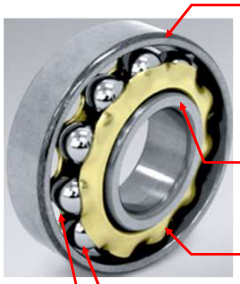
Guides - Ball bearings and linear guides

- The role of a motion bearing is to allow the movement **only in a privileged direction**
- A common motion bearing is the ball bearing



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Examples of applications:

- Guiding a motor shaft
- Implementation of a pivot of a robot arm
- Implementation of a ball joint
- Guiding a transmission screw

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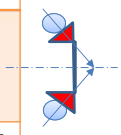
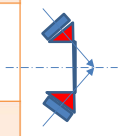
Some types of bearings

Deep groove ball bearings		**Most commonly used. Very good radial rigidity and low friction - High speed applications**
Angular contact ball bearings		Improves axial rigidity (off-axis axial load carrying point)
Cylindrical Roller Bearings		PMore contact surface therefore more radial load. No axial loads. Suitable for large bearings and radial shock applications.
Needle Roller Bearings		Same principle as the roller bearing and ideal for applications with space constraints.
Angular Roller Bearings		Support good radial and axial loads and are less suitable for high speeds.
Spherical bearings **Inventor- Sven Gustaf Wingqvist founder of SKF**		Spherical type if alignment changes. Can correct constructional overcnstraints





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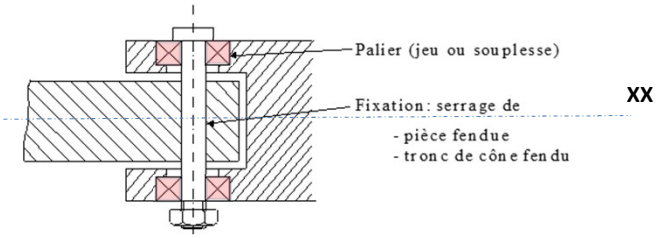
Various mountings:

The following link refers to a very interesting link from SKF with the different types of bearing mounts.

http://www.skf.com/group/products/bearings-units-housings/ball-bearings/principles/application-of-bearings/bearing-arrangements/index.html

Exercice:

Calculation of the angular stiffness of a double bearing



Construction of a joint by minimizing the influence of the play or flexibility of the bearings

K1 and K2 are the linear stiffnesses of the two bearings 1 and 2.

- **What is the resulting angular stiffness about the central axis XX?**

Example of a double SCARA - TP Pantograph haptic

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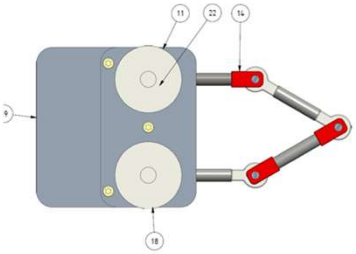
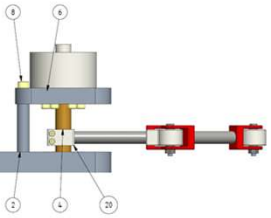
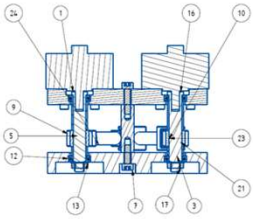
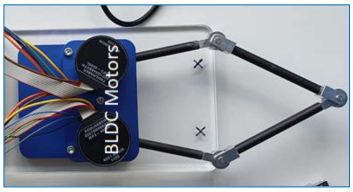


ITEM NO.	PART NUMBER	QTY	DESCRIPTION	NOTES
1	ARBRE	1	arbre.prt	
2	ARBRE_SUPPORT	3	arbre_support.prt	
3	COUSSINET_1	2	coussinet_1.prt	
4	COUSSINET_2	2	coussinet_2.prt	
5	ISO14579-M2X16-8_8	4		
6	ISO14579-M3X8-8_8	12		
7	ISO14579-M4X12-8_8	4		
8	ISO14579-M4X16-8_8	2		
9	ISO4034-M2-14H	4		
10	LIAISON_PIVOT	3	liaison_pivot.asm	
11	MOTEUR	1	p_gabarit.prt	
12	MR148ZZ	4		
13	PCIMAK_DII_V8_TO_5	2		
14	PIVOT_1	3	pivot_1.prt	
15	PRT0075	1	p_gabarit.prt	
16	PRT0076	1	arbre.prt	
17	SDIN439BM65509006000	12		
18	SUPPORT	1	support.prt	
19	SUPPORT_1	1	support_1.prt	
20	SUPPORT_2	2	support_2.prt	
21	TIGE_4	1	tige_4.prt	
22	TIGE_CARBONNE	1	tige_carbonne.prt	
23	TIGE_CARBONNE_1	1	tige_carbonne_1.prt	
24	TIGE_CARBONNE_2	1	tige_carbonne_2.prt	







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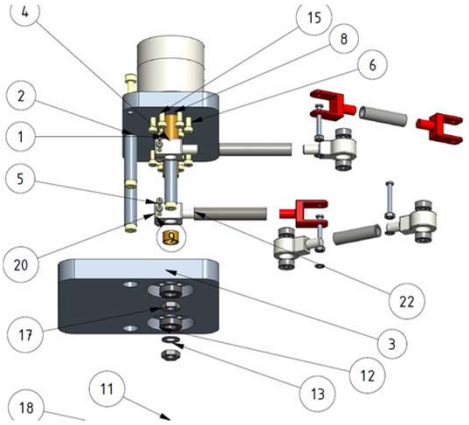

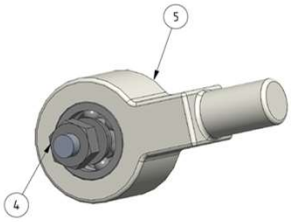

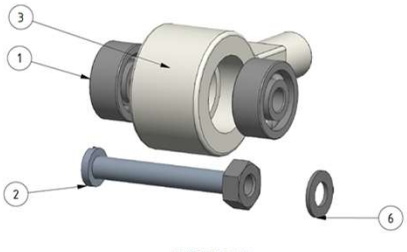

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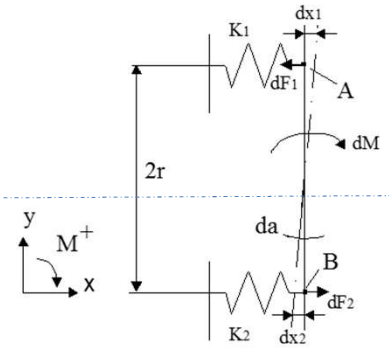
Answer:

Raideur d'un axe retenu par 2 éléments élastiques



Axe retenu par 2 liaisons élastiques.

Lorsque M = 0, $\alpha = 0$

XX

Relation entre dM et dα fonction de K_i et de r ?

Equations d'équilibre:

$$\begin{cases} \sum F_x = 0 \;:\; -dF_1 + dF_2 = 0 \\ \qquad\qquad \rightarrow \quad dF_1 = dF_2 = \dfrac{dM}{2 \cdot r} \\ \sum M_A = 0 : \quad dM - DF_2 \cdot 2 \cdot r = 0 \end{cases}$$

$$d\alpha = \frac{dx_1 + dx_2}{2 \cdot r} \qquad dx_1 = \frac{dF_1}{K_1} \qquad dx_2 = \frac{dF_2}{K_2}$$

$$d\alpha = \frac{dM}{4 \cdot r^2} \cdot \left(\frac{1}{K_1} + \frac{1}{K_2} \right)$$

$$K\alpha = \frac{dM}{d\alpha} = 4 \cdot r^2 \cdot \left(\frac{K_1 \cdot K_2}{K_1 + K_2} \right)$$

Cas Particulier: $K_1 = K_2 = K$

$$K_\alpha = 2 \cdot K \cdot r^2$$

(!) This result is **very important** : it shows how far it is possible to increase the angular stiffness of two combined bearings (function of the square of the distance).
PS, this calculation assumes that the stiffness of the segment between the two bearings is of infinite stiffness.

Linear guides

- **Dovetail sliding guides** (manual machine tools)
- **Recirculating ball bearing** guides
- **Ring** guideways with and withut re-circulating balls
- **U-shaped** roller guides
- **V-shaped** roller guides

The role of a linear guideway : Only the linear blue direction is free.
All the other directions **in red** are **blocked** :
- linear radial and normal,
- Tilting (roll and pitch) and Yaw

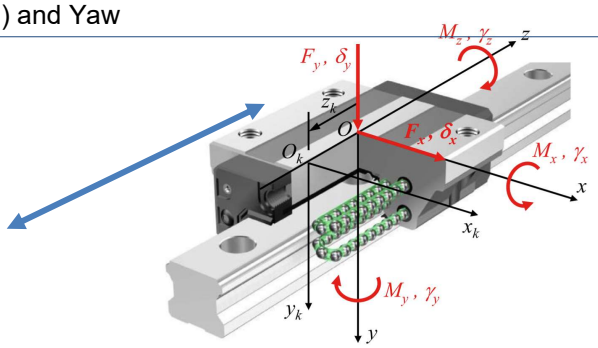


Fig. 1. A linear guide with loadings shown using a global coordinate system. Here, the carriage is subjected to external loads $\{\boldsymbol{F}\}^{\mathrm{T}} = \{F_x\ F_y\ M_x\ M_y\ M_z\}$ resulting in displacements $\{\boldsymbol{\delta}\}^{\mathrm{T}} = \{\delta_x\ \delta_y\ \gamma_x\ \gamma_y\ \gamma_z\}$. The cross-section by plane $(x_k O_k y_k)$ located at axial coordinate z_k is also shown.

Tong, Van-Canh, et al. "Construction and validation of a theoretical model of the stiffness matrix of a linear ball guide with consideration of carriage flexibility." *Mechanism and Machine Theory* 140 (2019): 123-143.

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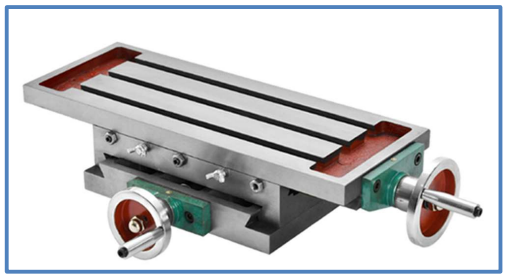
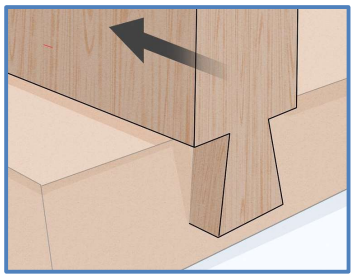
- **Dovetail sliding guides** (manual machine tools)





- Easy to use, for manual machine tools
- Non-backlash compensation

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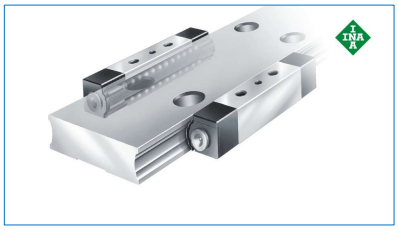
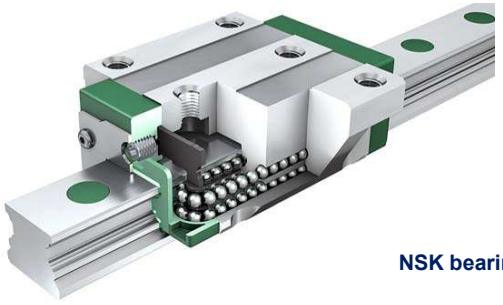
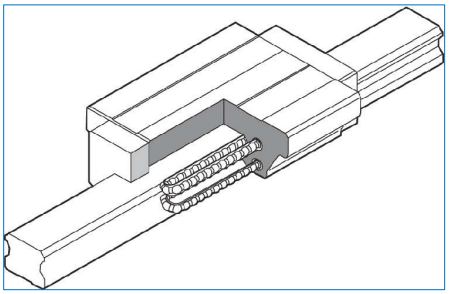
Recirculating ball bearing guideways



The most used because of their good rigidity and their speed of operation



NSK bearing



Recirculating ball bearing guideways

Mini Rails Schneeberger

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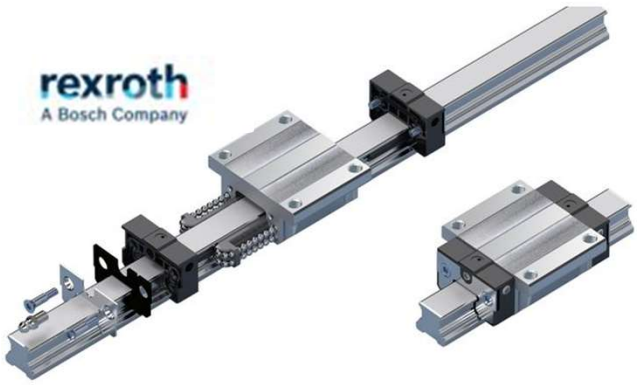
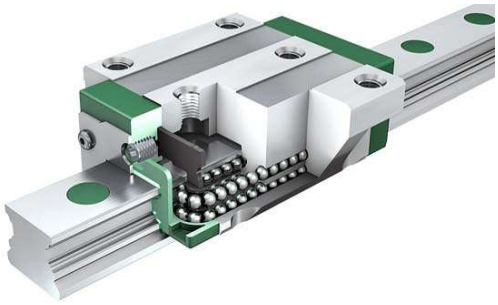


NSK bearing



Double recirculation for better rigidity

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Ring recirculating ball bearing guideways

Ring guideways, with recirculating ball bearing (ring without blocking the orientation)

Requires a second rail to lock the orientation and function as a linear guide.

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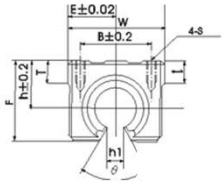
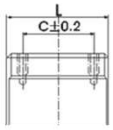
Ring ball bearing guideways

With ball ring without recirculation - without blocking the orientation

Requires a second rail to lock orientation and function as a linear guide





With grooved and recirculating ball bearing ring - Works only for linear guidance and requires a second rail to lock in place the orientation

The guide is more rigid and can support greater loads at higher speeds

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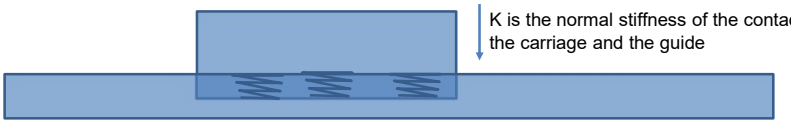
Exercice .
Consider the normal stiffness K of single carriage guideway.
Obtain the following stiffnesses :

- Stiffness (normal) of a double guideway
- Stiffness (Normal) and (angular about the axis of motion) of a double guideway / each single carriage .
- Calculate the corresponding mobility of the dual guide configuration.

- Identify other carriage arrangements.



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V shaped roller Guidways (Sorted by increasing stiffness)

V-shaped roller guide - 1 row

V-shaped roller guide - 2 rows

V2-shaped roller guide - 2 oblique rows

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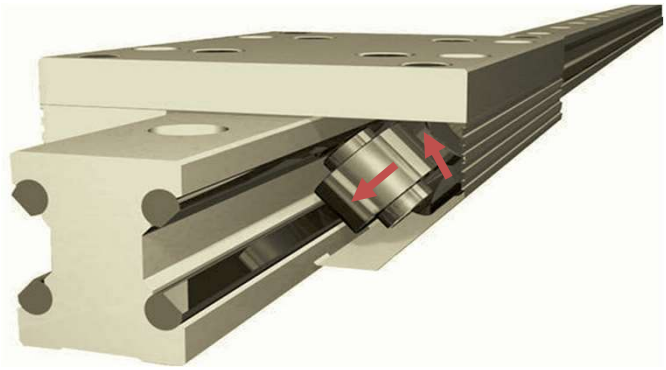
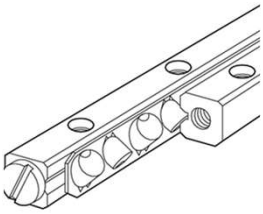
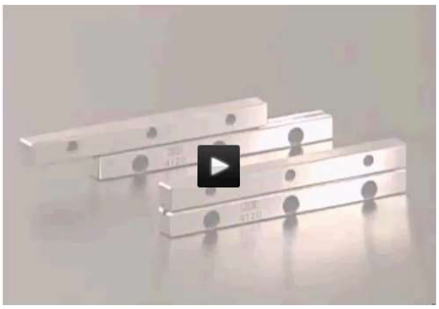
V-shaped roller guide - 2 rows with alternately crossed and slanted rollers



Roller guides for micro positioning applications - Space and precision constraints. Single row with crossed rollers



Guidages linéaires à rouleaux croisés : CRW, CRWU



Some references:

SCHNEEBERGER LINEAR TECHNOLOGY

IKO

FAG

THK

SKF

INA

SCHAEFFLER

HIWIN Motion Control and System Technology

NB Corporation

Example: Rack and pinion with bearing guide.
Reference **HepcoMotion**

HepcoMotion

GÜDEL

Good reference for large linear motion

Example: Rack with roller guide
Reference **WMH Herion**

WMH Herion

Plain bearing guides / dry guideways

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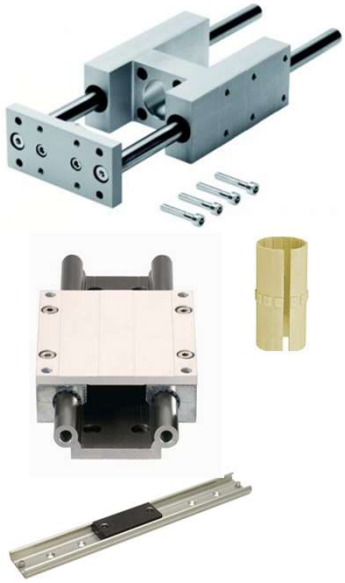

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V slot linear-motion bearing (source Openbuilds)

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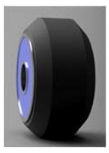

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V slot linear-motion bearing (source Openbuilds) - Video

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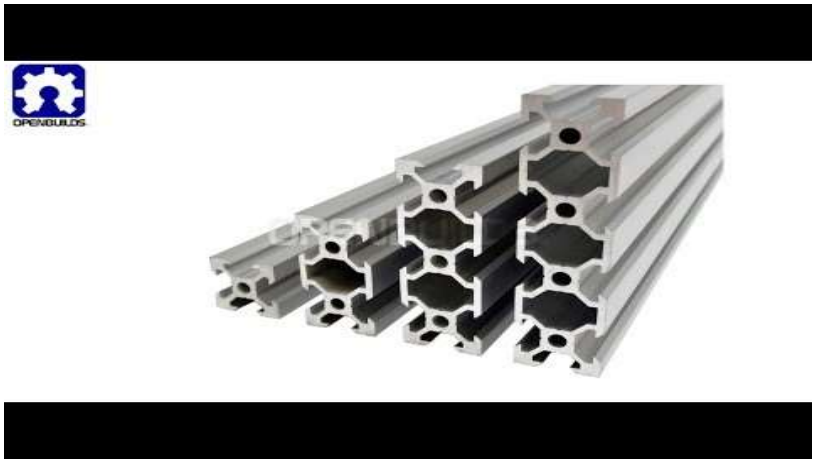

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V slot linear-motion bearing (source Openbuilds)
Rack and pinion assembly

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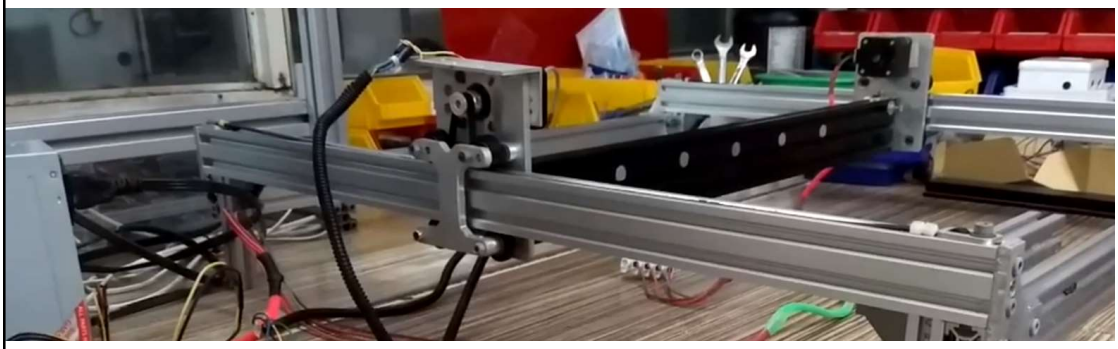

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