FORCES IN GENERAL STATICS

Book 3

Designer's Den

Contents

- SI Units
- Forces and moments
- Boundary conditions
- Free Body Diagram (FBD)

SI Units

SI: Système International d'Unités (defined since 1960)

Important Base:

- Length	m (meter)
- Time	s (second)
- Mass	kg (kilogram)
- Temperature	K (Kelvin)

Important Derivations:

- Force	N	$= kg \cdot m/s^2$	(Newton)
- Moment	Nm	$= N \cdot m$	(Newton-meter)
- Stress, pressure	Pa	$= N/m^2$	(Pascal) *

** In structural mechanics it is common to use Mega Pascals ($MPa = N/mm^2$) instead of Pascals due to the scale of stresses encountered in engineering applications.*

Forces and moments

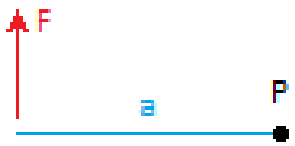
Force

In mechanics, force refers to a physical quantity that can cause an object to accelerate, deform, or change its motion. It is a vector quantity, which means it has both magnitude and direction. Force is commonly denoted by the symbol "F" and is measured in newtons (N) in the International System of Units (SI).

Moment

In mechanics, a moment is a rotational force or turning effect produced by a force acting on an object. It is also known as torque. Unlike force, which primarily causes linear motion, a moment causes angular or rotational motion. Similar to force, the moment is a vector quantity and has both magnitude and direction. The moment of a force about a particular point or axis depends on the magnitude of the force, its distance from the point or axis, and the angle between the force and a line perpendicular to the point or axis. The unit of moment is newton-meter (Nm).

Example:



In the figure to the left: The force (F) is acting perpendicular to the point (P) from a distance (a). In this system the moment at point P is defined as $M_{Point,P} = F \cdot a$

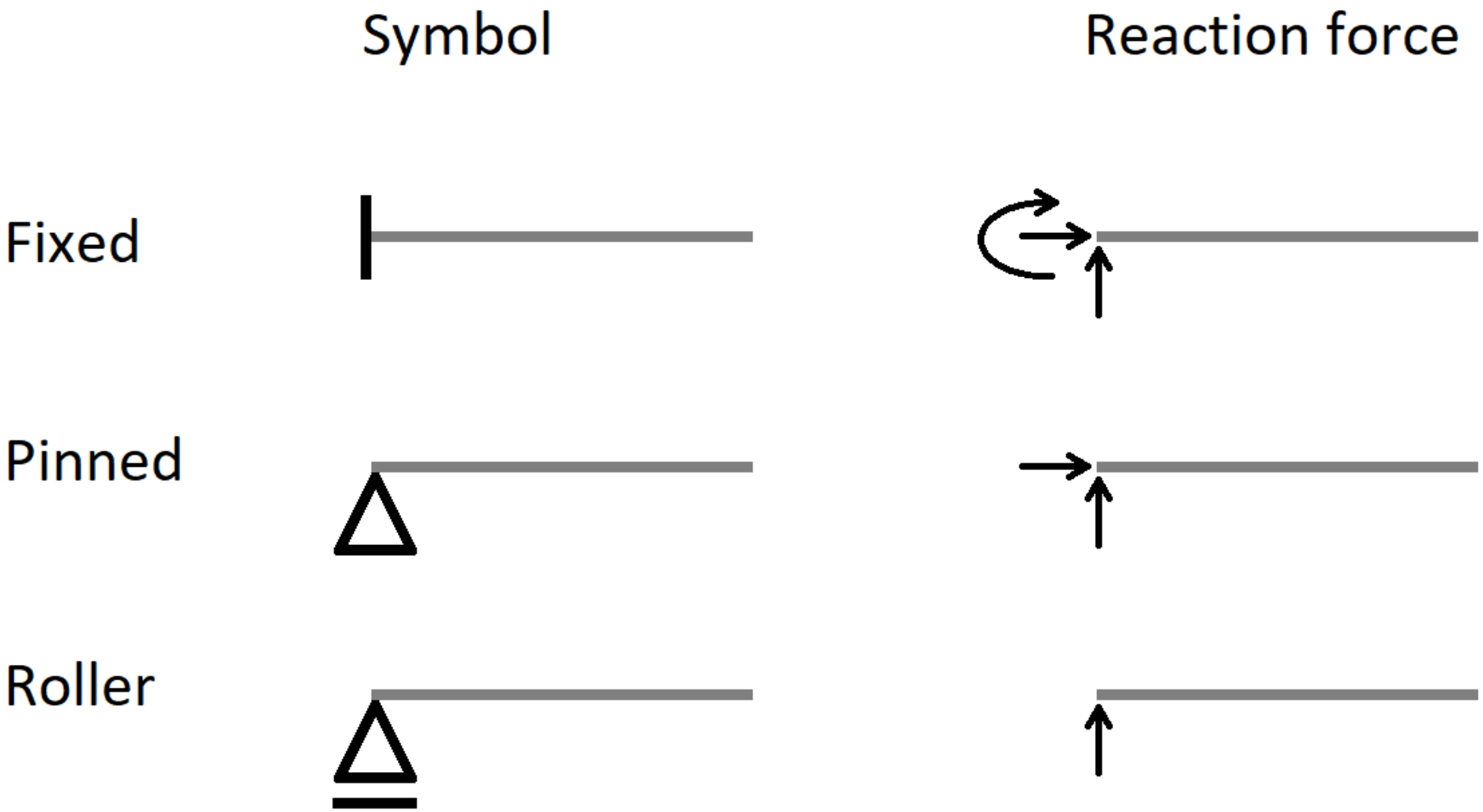
Boundary conditions

In statics, boundary conditions refer to the constraints or limitations imposed on a system or structure at its boundaries or supports. These conditions help define how the system interacts with its environment and play a critical role in analyzing the equilibrium and behavior of the system. Here are some common types of boundary conditions in statics:

Fixed Support: A fixed support, also known as a built-in or immovable support, completely restrains the translational and rotational motion of a structure or object at a specific location. It prevents both vertical and horizontal displacements as well as any rotation.

Pinned Support: A pinned support, also called a hinge support, allows rotation but prevents translation at the point of support. It allows the structure or object to pivot or rotate about the support, but it does not permit any horizontal or vertical movements.

Roller Support: A roller support allows only one translational degree of freedom, typically in the horizontal direction. It prevents vertical and rotational motions but allows the structure to move or roll horizontally along the support.


Symbol
Reaction force
Fixed
Pinned
Roller

Free Body Diagram (FBD)

A free body diagram (FBD) is a graphical representation that depicts an isolated object or body and all the forces acting on it. It is a fundamental tool used in physics and engineering to analyze the forces and their effects on a system. The purpose of a free body diagram is to simplify the analysis of forces acting on an object by isolating it from its surroundings and focusing solely on the forces acting on that object.

When creating a free body diagram, certain guidelines are followed:

1. Isolate the Object: The first step is to identify the specific object or body for which you want to analyze the forces. Mentally separate it from its surroundings and consider it as an individual entity.
2. Represent the Object: Draw a simple and clear sketch of the object as a single point or as a solid body, depending on the context and level of detail required for analysis.
3. Identify and Label Forces: Identify all the external forces acting on the object and label them using arrows. The arrows indicate the magnitude, direction, and sense of the forces. Common forces include applied forces, weight (due to gravity), normal forces, frictional forces, and any other relevant forces.
4. Position and Orientation: Position the forces correctly with respect to the object's geometry. Consider the direction and line of action of each force accurately.
5. Omit Irrelevant Forces: Include only the forces that are directly acting on the object of interest. Disregard forces internal to the object or forces that are not relevant to the analysis.