Where we are:

Chap 2  Configuration Space
Chap 3  Rigid-Body Motions
Chap 4  Forward Kinematics
Chap 5  Velocity Kinematics and Statics
      5.1 Manipulator Jacobian
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Chap 6  Inverse Kinematics
Chap 8  Dynamics of Open Chains
Chap 9  Trajectory Generation
Chap 11 Robot Control
Chap 13 Wheeled Mobile Robots
**Important concepts, symbols, and equations**

Robot statics: \( \tau = J_{*}^{T}(\theta) \mathcal{F}_{*} \), where \( * = s \) or \( b \).

**Proper interpretation**: if a wrench \(-\mathcal{F}\) is applied to the last link, then \( \tau = J^{T}(\theta) \mathcal{F} \) is required to resist it.

If \( J(\theta) \) has rank 6, then the robot can *actively* generate an end-effector wrench in any direction. The static equation is useful for force control.

If \( J(\theta) \) has rank \( k < 6 \), then any applied wrench can be decomposed into the sum of components in \( k \) directions requiring motors to resist and components in \( 6 - k \) directions that are resisted by the bearings.
What is the $6 \times 3$ Jacobian $J_b$? What is its rank? What wrenches can be resisted without using the motors?
A linear force $f$ to the right is applied to link 3 at the point shown. What is the corresponding wrench $-F_b$? $\tau$ needed to resist it?