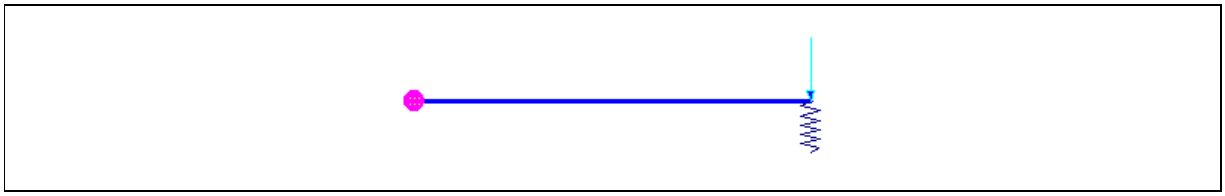
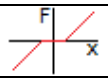
Validation of Sargon Nonlinear solver (CURAN, version 9.70)			
TEST SP005	**VALIDATION, RELIABILITY, BENCHMARK**	**Marco Croci**	**Rev.1-10/03/2011**



Test description
A spring has been added under the free end of a cantilever. The spring has a gap so that it starts to react after a displacement equal to 10mm.
Test model: **curanSP_005.WSR**

Springs properties						
k_1 [N/mm]	D_y [mm]	(k_2) [N/mm]	(D_u) [mm]	Gap [mm]	Law	
1950,078	100	0	∞	$\pm$10	symmetric	

Beam properties					
Length	Shape		Material		
3000mm	IPE300	J=83561000mm^4	S235	E=210000N/mm^2	ν=0,3

Loads and constraints		
Left end	Right end	Force
Fixed	Spring	F = -50000N

CHECK

Without the spring, the displacement of the simple cantilever would be equal to $FL^3/(3EJ)$=-25,64mm and maximum bending moment would be equal to F*L=1,5*10^{8}Nmm. After a displacement equal to -10mm the spring starts to react: in this test k_1 is equal to $3EJ/L^3$, so the stiffness of cantilever+spring is 2 times greater than the stiffness of the simple cantilever and the additional displacement is equal to [-25,64mm-(-10mm)]/2=-7,82mm. Total displacement is -10mm-7,82mm=-17,82mm. Computed moment should be equal to 1,5*10^{8}Nmm*17,82mm/25,64mm=1,0425*10^8.

Load case	**Value**	**Unit**	**CURAN**	**THEORETICAL**	**% diff.**
1	Node 8 displacement (z)	mm	-1,782E+01	-1,782E+01	0,00
1	Beam #1 max bending moment	Nmm	1,042E+08	1,043E+08	-0,01

% difference = (CURAN - THEORETICAL) / THEORETICAL * 100

Precision of limit multiplier for the analysis: 0.005

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