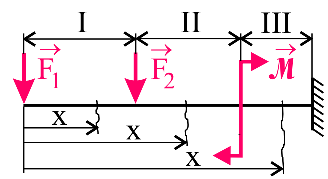
Back to problem analysis

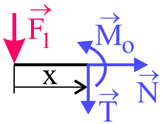
Classification of the bar: straight, loaded by external forces, supported.
Statical analysis: $\mu = 3, \quad \nu = 3$ (a general in-plane system of forces)
$s = \mu - \nu = 3 - 3 = 0$

Now we usually isolate the bar as a free body and calculate the reactions in supports. The bar in question, however, has a free end, so that we need not to calculate the reactions; we can isolate elements containing this free end. We divide the bar into three intervals, namely in the points where external forces or couples are acting on the bar.



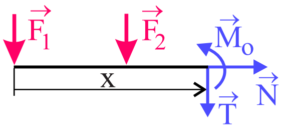
Integral approach:

integral approach



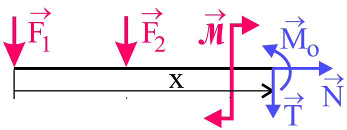
Inner resultants in the interval I: $x \in (0; a)$

$$
\begin{aligned}
F_x &: \quad N(x) = 0, \\
F_z &: \quad T(x) = -F_1 \\
M_y &: \quad M_o(x) = -F_1 x
\end{aligned}
$$



Inner resultants in the interval II: $x \in (a; a+b)$

$$
\begin{aligned}
F_x &: \quad N(x) = 0, \\
F_z &: \quad T(x) = -F_1 - F_2, \\
M_y &: \quad M_o(x) = -F_1 x - F_2(x-a),
\end{aligned}
$$



Inner resultants in the interval III: $x \in (a+b; l)$

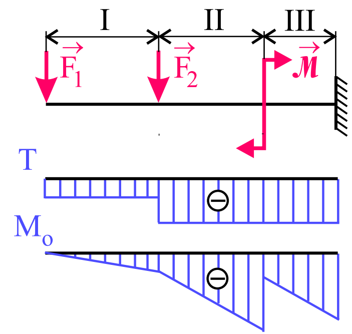
$$
\begin{aligned}
F_x &: \quad N(x) = 0, \\
F_z &: \quad T(x) = -F_1 - F_2, \\
M_y &: \quad M_o(x) = -F_1 x - F_2(x-a) + \mathcal{M}.
\end{aligned}
$$

Differential approach:

differential approach

Graphical representation of the distribution of components of inner resultants:

Shear force:



I. interval: constant shear force $T(x) = -F_1$

II. interval: shear force F_2 increased $\rightarrow$ $T(x) = -(F_1 + F_2)$

III. interval: without changes in forces $\rightarrow T(x) = -(F_1 + F_2)$

There is no distributed load in all the intervals $q_T(x) = 0$:

$\dfrac{\mathrm{d}T(x)}{\mathrm{d}x} = -q_T(x) = 0 \rightarrow T(x)$ parallel to the x axis.

Bending moment:

rules

I. interval: $T(x) =$ const.$\rightarrow \dfrac{\mathrm{d}M_o(x)}{\mathrm{d}x} = T(x) =$ const.$\rightarrow$ linear function of $M_o(x)$.
$T(x) < 0 \rightarrow$ function $M_o(x)$ is decreasing with zero value in the end of the bar, because there is no couple acting upon this end.

II. interval: $T(x) =$ const.$\rightarrow$ function $M_o(x)$ is linear decreasing again but with a higher slope.

III. interval: there is a stepwise change in the location of the couple. Shear force is constant and of the same value as in the 2nd interval so that the representation of $M_o(x)$ is a straight line parallel to that valid for the 2nd interval.