MEMORIAL UNIVERSITY OF NEWFOUNDLAND

Faculty of Engineering and Applied Science

Engineering 5003 - Ship Structures

FINAL EXAMINATION
(SOLUTIONS)

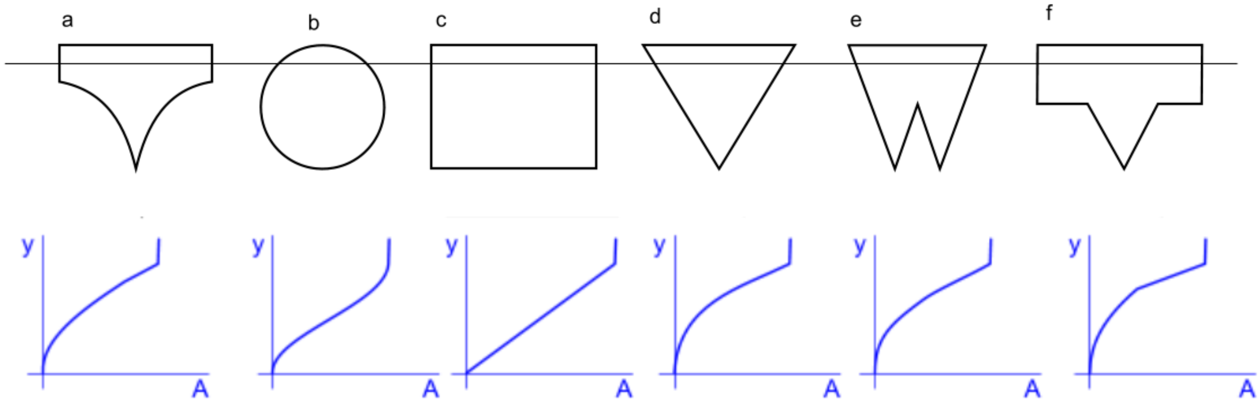
Date: Thursday April 12, 2018 **Professor: Dr. C. Daley**
Time: 1:00 - 3:30 pm
Maximum Marks: 100

Instructions:
Please write/sketch clearly in the white answer book.
Answer all 7 questions.

This is a closed book exam. Some formulae are given at the end of the question paper.

1. Bonjean Curves (12 marks)

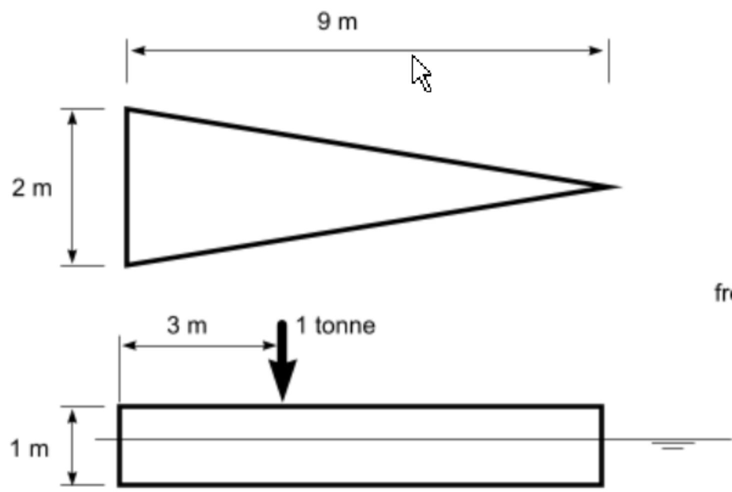
For each of the six cross sections shown, sketch the bonjean curve.

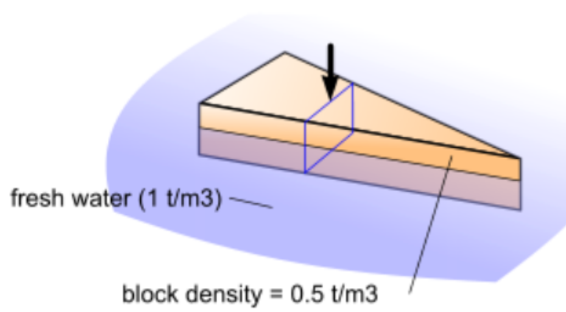


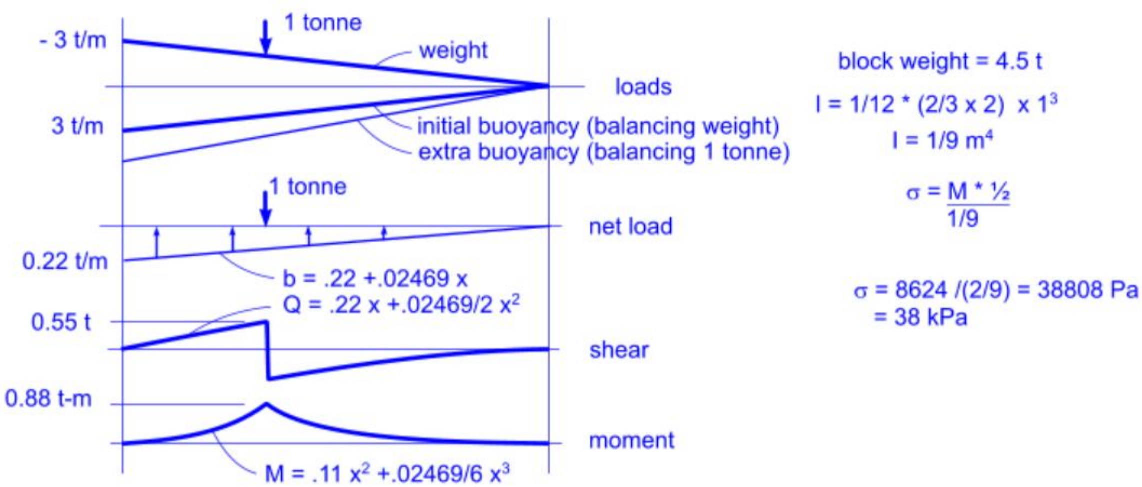
2. Still Water Bending Stresses (18 Marks)

a) a triangular block as sketched below is floating in fresh water. A 1 tonne load is added at the centroid. By considering the block as a 9m beam, of tapered width, draw the shear and bending moment diagrams, with values. What would the max bending stress be?

b) Concisely describe how the calculations would change if the load were not at the centroid.

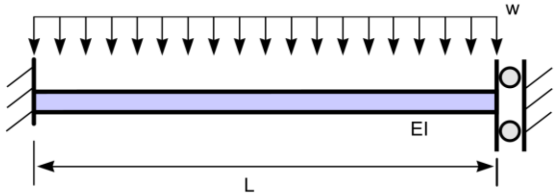


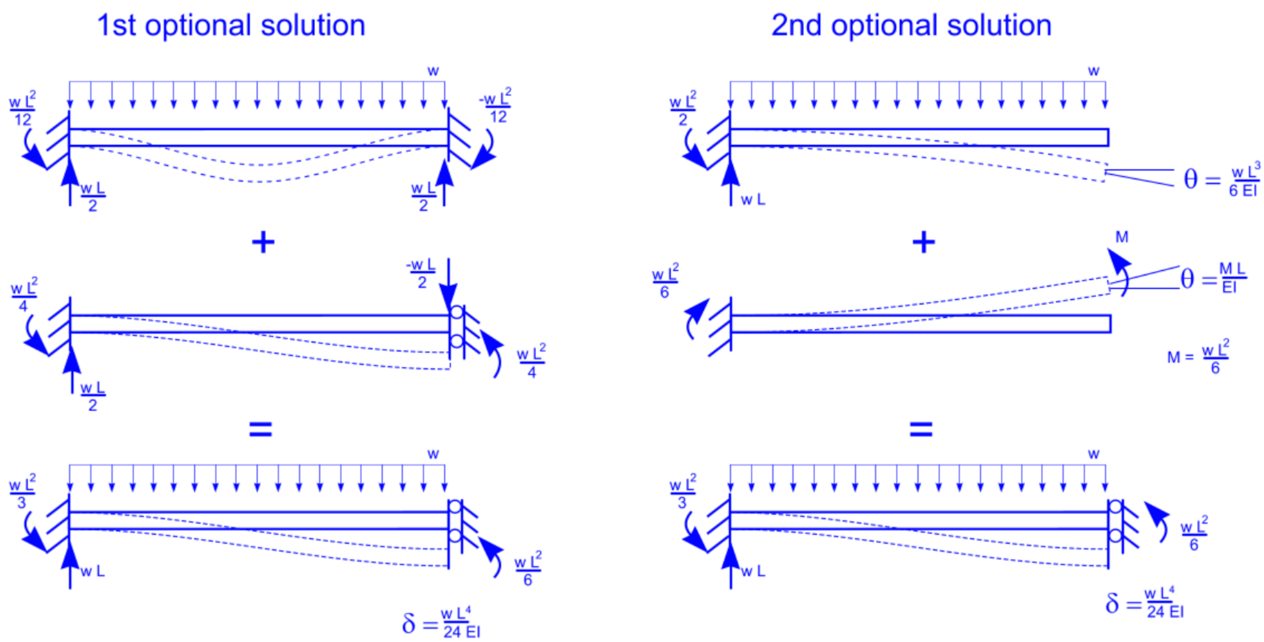




3. Beam bending (15 Marks)

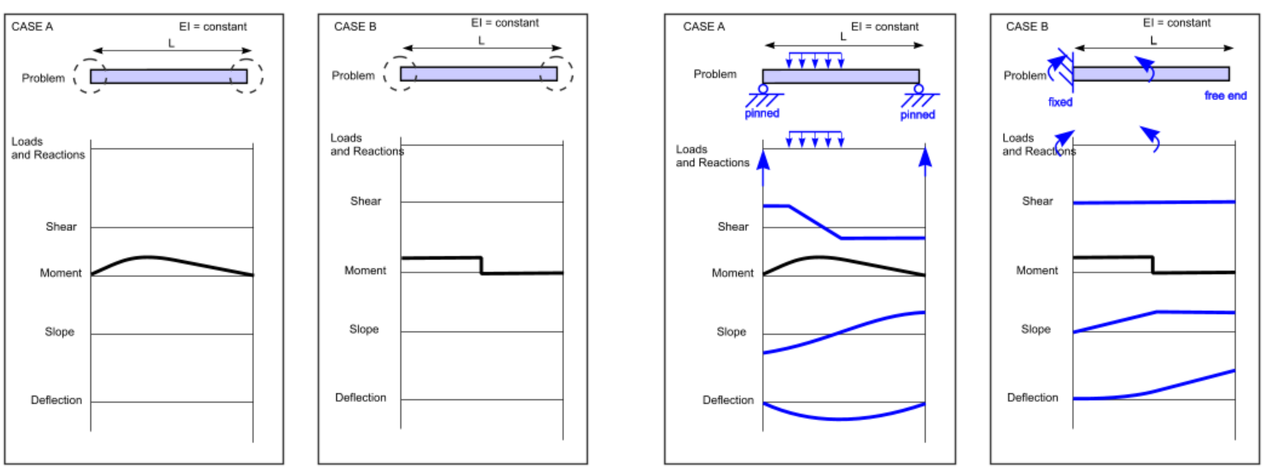
Find the end reactions and maximum deflection in terms of w L and EI. Use any means you wish.





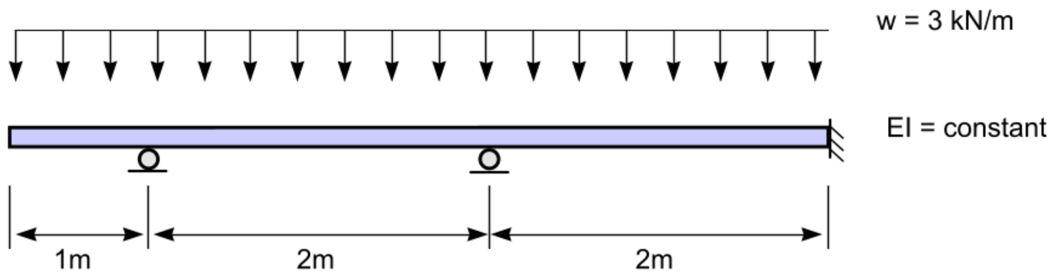
4. Beam Solutions (10 Marks)

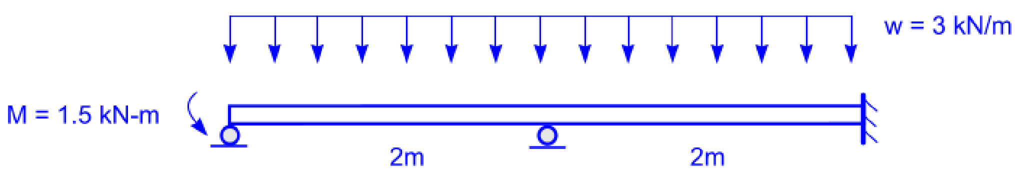
For the two cases shown below, the bending moment diagrams are sketched. Show a possible set of supports and loading. Sketch the shear, slope and deflection patterns. No numerical values are required. (5 marks each problem) (answer in the answer book- not on this sheet)



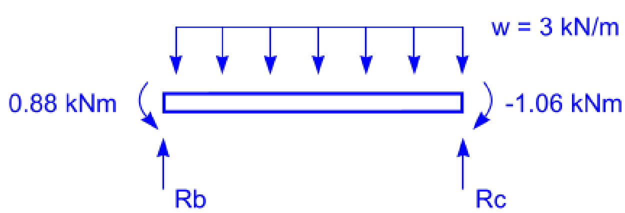
5. Moment Distribution Method (15 Marks)

a) solve the Moment distribution problem shown below. Solve 2 cycles. (10)
b) Using the solution from above - find the vertical reaction at the fixed support. (5)





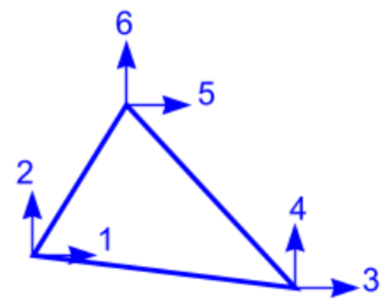
Target moment	-1.5		0			-
Moment Dist. Factor	1		1/2	1/2		0
Fixed end moments	-1		1	-1		1
err	-0.5		0			
corr	-0.5		0	0		
co	-0		-0.25	0		0
end moments	-1.5		0.75	-1		1
err	0		0.25			
corr	0		0.125	0.125		
co	0.06		0	0		0.06
	-1.44		0.88	-0.88		1.06



Rc x2 +0.88 - 3x2x1 - 1.06 =0
Rc=3.09 kN

6. Matrix Structural Analysis (15 Marks)

a) Sketch a triangular finite element (constant stress triangle) with two degrees of freedom at each corner. Write down a possible stiffness matrix for this element (assume k_11 = 1 kN/m). No calculations are needed.



$$K = \begin{bmatrix} 1 & 0.1 & -0.4 & 0.1 & -0.6 & -0.2 \\ 0.1 & 1 & -0.1 & 1 & 0 & -2 \\ -0.4 & -0.1 & 1 & 0.1 & -0.6 & 0 \\ 0.1 & 1 & 0.1 & 0.8 & -0.2 & -1.8 \\ -0.6 & 0 & -0.6 & -0.2 & 1.2 & 0.2 \\ -0.2 & -2 & 0 & -1.8 & 0.2 & 3.8 \end{bmatrix}$$

b) Explain why the units of the terms in a stiffness matrix can have a range of different units.

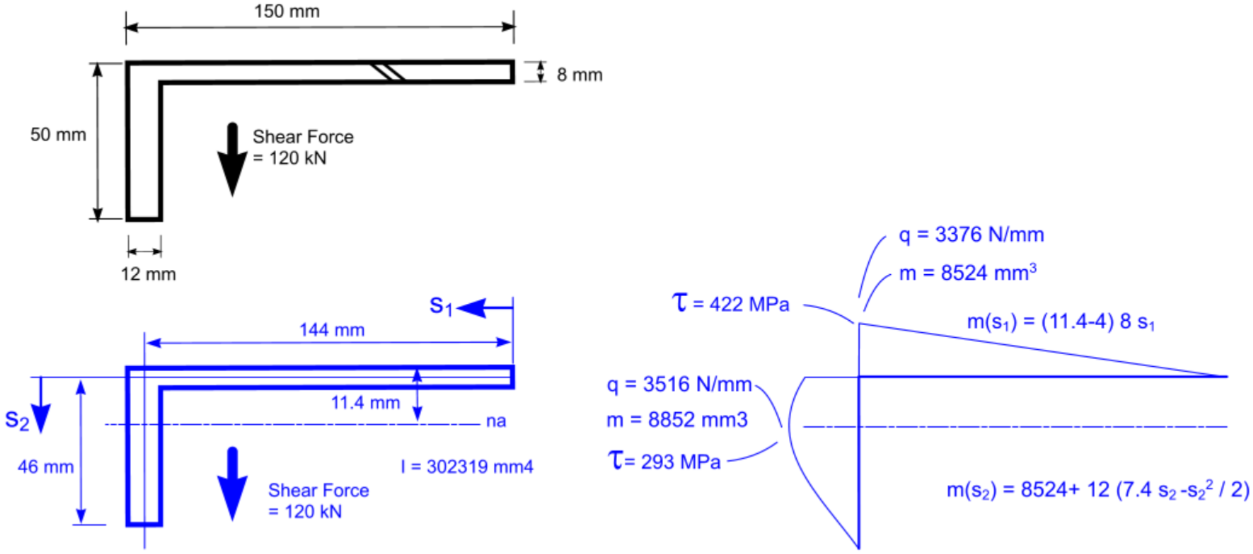
When translation and rotations are both involved, units can be different: Moment per translation is different that force per translation.

c) For the constant stress triangle, do the stiffness terms have all the same units? Why or why not?

For the case of a CST, there are only translations, so all stiffness terms have the units of Force per translation (eg N/m)

7. Shear and Torsion (15 Marks)

a) Solve the shear flow and shear stress problem shown below. (10)
b) What are the units of shear flow and what do they mean physically? (5)



Formulae Sheet

Weight of a Vessel:

$$W = \Delta = C_B \cdot L \cdot B \cdot T \cdot \gamma$$

Prohaska for parallel middle body : $\overline{W} = \frac{W_{hull}}{L}$ the values of a and b are ;

	$\frac{a}{\overline{\overline{W}}}$	$\frac{b}{\overline{\overline{W}}}$
Tankers (C_B = .85)	.75	1.125
Full Cargo Ships (C_B = .8)	.55	1.225
Fine Cargo Ships (C_B=.65)	.45	1.275
Large Passenger Ships (C_B=.55)	.30	1.35

$$\Delta lcg = \frac{x}{\overline{\overline{W}}} L \frac{7}{54}$$

Murray's Method

$$BM_B = \frac{1}{2}\left(\Delta_a g_a + \Delta_f g_f\right) = \frac{1}{2}\Delta \cdot \bar{x}$$

$$\bar{x} = L(a \cdot C_B + b)$$

Where

T/L	a	b
.03	.209	.03
.04	.199	.041
.05	.189	.052
.06	.179	.063

This table for a and b can be represented adequately by the equation;

$$a = .239 - T/L$$

$$b = 1.1\ T/L - .003$$

Trochoidal Wave Profile

$$x = R\theta - r \sin \theta$$

$$z = r(1 - \cos \theta)$$

θ = rolling angle

Section Modulus Calculations

Ina = 1/12 a d^2

= 1/12 t b^3 $\cos^2\theta$

Family of Differential Equations Beam Bending

$v =$ deflection [m]

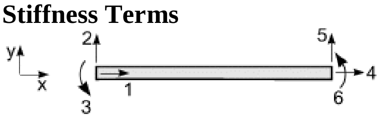
$v' = \theta =$ slope [rad]

$v''EI = M =$ bending moment [N-m]

$v'''EI = Q =$ shear force [N]

$v''''EI = P =$ line load [N/m]

Stiffness Terms



2D beam = 6 degrees of freedom

$$K = \begin{bmatrix} \frac{AE}{L} & 0 & 0 & \frac{-AE}{L} & 0 & 0 \\ 0 & \frac{12EI}{L^3} & \frac{6EI}{L^2} & 0 & \frac{-12EI}{L^3} & \frac{6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{4EI}{L} & 0 & \frac{-6EI}{L^2} & \frac{2EI}{L} \\ \frac{-AE}{L} & 0 & 0 & \frac{AE}{L} & 0 & 0 \\ 0 & \frac{-12EI}{L^3} & \frac{-6EI}{L^2} & 0 & \frac{12EI}{L^3} & \frac{-6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{2EI}{L} & 0 & \frac{-6EI}{L^2} & \frac{4EI}{L} \end{bmatrix}$$

the rotation matrix is:

$$\lambda = \begin{bmatrix} \cos\alpha & \sin\alpha & 0 & 0 & 0 & 0 \\ -\sin\alpha & \cos\alpha & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & \cos\alpha & \sin\alpha & 0 \\ 0 & 0 & 0 & -\sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$[K]_{global} = \lambda^T [K]_{local} \lambda$$

$$\alpha_i = \frac{(EI/L)_i}{\sum_{all}(EI/L)}$$

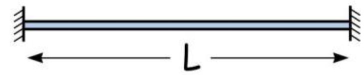
Shear flow: $q = \tau t, \quad q = Q\, m / I$

$m = \int yt\, ds$

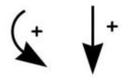
Torque: $Mx = 2qA$

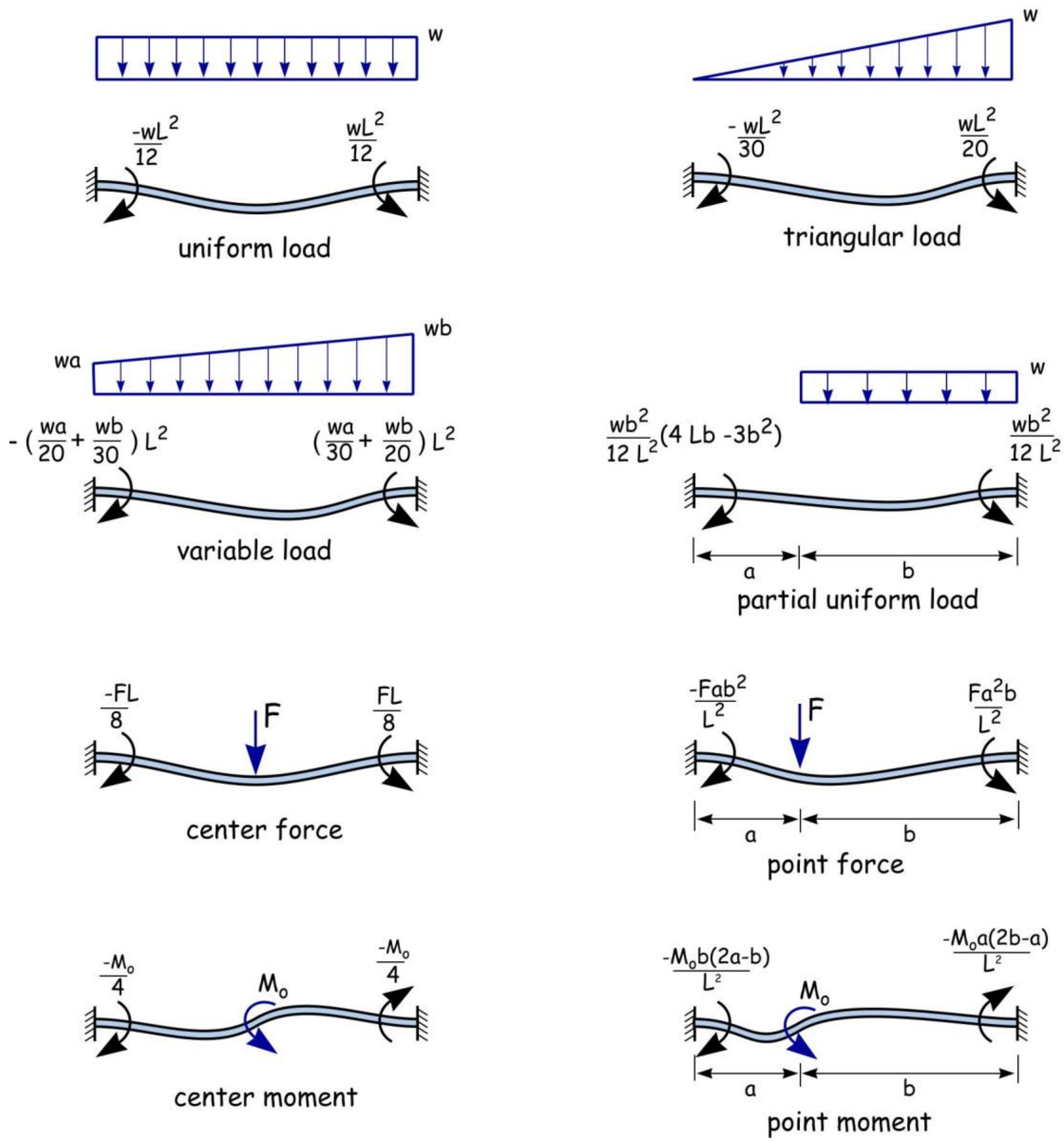
Fixed End Loads

fixed fixed beam, length L, constant EI:

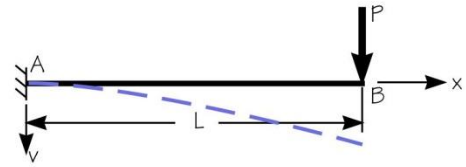
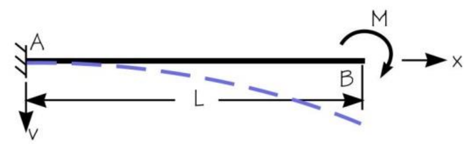
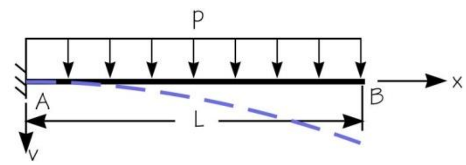
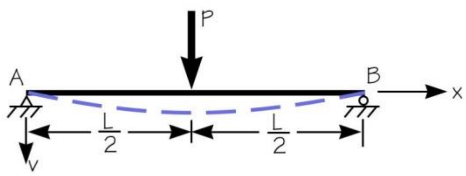
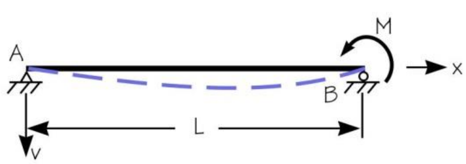
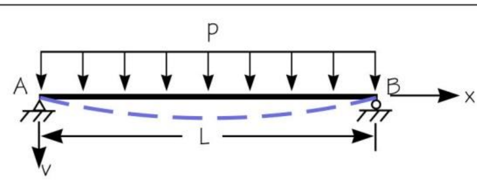
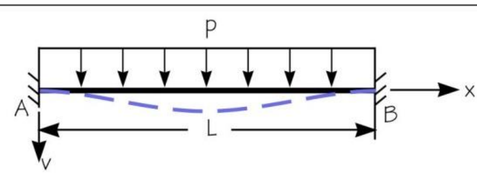
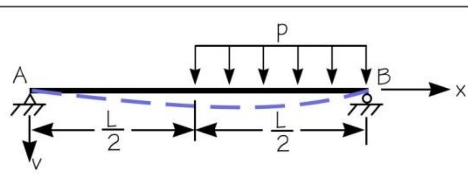


sign for moments and forces:





Deflection and Slopes of Beams

Loading	Deflection	Slope
	$v = \frac{Px^2}{6EI}(3L - x)$ $v_{max} = v_B = \frac{PL^3}{3EI}$	$\theta_B = \frac{PL^2}{2EI}$
	$v = \frac{Mx^2}{2EI}$ $v_{max} = v_B = \frac{ML^2}{2EI}$	$\theta_B = \frac{ML}{EI}$
	$v = \frac{px^2}{24EI}(6L^2 - 4Lx + x^2)$ $v_{max} = v_B = \frac{pL^4}{8EI}$	$\theta_B = \frac{pL^3}{6EI}$
	$v = \frac{Px^2}{48EI}(3L^2 - 4x^2)$ $v_{max} = \frac{PL^3}{48EI}$ @ $x=L/2$	$\theta_A = -\theta_B = \frac{PL^2}{16EI}$
	$v = \frac{Mx}{6EI\,L}(L^2 - x^2)$ $v_{max} = \frac{ML^2}{9\sqrt{3}\,EI}$ @ $x=L/\sqrt{3}$	$\theta_A = \frac{ML}{6EI}$ $\theta_B = -\frac{ML}{3EI}$
	$v = \frac{px}{24EI}(L^3 - 2Lx^2 + x^3)$ $v_{max} = \frac{5\,pL^4}{384\,EI}$ @ $x=L/2$	$\theta_A = -\theta_B = \frac{pL^3}{24EI}$
	$v = \frac{px^2}{24EI}(L - x)^2$ $v_{max} = \frac{pL^4}{384\,EI}$ @ $x=L/2$	$\theta_A = \theta_B = 0$
	$v_{cent} = \frac{3\,pL^4}{256\,EI}$ @ $x=L/2$	$\theta_A = \frac{-7\,pL^3}{384\,EI}$ $\theta_B = \frac{3\,pL^3}{128\,EI}$