School of Engineering & Built Environment

MEng/BEng(Hons) in:

Mechanical-Electronic Systems Engineering
Mechanical & Power Plant Systems
Electrical Power Engineering
Computer-Aided Mechanical Engineering

Module: Engineering Design & Analysis 2
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Beams:
Thrust, Shear Force & Bending Moment Diagrams:
A Summary

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Beams: Thrust, Shear Forces and Bending Moments

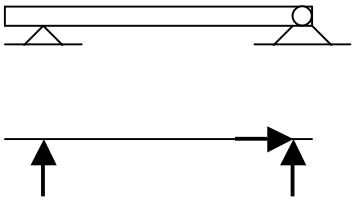
A ***beam*** is a structure that is subjected to external forces inclined to its longitudinal axis. In most cases, beams are horizontal and the loads they carry act vertically downwards, perpendicular to the longitudinal axis.

In order to carry external forces, a beam has to be placed on supports which provide *reactions* to the external actions. The types of supports commonly used are:

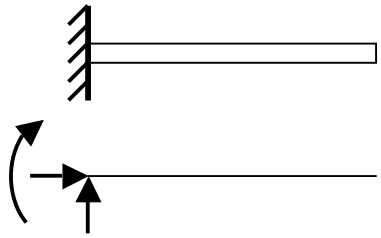
1. knife edges, rollers or pins *(simply-supported beam*).
2. built-in at one end (*cantilever beam*).
3. built-in at one end, simply-supported at the other (*propped cantilever*).
4. built-in at both ends (*encastre beam*).

Figure 1 below shows examples of the beams described in 1 – 4 above and their associated free-body diagrams.

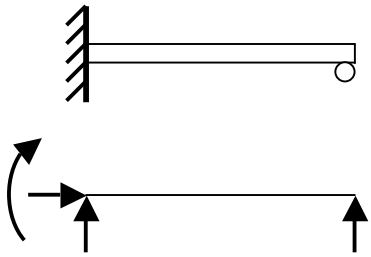
Case 1:



Case 2:



Case 3:



Case 4:

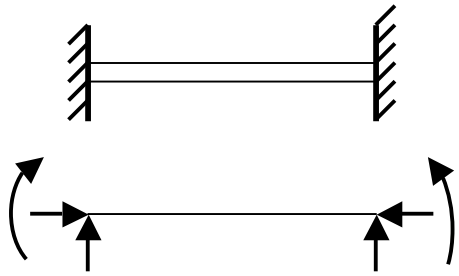
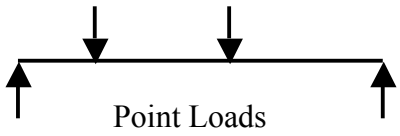


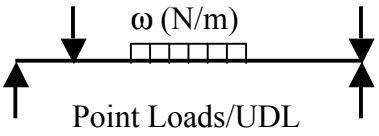
Figure 1

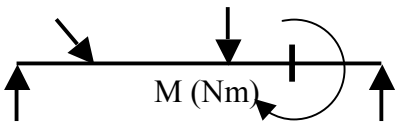
Equilibrium of Beams

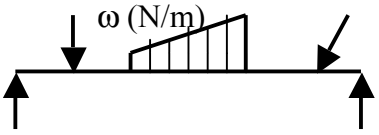
$$\sum F_x = o; \quad \sum F_y = o; \quad \sum M_A = o$$

Types of Load









General Rules

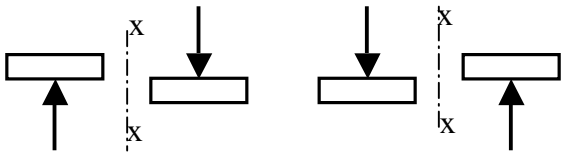
When drawing Thrust, SF and BM diagrams, some general rules apply:

i) In the absence of distributed loads (UDLs), the SF diagram consists of horizontal steps and the BM diagram is a series of straight lines.
ii) For a beam (or part of a beam) carrying a UDL only, the SF diagram is a sloping straight line and the BM diagram is a parabola.
iii) At a point where the SF diagram passes through zero (i.e. where the SF changes sign), the BM diagram has a maximum or minimum value.
iv) Over a part of the span for which SF is zero, the BM has constant value.
v) At a point where the BM diagram passes through zero, this is called a point of contraflexure (or inflexion).

Sign Conventions

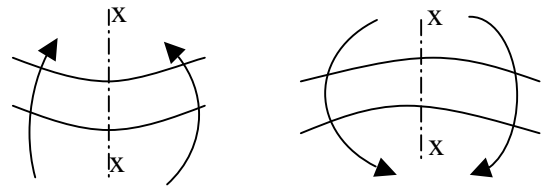
A simple sign convention should be followed when dealing with shear forces and bending moments as follows:

Shear Force:



+SF -SF

Bending Moment:



+M – ‘sagging’ -M – ‘hogging’

Standard Beams

Four standard beam cases are shown in the figure: two simply-supported beams - one with a point load at mid-span and one with a UDL over the whole span; two cantilevers – one with a point load at the free end and one with a UDL over the whole span. Also shown are the corresponding SF and BM diagrams with the maximum values highlighted.