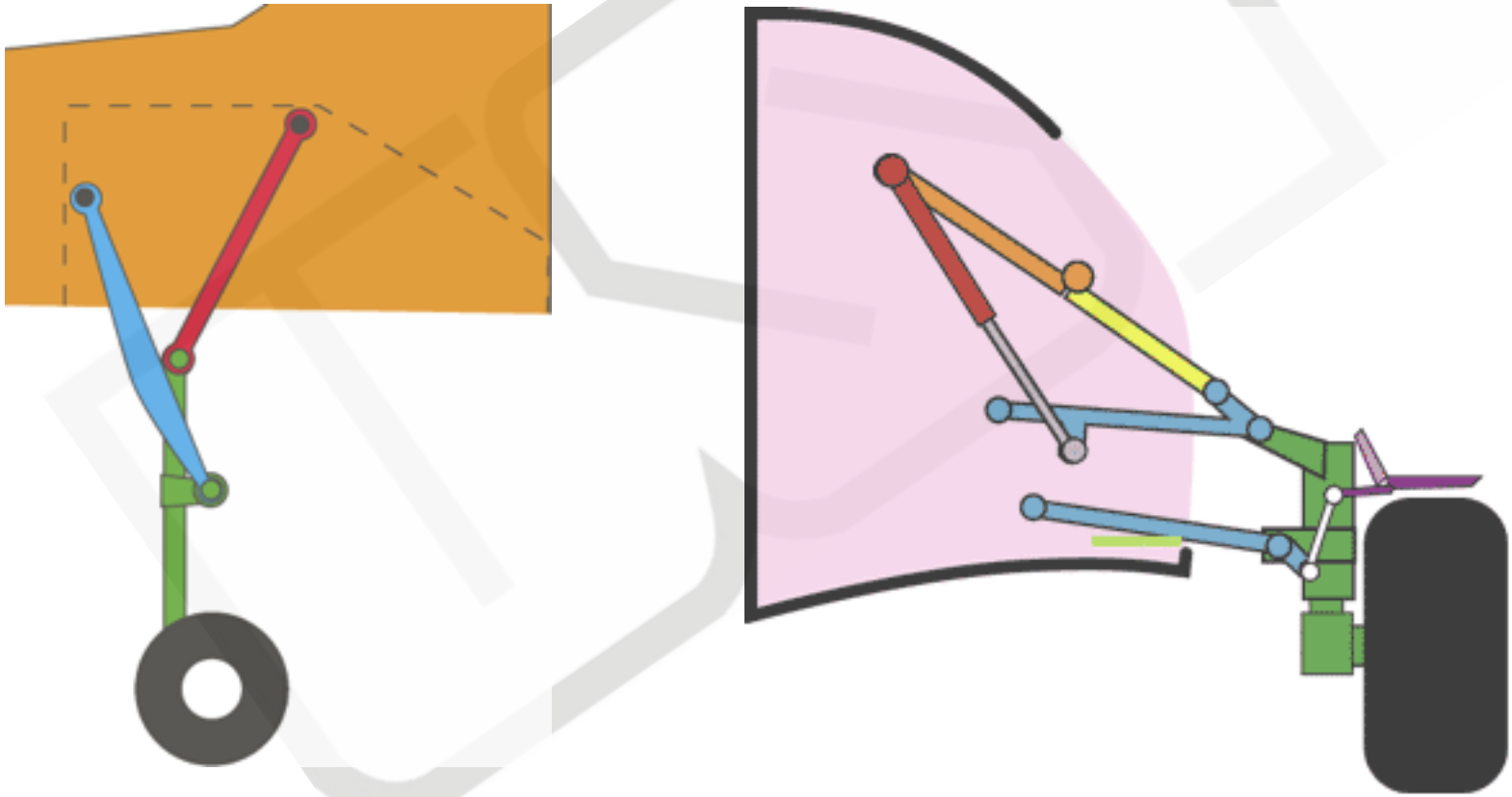
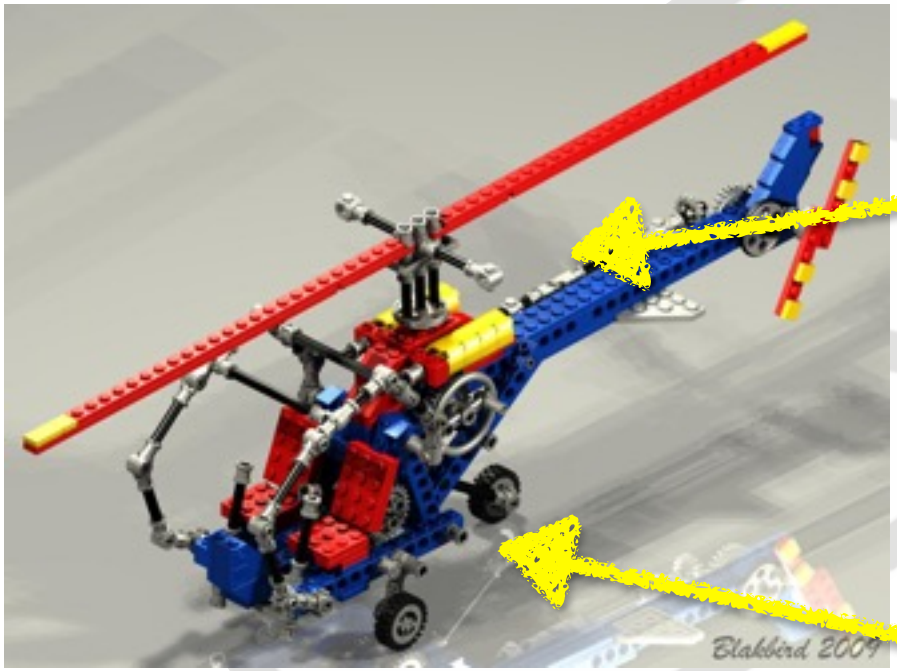
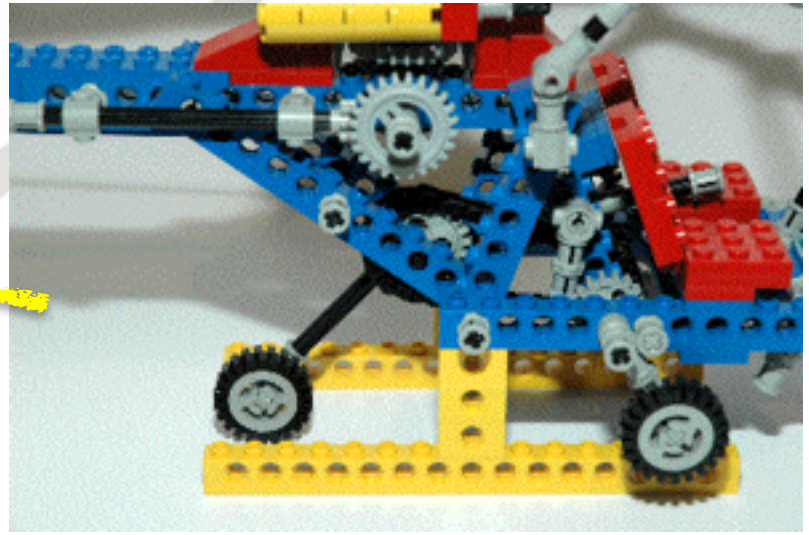


Mecanismos Complexos

– Trens de Pouso

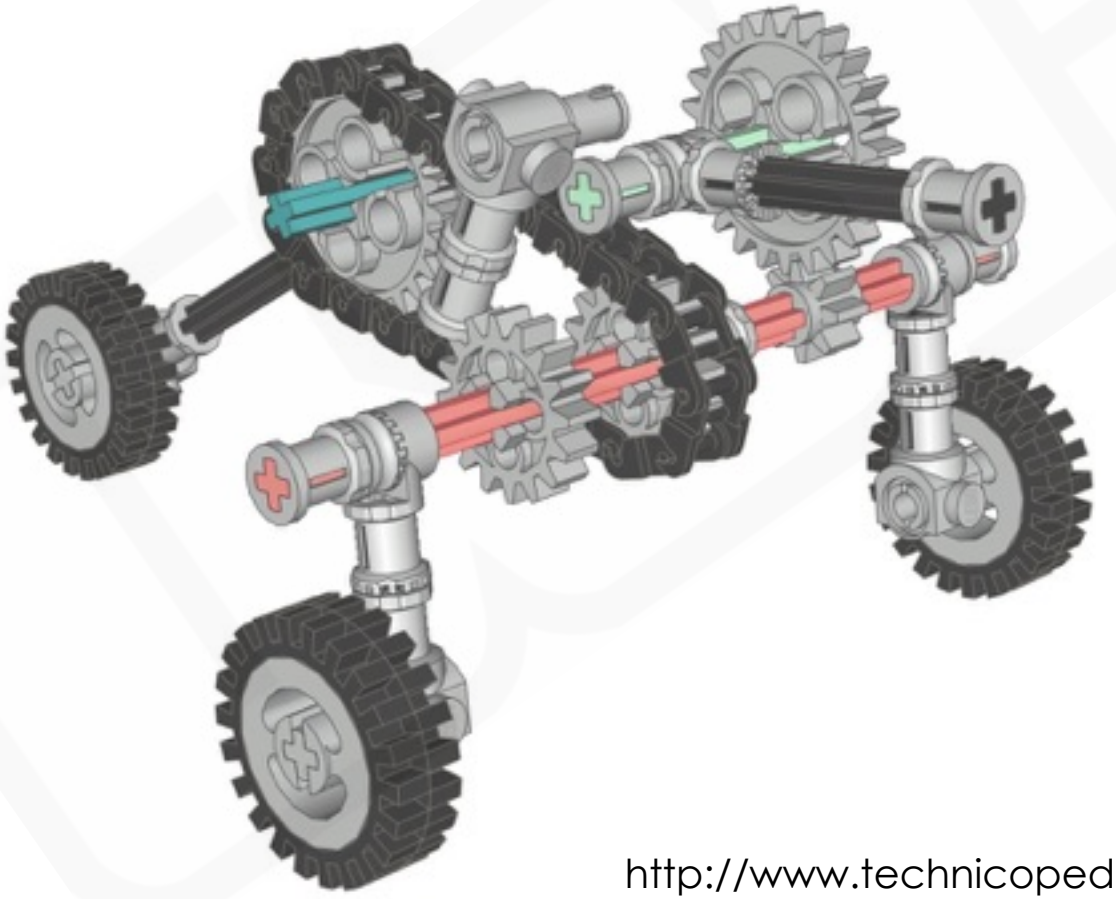




http://www.technicopedia.com/8844.html

Mecanismos Complexos

– Trens de Pouso



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- MABIE, H.H., OCVIRK, F.W. "Mecanismos e dinâmica das máquinas".
- MARTIN, G.H. "Cinematics and dynamics of machines".
- NORTON, R. L. "Design of Machinery - An Introduction to the Synthesis and Analysis of Mechanisms and Machines"
- Notas de Aula