Example examination question #1_1:

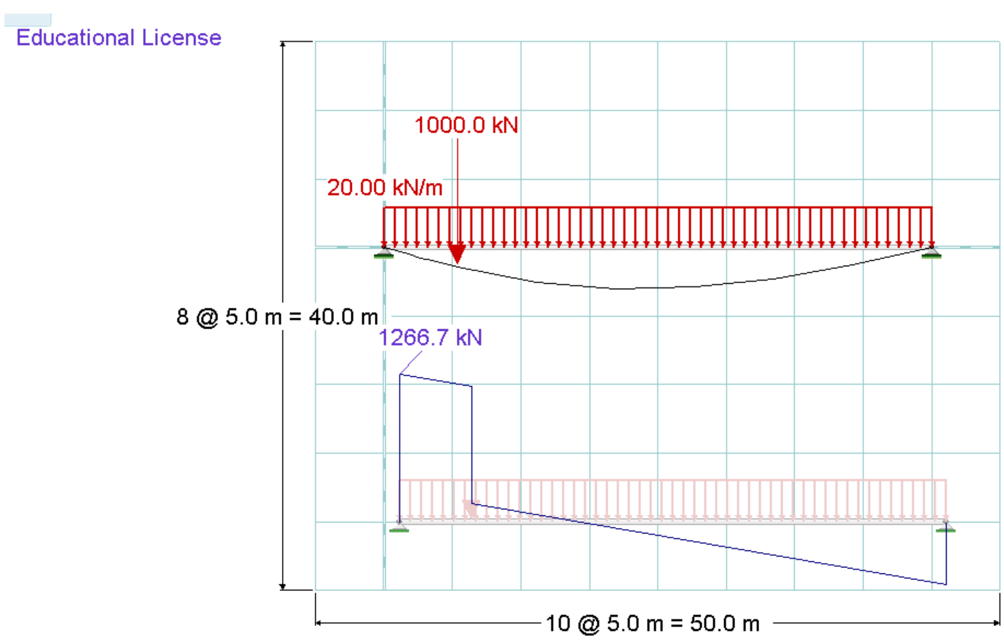
Model a simply supported beam of 40 m length, loaded with a UDL of 20 kN/m over the full length and a concentrated load of 1000 kN at a distance of 6 m from the left end. Additional information on the beam to the right:

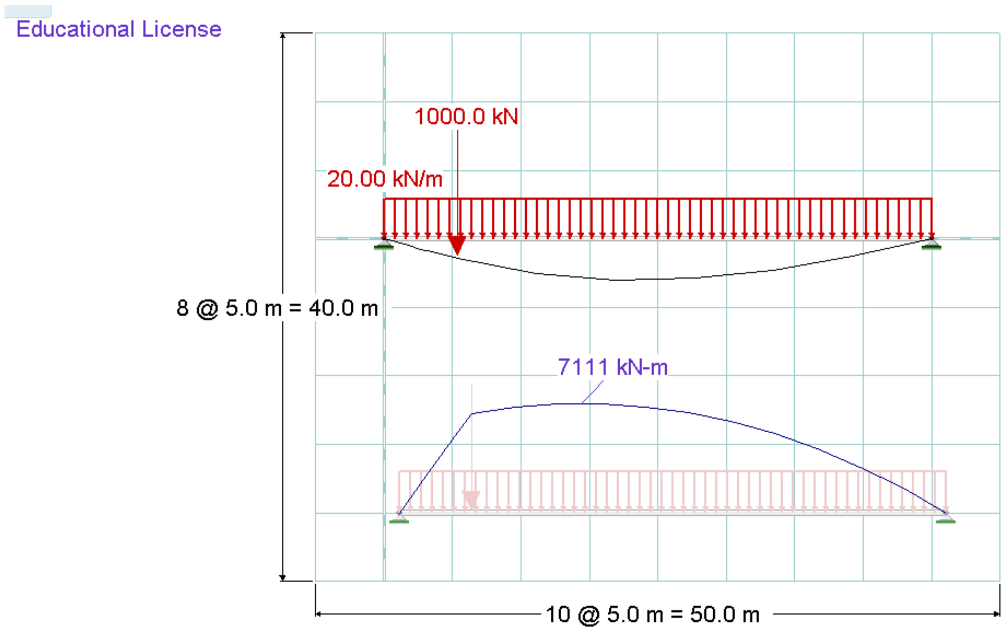
a) Compute manually shear, moment and deflected shape for the beam. Feel free to use the formulae as provided by the Handbook of Steel Construction (copies of relevant pages follow below).

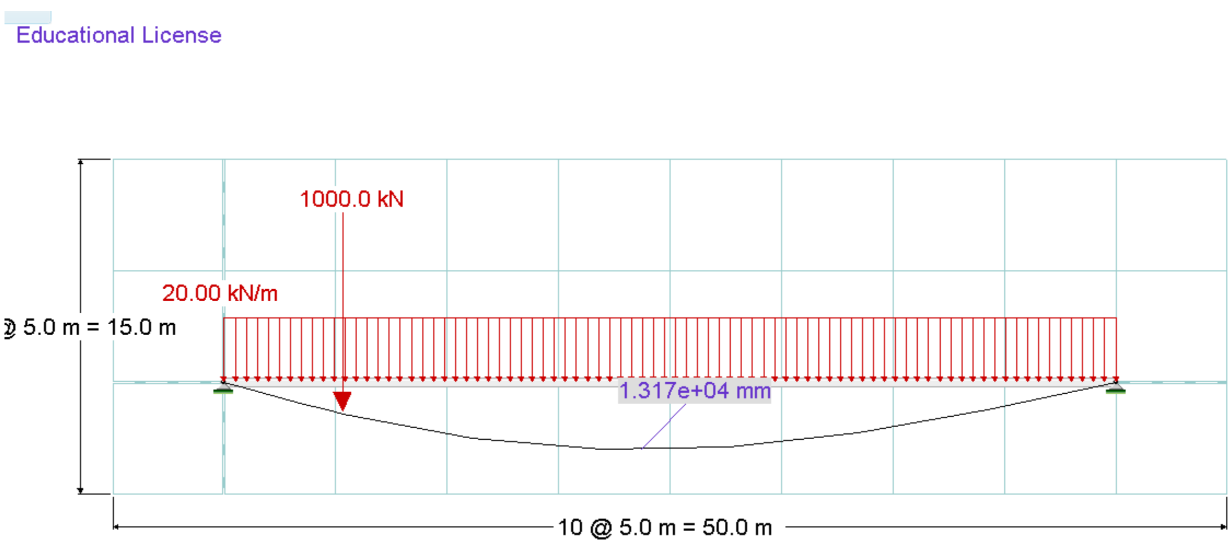
Now use DrFrame2D and compare your manual computations. Try to achieve screen appearance similar to the images shown below.

b) Inspect the shear distribution over the length of the beam and identify the location of zero shear. What would this location be useful for?
c) Inspect the moment distribution over the length of the beam and identify the location of maximum moment.
d) Show the value of maximum deflection in your diagramme, without any shear or moment plot.

Section Subtype	I-Section
Depth	355.6 mm
Flange Width	304.8 mm
Flange Thickness	25.4 mm
Web Thickness	12.7 mm
Properties	Area = 194 cm^2
In-plane Axis	Strong Axis
Lateral Bracing	No
EI Reduction	1
Material Properties	
Elastic Modulus	199.9 GPa
Yield Stress	248.2 MPa
Density	7849 kg/m^3
Shear Modulus	76.9 GPa
End Conditions	
End 1 Fixity	Hinged
Rotational Stiffness	0 N-m/rad
End 2 Fixity	Hinged
Rotational Stiffness	0 N-m/rad



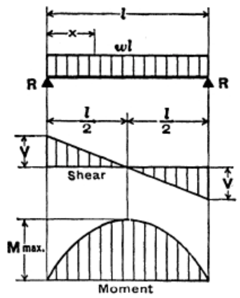

Educational License
1000.0 kN
20.00 kN/m
8 @ 5.0 m = 40.0 m
7111 kN-m
10 @ 5.0 m = 50.0 m


Educational License
1000.0 kN
20.00 kN/m
5.0 m = 15.0 m
1.317e+04 mm
10 @ 5.0 m = 50.0 m

BEAM DIAGRAMS AND FORMULAE

Equivalent Tabular Load is the uniformly distributed factored load given in the Beam Load Tables

1 SIMPLE BEAM—UNIFORMLY DISTRIBUTED LOAD



Equivalent Tabular Load . . . . $= wl$

$R = V$ . . . . $= \frac{wl}{2}$

V_x . . . . $= w\left(\frac{l}{2} - x\right)$

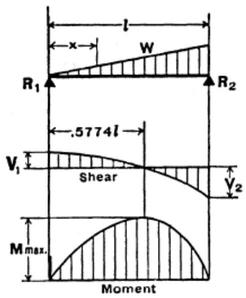
M max. (at center) . . . . . $= \frac{wl^2}{8}$

M_x . . . . $= \frac{wx}{2}(l - x)$

Δmax. (at center) . . . . . $= \frac{5\,wl^4}{384\,EI}$

Δx . . . . $= \frac{wx}{24EI}(l^3 - 2lx^2 + x^3)$

2 SIMPLE BEAM—LOAD INCREASING UNIFORMLY TO ONE END



Equivalent Tabular Load . . . . $= \frac{16W}{9\sqrt{3}} = 1.0264W$

$R_1 = V_1$ . . . . $= \frac{W}{3}$

$R_2 = V_2$ max. . . . . $= \frac{2W}{3}$

V_x . . . . $= \frac{W}{3} - \frac{Wx^2}{l^2}$

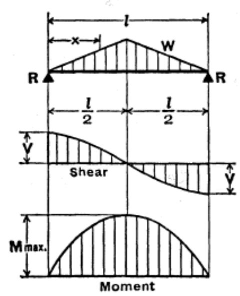
M max. $\left(\text{at } x = \frac{l}{\sqrt{3}} = .5774l\right)$ . . . $= \frac{2Wl}{9\sqrt{3}} = .1283\,Wl$

M_x . . . . $= \frac{Wx}{3l^2}(l^2 - x^2)$

Δmax. $\left(\text{at } x = l\sqrt{1 - \sqrt{\frac{8}{15}}} = .5193l\right) = .01304\,\frac{Wl^3}{EI}$

Δx . . . . $= \frac{Wx}{180EI\,l^2}(3x^4 - 10l^2x^2 + 7l^4)$

3 SIMPLE BEAM—LOAD INCREASING UNIFORMLY TO CENTER



Equivalent Tabular Load . . . . $= \frac{4W}{3}$

$R = V$ . . . . $= \frac{W}{2}$

V_x $\left(\text{when } x < \frac{l}{2}\right)$ . . . . $= \frac{W}{2l^2}(l^2 - 4x^2)$

M max. (at center) . . . . . $= \frac{Wl}{6}$

M_x $\left(\text{when } x < \frac{l}{2}\right)$ . . . . $= Wx\left(\frac{1}{2} - \frac{2x^2}{3l^2}\right)$

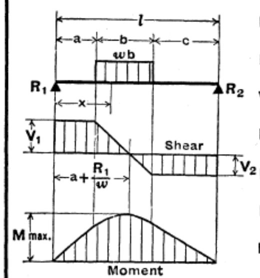
Δmax. (at center) . . . . . $= \frac{Wl^3}{60EI}$

Δx . . . . $= \frac{Wx}{480\,EI\,l^2}(5l^2 - 4x^2)^2$

Note: For deflection calculations, use specified loads.

BEAM DIAGRAMS AND FORMULAE

4 SIMPLE BEAM—UNIFORM LOAD PARTIALLY DISTRIBUTED



$R_1 = V_1 \left(\text{max. when } a < c\right) \ldots = \frac{wb}{2l}(2c + b)$

$R_2 = V_2 \left(\text{max. when } a > c\right) \ldots = \frac{wb}{2l}(2a + b)$

$V_x \left(\text{when } x > a \text{ and } < (a+b)\right) . = R_1 - w(x - a)$

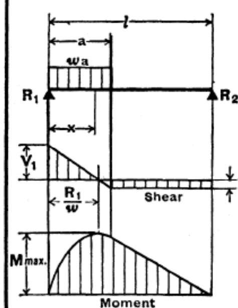
$M\ \text{max.} \left(\text{at } x = a + \frac{R_1}{w}\right) \ldots = R_1\left(a + \frac{R_1}{2w}\right)$

$M_x \left(\text{when } x < a\right) \ldots = R_1 x$

$M_x \left(\text{when } x > a \text{ and } < (a+b)\right) . = R_1 x - \frac{w}{2}(x - a)^2$

$M_x \left(\text{when } x > (a+b)\right) \ldots = R_2(l - x)$

5 SIMPLE BEAM—UNIFORM LOAD PARTIALLY DISTRIBUTED AT ONE END



$R_1 = V_1\ \text{max.} \ldots = \frac{wa}{2l}(2l - a)$

$R_2 = V_2 \ldots = \frac{wa^2}{2l}$

$V \left(\text{when } x < a\right) \ldots = R_1 - wx$

$M\ \text{max.} \left(\text{at } x = \frac{R_1}{w}\right) \ldots = \frac{R_1^2}{2w}$

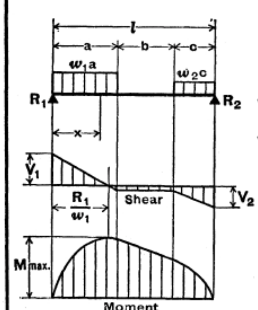
$M_x \left(\text{when } x < a\right) \ldots = R_1 x - \frac{wx^2}{2}$

$M_x \left(\text{when } x > a\right) \ldots = R_2(l - x)$

$\Delta_x \left(\text{when } x < a\right) \ldots = \frac{wx}{24EIl}\left(a^2(2l-a)^2 - 2ax^2(2l-a) + lx^3\right)$

$\Delta_x \left(\text{when } x > a\right) \ldots = \frac{wa^2(l-x)}{24EIl}(4xl - 2x^2 - a^2)$

6 SIMPLE BEAM—UNIFORM LOADS PARTIALLY DISTRIBUTED AT EACH END



$R_1 = V_1 \ldots = \frac{w_1 a(2l - a) + w_2 c^2}{2l}$

$R_2 = V_2 \ldots = \frac{w_2 c(2l - c) + w_1 a^2}{2l}$

$V_x \left(\text{when } x < a\right) \ldots = R_1 - w_1 x$

$V_x \left(\text{when } x > a \text{ and } < (a+b)\right) . = R_1 - w_1 a$

$V_x \left(\text{when } x > (a+b)\right) \ldots = R_2 - w_2(l - x)$

$M\ \text{max.} \left(\text{at } x = \frac{R_1}{w_1} \text{ when } R_1 < w_1 a\right) . = \frac{R_1^2}{2w_1}$

$M\ \text{max.} \left(\text{at } x = l - \frac{R_2}{w_2} \text{ when } R_2 < w_2 c\right) = \frac{R_2^2}{2w_2}$

$M_x \left(\text{when } x < a\right) \ldots = R_1 x - \frac{w_1 x^2}{2}$

$M_x \left(\text{when } x > a \text{ and } < (a+b)\right) . = R_1 x - \frac{w_1 a}{2}(2x - a)$

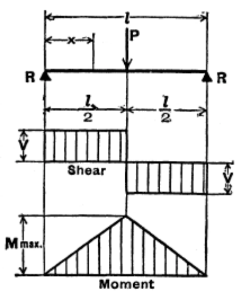
$M_x \left(\text{when } x > (a+b)\right) \ldots = R_2(l - x) - \frac{w_2(l - x)^2}{2}$

Note: For deflection calculations, use specified loads.

BEAM DIAGRAMS AND FORMULAE

Equivalent Tabular Load is the uniformly distributed factored load given in the Beam Load Tables

7 SIMPLE BEAM—CONCENTRATED LOAD AT CENTER



Equivalent Tabular Load . . . . . . $= 2P$

$R = V$ . . . . $= \frac{P}{2}$

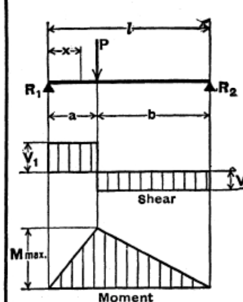
M max. (at point of load) . . . . . . $= \frac{Pl}{4}$

M_x (when $x < \frac{l}{2}$) . . . . . . $= \frac{Px}{2}$

Δmax. (at point of load) . . . . . . $= \frac{Pl^3}{48EI}$

Δx (when $x < \frac{l}{2}$) . . . . . . $= \frac{Px}{48EI}(3l^2 - 4x^2)$

8 SIMPLE BEAM—CONCENTRATED LOAD AT ANY POINT



Equivalent Tabular Load . . . . . . $= \frac{8\,Pab}{l^2}$

$R_1 = V_1$ (max. when $a < b$) . . . . . $= \frac{Pb}{l}$

$R_2 = V_2$ (max. when $a > b$) . . . . . $= \frac{Pa}{l}$

M max. (at point of load) . . . . . $= \frac{Pab}{l}$

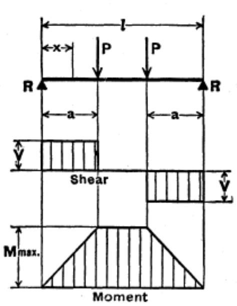
M_x (when $x < a$) . . . . . $= \frac{Pbx}{l}$

Δmax. (at $x = \sqrt{\frac{a(a+2b)}{3}}$ when $a > b$) $= \frac{Pab\,(a+2b)\,\sqrt{3a\,(a+2b)}}{27\,EI\,l}$

Δa (at point of load) . . . . . $= \frac{Pa^2b^2}{3EI\,l}$

Δx (when $x < a$) . . . . . $= \frac{Pbx}{6EI\,l}(l^2 - b^2 - x^2)$

9 SIMPLE BEAM—TWO EQUAL CONCENTRATED LOADS SYMMETRICALLY PLACED



Equivalent Tabular Load . . . . . . $= \frac{8\,Pa}{l}$

$R = V$ . . . . $= P$

M max. (between loads) . . . . . . $= Pa$

M_x (when $x < a$) . . . . . . $= Px$

Δmax. (at center) . . . . $= \frac{Pa}{24EI}(3l^2 - 4a^2)$

Δx (when $x < a$) . . . . $= \frac{Px}{6EI}(3la - 3a^2 - x^2)$

Δx (when $x > a$ and $< (l - a)$) . . . $= \frac{Pa}{6EI}(3lx - 3x^2 - a^2)$

Note: For deflection calculations, use specified loads.