MULTI-SPAN BEAM WITH CANTILEVERS

Beam spans

Left cantilever lenght	$L1 := 1000\ mm$
First span lenght	$L2 := 4000\ mm$
Second span lenght	$L3 := 4000\ mm$
Right cantilever lenght	$L4 := 1000\ mm$
Total beam lenght	$L := L1 + L2 + L3 + L4 = 10\ m$

Section geometry	*Width*	*Height*
Top subsection	$b_1 := 60\ mm$	$h_1 := 39\ mm$
Middle subsection	$b_2 := 8\ mm$	$h_2 := 162\ mm$
Bottom subsection	$b_3 := 60\ mm$	$h_3 := 39\ mm$
Total section height	$h := h_1 + h_2 + h_3$	

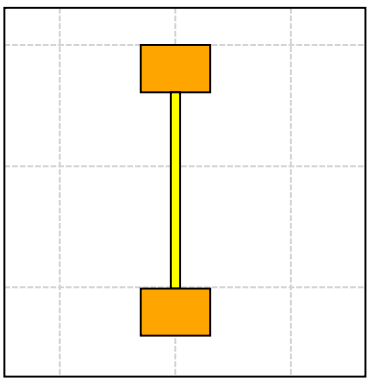
Section material	*Elastic modulus*	*Shear modulus*
Top subsection	$E_1 := 14500\ \frac{N}{mm^2}$	$G_1 := 600\ \frac{N}{mm^2}$
Middle subsection	$E_2 := 5300\ \frac{N}{mm^2}$	$G_2 := 2100\ \frac{N}{mm^2}$
Bottom subsection	$E_3 := 14500\ \frac{N}{mm^2}$	$G_3 := 600\ \frac{N}{mm^2}$
Shear stiffness	$GA := G_1 \cdot h_1 \cdot b_1 + G_2 \cdot h_2 \cdot b_2 + G_3 \cdot h_3 \cdot b_3 = 5,5296 \cdot 10^6\ N$	

Beam load

Uniform distribuited load (fieldwise)	$qq := (-1)\ \frac{kN}{m}$

SECTION VIEW

Section view



$$y_n := \frac{b_3 \cdot h_3 \cdot E_3 \cdot \left(h_1 + h_2 + \frac{h_3}{2}\right) + b_2 \cdot h_2 \cdot E_2 \cdot \left(h_1 + \frac{h_2}{2}\right) + b_1 \cdot h_1 \cdot E_1 \cdot \frac{h_1}{2}}{b_1 \cdot h_1 \cdot E_1 + b_2 \cdot h_2 \cdot E_2 + b_3 \cdot h_3 \cdot E_3}$$

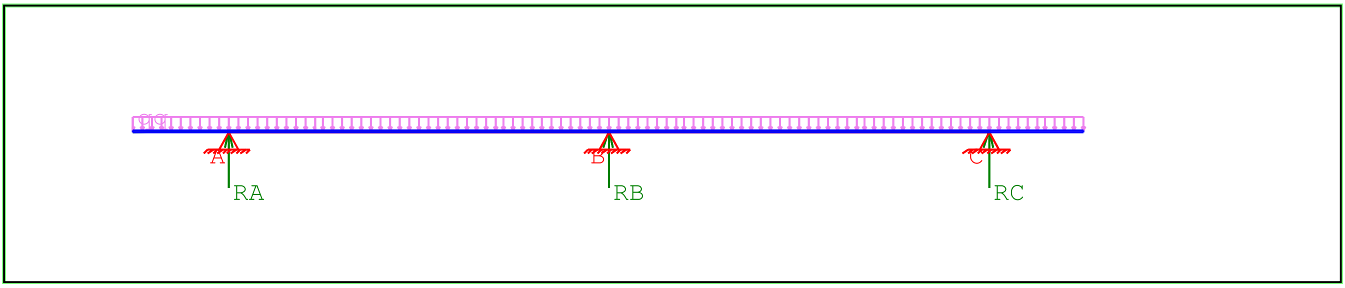
$$EI := \frac{h_1^{\ 3} \cdot b_1 \cdot E_1}{12} + \frac{h_2^{\ 3} \cdot b_2 \cdot E_2}{12} + \frac{h_3^{\ 3} \cdot b_3 \cdot E_3}{12} + b_1 \cdot h_1 \cdot E_1 \cdot \left(y_n - \frac{h_1}{2}\right)^2 + b_2 \cdot h_2 \cdot E_2 \cdot \left(h_1 + \frac{h_2}{2} - y_n\right)^2 + b_3 \cdot h_3 \cdot E_3 \cdot \left(h_1 \right.$$

$$k_s := \frac{6 \cdot \left(-E_2 \cdot b_2 \cdot \left(h_3 + h_1 - h\right) + E_3 \cdot b_3 \cdot h_3 + E_1 \cdot b_1 \cdot h_1\right)^4 \cdot \left(\left(E_1^{\ 2} \cdot b_1 \cdot h_1^{\ 3} \cdot \left(10 \cdot E_2^{\ 5} \cdot b_2^{\ 5} \cdot h^7 + h_3 \cdot \left(h_3 \cdot \left(h_3 \cdot \left(h_3 \cdot \left(h_3 \right.\right.\right.\right.\right.\right.\right.}{}$$

$$GAc := \frac{GA}{k_s} = 3{,}9408 \cdot 10^6 \ \text{N}$$

⊞— BEAM DIAGRAM

Beam diagram:



⊞— DEFINITION OF INTERNAL FORCES AND REACTIONS

$$Vmin(x) := \begin{cases} \text{Min}\left(V1(x;\, qq;\, 0;\, qq;\, 0);\ V1(x;\, 0;\, qq;\, 0;\, qq);\ V1(x;\, qq;\, qq;\, 0;\, qq);\ V1(x;\, 0;\, qq;\, qq;\, 0);\ V1(\right. \\ \text{Min}\left(V2(x - L1;\, qq;\, 0;\, qq;\, 0);\ V2(x - L1;\, 0;\, qq;\, 0;\, qq);\ V2(x - L1;\, qq;\, qq;\, 0;\, qq);\ V2(x - L1;\, 0\right. \\ \text{Min}\left(V3(x - L1 - L2;\, qq;\, 0;\, qq;\, 0);\ V3(x - L1 - L2;\, 0;\, qq;\, 0;\, qq);\ V3(x - L1 - L2;\, qq;\, qq;\, 0;\, qq)\right. \\ \text{Min}\left(V4(x - L1 - L2 - L3;\, qq;\, 0;\, qq;\, 0);\ V4(x - L1 - L2 - L3;\, 0;\, qq;\, 0;\, qq);\ V4(x - L1 - L2 - L3;\, q\right. \\ 0 \end{cases}$$

$$Mmin(x) := \begin{cases} \text{Min}\left(M1(x;\, qq;\, 0;\, qq;\, 0);\ M1(x;\, 0;\, qq;\, 0;\, qq);\ M1(x;\, qq;\, qq;\, 0;\, qq);\ M1(x;\, 0;\, qq;\, qq;\, 0);\ M1(\right. \\ \text{Min}\left(M2(x - L1;\, qq;\, 0;\, qq;\, 0);\ M2(x - L1;\, 0;\, qq;\, 0;\, qq);\ M2(x - L1;\, qq;\, qq;\, 0;\, qq);\ M2(x - L1;\, 0\right. \\ \text{Min}\left(M3(x - L1 - L2;\, qq;\, 0;\, qq;\, 0);\ M3(x - L1 - L2;\, 0;\, qq;\, 0;\, qq);\ M3(x - L1 - L2;\, qq;\, qq;\, 0;\, qq)\right. \\ \text{Min}\left(M4(x - L1 - L2 - L3;\, qq;\, 0;\, qq;\, 0);\ M4(x - L1 - L2 - L3;\, 0;\, qq;\, 0;\, qq);\ M4(x - L1 - L2 - L3;\, q\right. \\ 0 \end{cases}$$

$$umin(x) := \begin{cases} \text{Min}\left(u1(x;\, qq;\, 0;\, qq;\, 0);\ u1(x;\, 0;\, qq;\, 0;\, qq);\ u1(x;\, qq;\, qq;\, 0;\, qq);\ u1(x;\, 0;\, qq;\, qq;\, 0);\ u1(\right. \\ \text{Min}\left(u2(x - L1;\, qq;\, 0;\, qq;\, 0);\ u2(x - L1;\, 0;\, qq;\, 0;\, qq);\ u2(x - L1;\, qq;\, qq;\, 0;\, qq);\ u2(x - L1;\, 0\right. \\ \text{Min}\left(u3(x - L1 - L2;\, qq;\, 0;\, qq;\, 0);\ u3(x - L1 - L2;\, 0;\, qq;\, 0;\, qq);\ u3(x - L1 - L2;\, qq;\, qq;\, 0;\, qq)\right. \\ \text{Min}\left(u4(x - L1 - L2 - L3;\, qq;\, 0;\, qq;\, 0);\ u4(x - L1 - L2 - L3;\, 0;\, qq;\, 0;\, qq);\ u4(x - L1 - L2 - L3;\, q\right. \\ 0 \end{cases}$$

$$Vmax(x) := \begin{cases} \text{Max}(V1(x; qq; 0; qq; 0); V1(x; 0; qq; 0; qq); V1(x; qq; qq; 0; qq); V1(x; 0; qq; qq; 0); V1(x \\ \text{Max}(V2(x - L1; qq; 0; qq; 0); V2(x - L1; 0; qq; 0; qq); V2(x - L1; qq; qq; 0; qq); V2(x - L1; 0 \\ \text{Max}(V3(x - L1 - L2; qq; 0; qq; 0); V3(x - L1 - L2; 0; qq; 0; qq); V3(x - L1 - L2; qq; qq; 0; qq) \\ \text{Max}(V4(x - L1 - L2 - L3; qq; 0; qq; 0); V4(x - L1 - L2 - L3; 0; qq; 0; qq); V4(x - L1 - L2 - L3; q \\ 0 \end{cases}$$

$$Mmax(x) := \begin{cases} \text{Max}(M1(x; qq; 0; qq; 0); M1(x; 0; qq; 0; qq); M1(x; qq; qq; 0; qq); M1(x; 0; qq; qq; 0); M1(x \\ \text{Max}(M2(x - L1; qq; 0; qq; 0); M2(x - L1; 0; qq; 0; qq); M2(x - L1; qq; qq; 0; qq); M2(x - L1; 0 \\ \text{Max}(M3(x - L1 - L2; qq; 0; qq; 0); M3(x - L1 - L2; 0; qq; 0; qq); M3(x - L1 - L2; qq; qq; 0; qq) \\ \text{Max}(M4(x - L1 - L2 - L3; qq; 0; qq; 0); M4(x - L1 - L2 - L3; 0; qq; 0; qq); M4(x - L1 - L2 - L3; q \\ 0 \end{cases}$$

$$umax(x) := \begin{cases} \text{Max}(u1(x; qq; 0; qq; 0); u1(x; 0; qq; 0; qq); u1(x; qq; qq; 0; qq); u1(x; 0; qq; qq; 0); u1(x \\ \text{Max}(u2(x - L1; qq; 0; qq; 0); u2(x - L1; 0; qq; 0; qq); u2(x - L1; qq; qq; 0; qq); u2(x - L1; 0 \\ \text{Max}(u3(x - L1 - L2; qq; 0; qq; 0); u3(x - L1 - L2; 0; qq; 0; qq); u3(x - L1 - L2; qq; qq; 0; qq) \\ \text{Max}(u4(x - L1 - L2 - L3; qq; 0; qq; 0); u4(x - L1 - L2 - L3; 0; qq; 0; qq); u4(x - L1 - L2 - L3; q \\ 0 \end{cases}$$

$$R1min := \text{Min}(R1(qq; 0; qq; 0); R1(0; qq; 0; qq); R1(qq; qq; 0; qq); R1(0; qq; qq; 0); R1(qq; 0; qq; qq);$$

$$R1max := \text{Max}(R1(qq; 0; qq; 0); R1(0; qq; 0; qq); R1(qq; qq; 0; qq); R1(0; qq; qq; 0); R1(qq; 0; qq; qq);$$

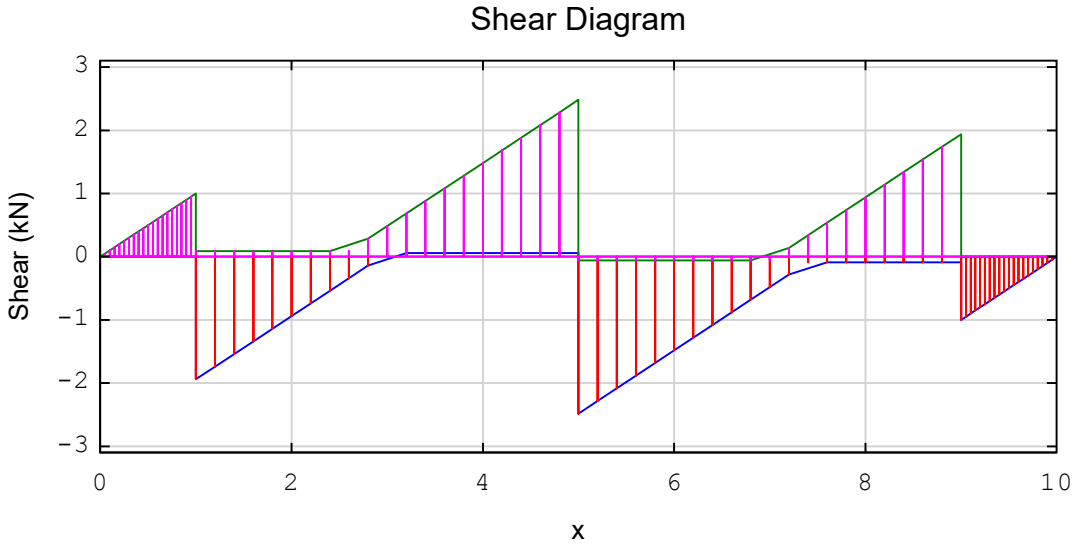
$$R2min := \text{Min}(R2(qq; 0; qq; 0); R2(0; qq; 0; qq); R2(qq; qq; 0; qq); R2(0; qq; qq; 0); R2(qq; 0; qq; qq);$$

$$R2max := \text{Max}(R2(qq; 0; qq; 0); R2(0; qq; 0; qq); R2(qq; qq; 0; qq); R2(0; qq; qq; 0); R2(qq; 0; qq; qq);$$

$$R3min := \text{Min}(R3(qq; 0; qq; 0); R3(0; qq; 0; qq); R3(qq; qq; 0; qq); R3(0; qq; qq; 0); R3(qq; 0; qq; qq);$$

$$R3max := \text{Max}(R3(qq; 0; qq; 0); R3(0; qq; 0; qq); R3(qq; qq; 0; qq); R3(0; qq; qq; 0); R3(qq; 0; qq; qq);$$

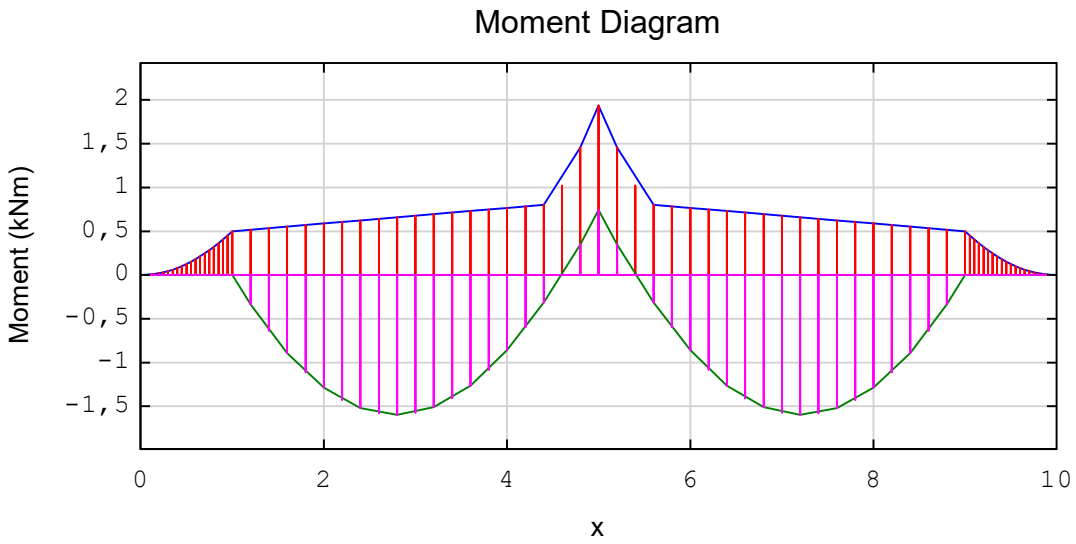
SHEAR DIAGRAM



$V_{max} = 2,4837\ \text{kN}$

$V_{min} = -2,4837\ \text{kN}$

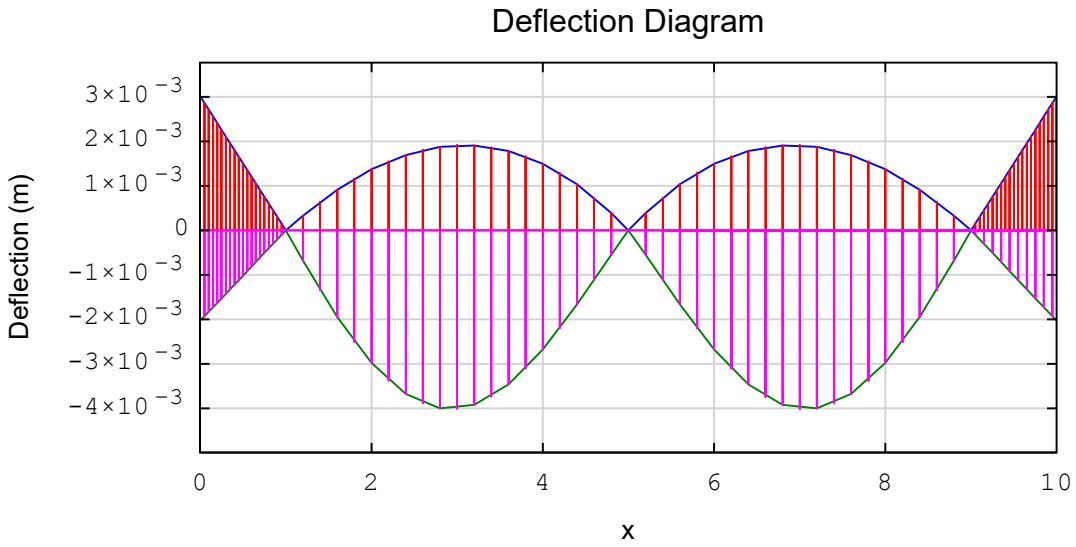
MOMENT DIAGRAM



$M_{max} = 1,9347$ kN m

$M_{min} = -1,5954$ kN m

DEFLECTION DIAGRAM



$\Delta_{max} = 0,251$ mm

$\Delta_{min} = -0,3328$ mm

Reactions

$R1min = 911,3491$ N

$R1max = 2939,5396$ N

$R2min = 2120,9207$ N

$R2max = 4967,366$ N

$R3min = 911,3491$ N

$R3max = 2939,5396$ N