MEMORIAL UNIVERSITY OF NEWFOUNDLAND

Faculty of Engineering and Applied Science

Engineering 5003 - Ship Structures

FINAL EXAMINATION

Date: Friday. April 13, 2012 **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 8 questions.

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

1. Sketch of ship structure (10 marks)

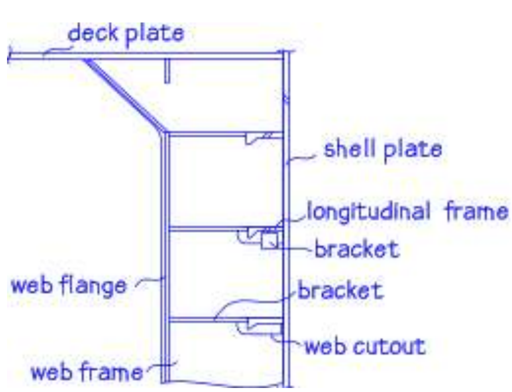
The photograph below shows some components of ship structure. In the right half of the photo there are longitudinal (horizontal) frames attached to the outer shell. The frames are supported by a deep web frame.

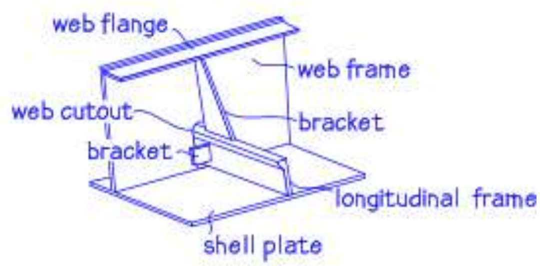
Make two sketches by hand as follows;

1) Sketch the web frame looking directly at (ie normal to) the web. Include in the sketch the cross sections of the longitudinal frames. The sketch would be as viewed from a point at the right edge of the photo. Just include the web frame and not the various bits in the left side of the photo (i.e. not the piping, or partial bulkhead).

2) Make a 3D sketch of the detail joint between the web frame and the longitudinal frame.

Be sure to label the main items in both sketches.

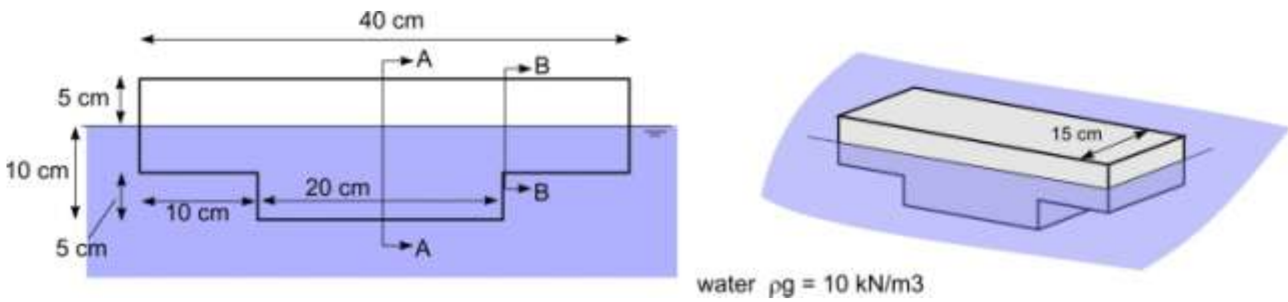




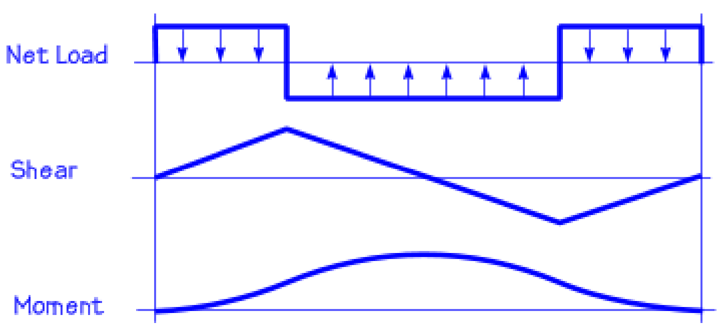
2. Still water bending (20 Marks)

There is a floating block of wood, as shown in the image below. The block has uniform density. It is 40 cm long and 15 cm wide. It is 10 cm thick at the ends and 15cm thick in the middle. It is floating in salt water with a weight density of 10kN/m3.

a) what is the weight of the block? (4)
b) What are the shear and bending moment values at cross section B-B? (4)
c) What are the shear and bending moment values at cross section A-A? (4)
d) Sketch the: net load, shear and bending moment diagrams (no numbers needed). (8)

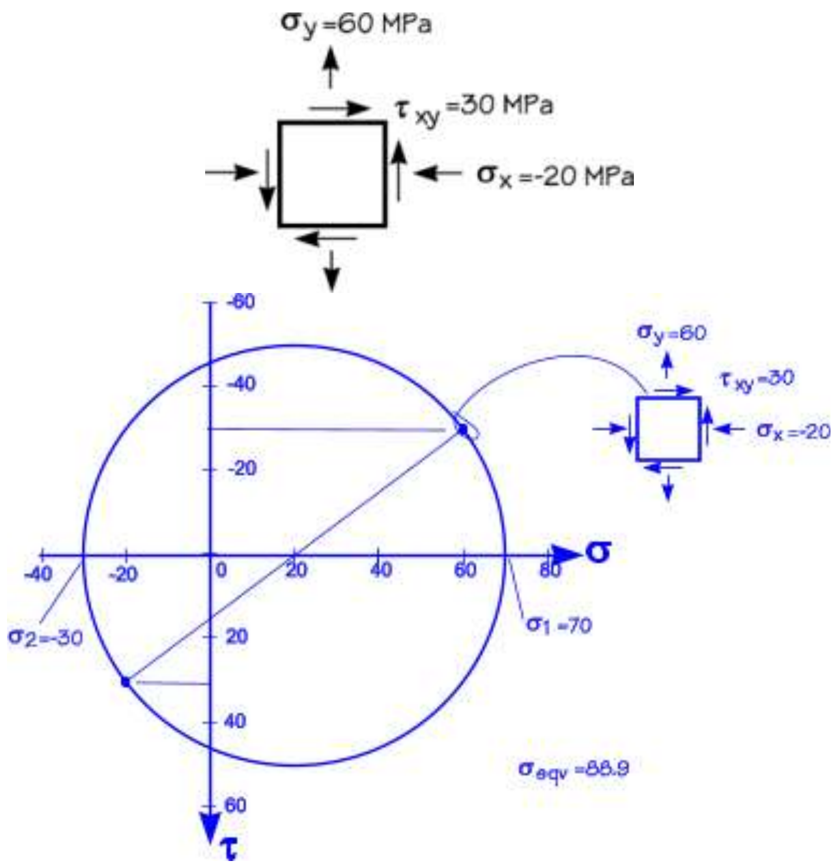


a) 45N
b) At B-B: Q=1.5N, M=7.5 N-cm
c) At A-A: Q=0, M=15 N-cm
d)



3. Stress and Strain (12 Marks)

a) For the state of stress shown below find the von-Mises equivalent stress. (7)

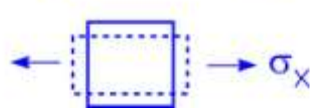


b) describe the Poisson effect and define Poisson's ratio. (5)

The Poisson effect occurs when stresses are applied to solids. As the solid is stretched in one direction it tends to shrink in the other direction(s). Poisson's ratio is the (negative of the) ratio of the strain in the unloaded direction to the strain in the loaded direction.

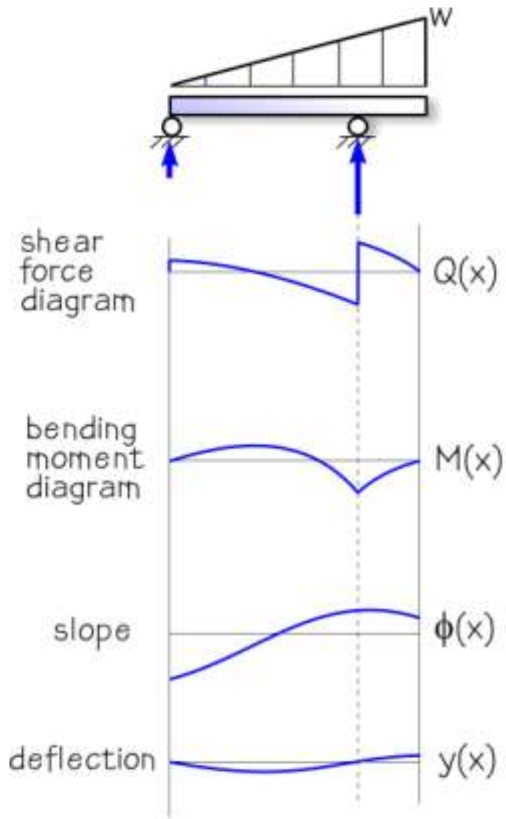
$$\nu = -\frac{\varepsilon_y}{\varepsilon_x}$$

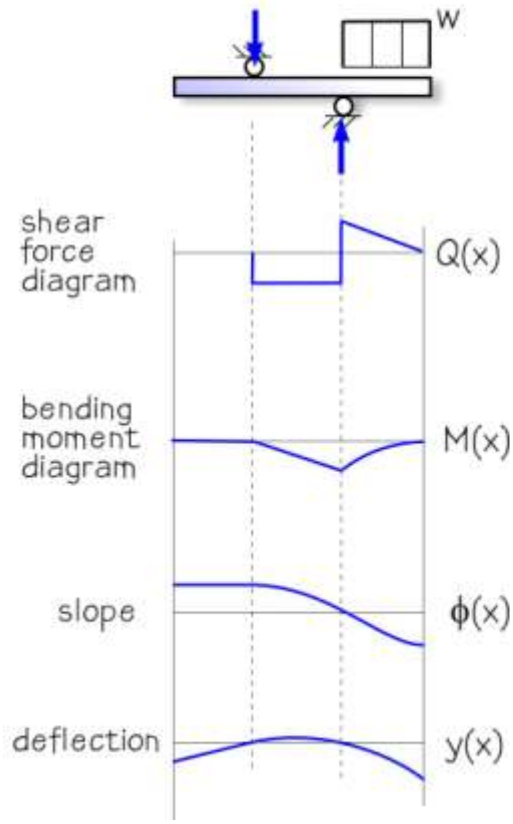
$$\varepsilon_y = \frac{\Delta L_y}{L_y} \qquad \varepsilon_x = \frac{\Delta L_x}{L_x}$$



4. Beam Responses (10 Marks)

Sketch the shear, bending, slope and deflection patterns for the four cases shown below. No numerical values are required. (5 marks each problem)



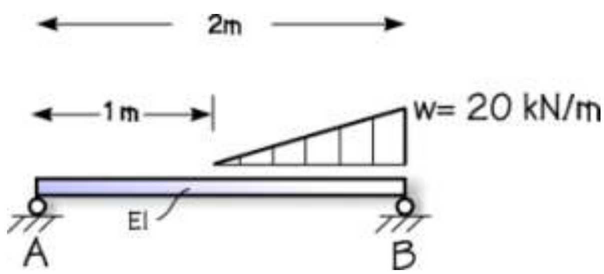


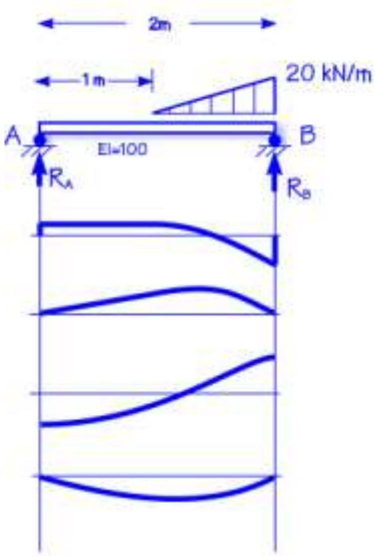
5. Macaulay Method (15 Marks)

A simply supported beam with a partial load is shown below. EI is 100 kN-m^2

a) Write the equation for the load on Macaulay notation. (6)

b) Find the deflection at the center and the slope at B (the right end). (9)



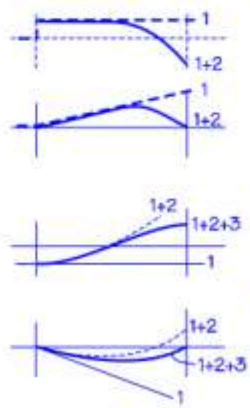


$Load(x)[kN/m] = R_A\langle x-0\rangle^{-1} - 20\langle x-L/2\rangle^{1} + R_B\langle x-L\rangle^{-1}$

From statics: R_A=1.67 kN R_B=8.33 kN

$Load(x) = 1.67\langle x-0\rangle^{-1} - 20\langle x-1\rangle^{1} + 8.33\langle x-L\rangle^{-1}$

We will leave out terms with <x-L> as they show no useful info



Shear [kN]

$Q(x) = \overbrace{1.67\langle x-0\rangle^{0}}^{1} \overbrace{- 10\langle x-1\rangle^{2}}^{2}$

Moment [kNm]

$M(x) = \cancel{M(0)} + \overbrace{1.67\langle x-0\rangle^{1}}^{1} \overbrace{- 3.33\langle x-1\rangle^{3}}^{2}$

Slope [Nm^2/Nm^2= rad]

$\theta(x) = \overbrace{\theta(0)}^{1} + 1/EI(\overbrace{.833\langle x-0\rangle^{2}}^{2} \overbrace{- .833\langle x-1\rangle^{4}}^{3})$

Deflection [Nm^3/Nm^2=m]

$v(x) = \cancel{v(0)} + \overbrace{\theta(0)\,x}^{1} + 1/EI(\overbrace{.278\langle x-0\rangle^{3}}^{2} \overbrace{- .167\langle x-1\rangle^{5}}^{3})$

$v(2) = 0 = \theta(0)\,2 + 1/EI(.278\ 2^3 - .167\ 1^5)$

$\theta(0) = -1/200(.278\ 2^3 - .167\ 1^5) = -.0103$ rad

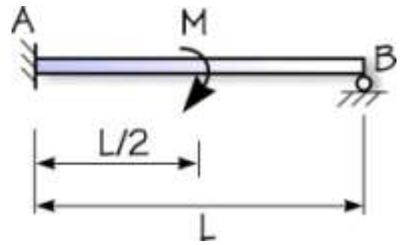
$v(1) = -.0103 \times 1 + 1/100 \times .278 = -.0075$ (ok)

$\theta(2) = -.0103 + 1/100(.833\langle 2-0\rangle^{2} - .833\langle 2-1\rangle^{4})$

$= +.0147$ (ok)

6. Force Method (10 Marks)

Use the Force Method and the solutions in the Table at the end to solve of the reaction at B in the problem below.

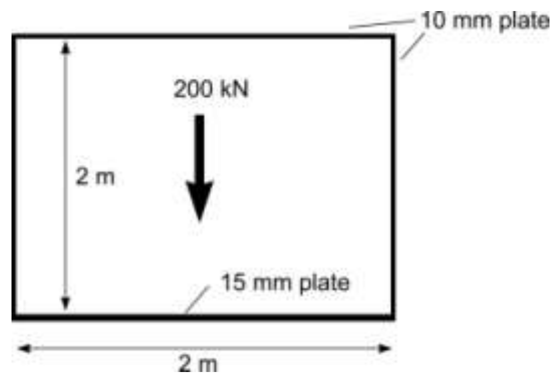


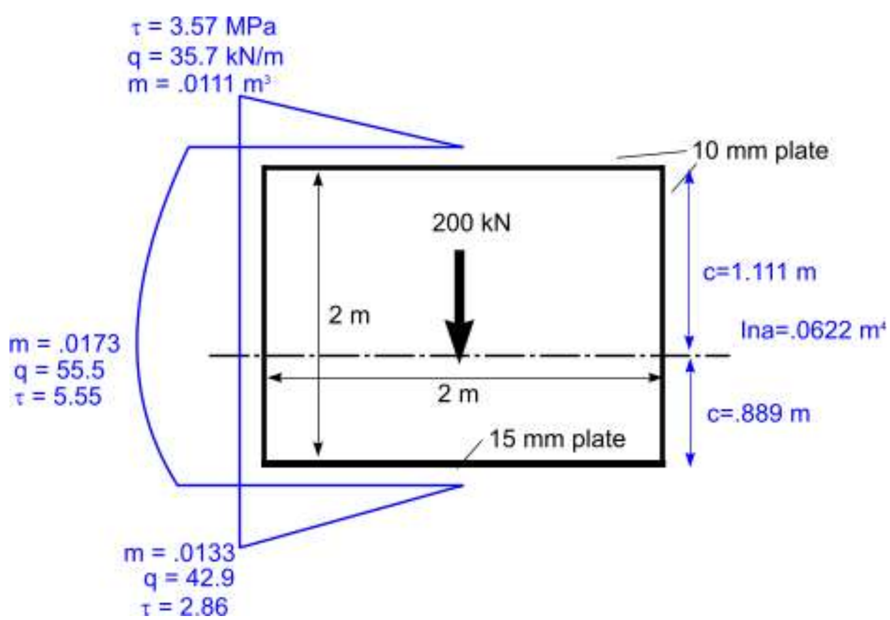
$R_B = 9/8\ M/L$

7. Shear Flow (15 Marks)

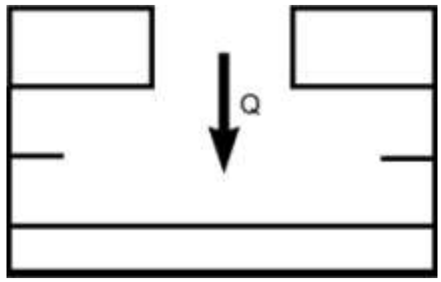
A cross section of a box girder is shown below. A vertical shear force of 200kN is applied.

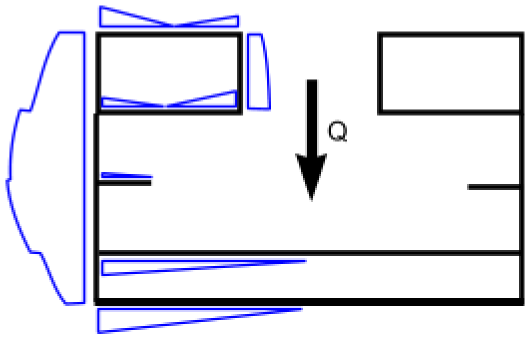
a) Solve the shear flow, plot it and then also show the shear stress values (9).





b) Sketch the shear flow pattern for the section shown below (no numbers needed) (6).





8. Matrix Structural Analysis (8 Marks)

Explain the difference between the terms “local stiffness matrix” and "global stiffness matrix".

Formulae

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 ;

	$\frac{a}{\overline{W}}$	$\frac{b}{\overline{W}}$
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

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

Murray's Method

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

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

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

2D Hooke's Law

$$\begin{bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{bmatrix} = \frac{E}{1-\nu^2} \begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix} \begin{bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{bmatrix}$$

von Mises

yield envelope: $\sigma_1^2 - \sigma_1\sigma_2 + \sigma_2^2 = \sigma_{yield}^2$

equivalent stress: $\sigma_{eqv} = \sqrt{\sigma_1^2 - \sigma_1\sigma_2 + \sigma_2^2}$

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

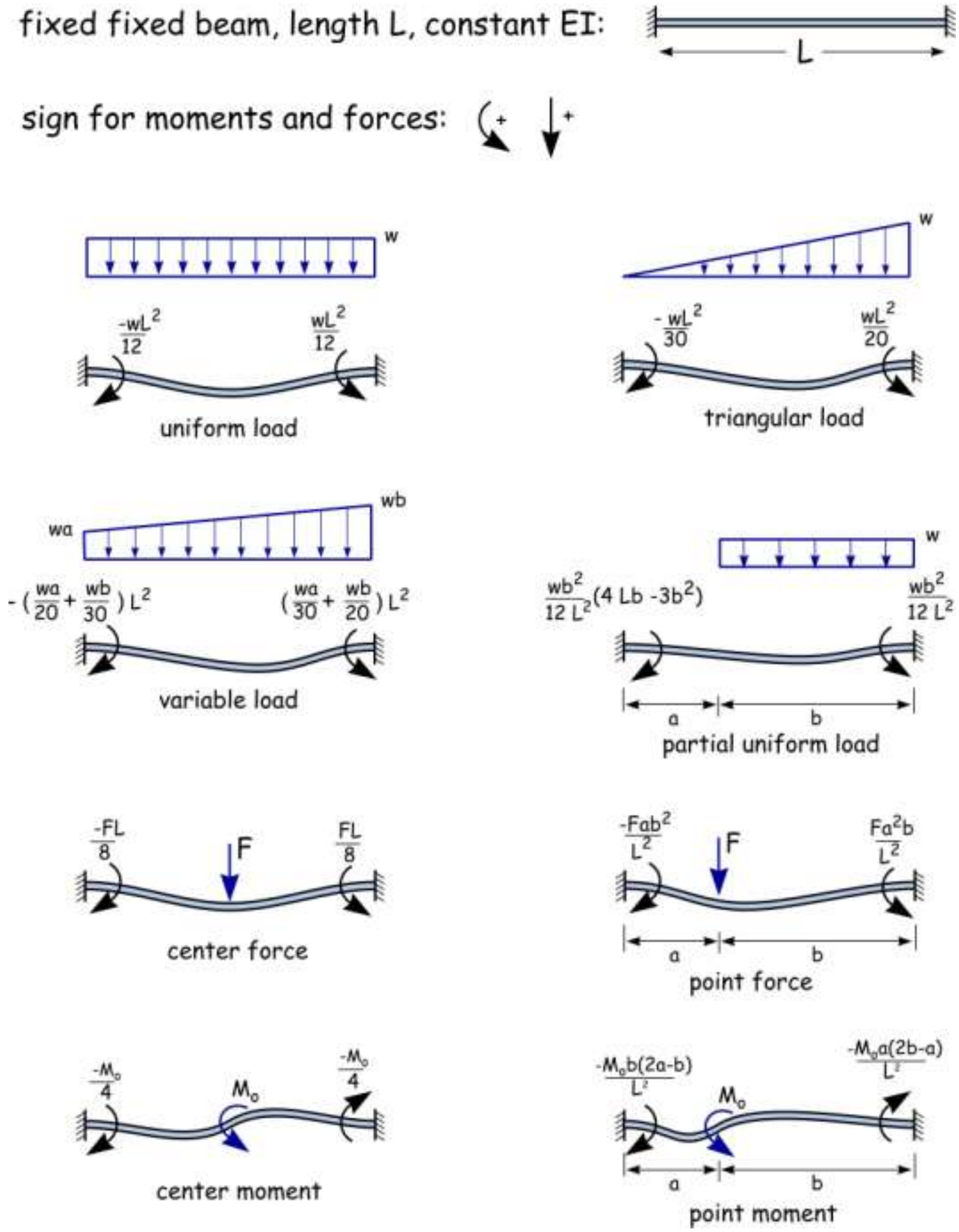
$$K = \begin{bmatrix} \frac{AE}{L} & 0 & 0 & \frac{-AE}{L} & 0 & 0 \\ 0 & \frac{12EI}{L^3} & \frac{6EI}{L^2} & 0 & \frac{-12EI}{L^3} & \frac{6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{4EI}{L} & 0 & \frac{-6EI}{L^2} & \frac{2EI}{L} \\ \frac{-AE}{L} & 0 & 0 & \frac{AE}{L} & 0 & 0 \\ 0 & \frac{-12EI}{L^3}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

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

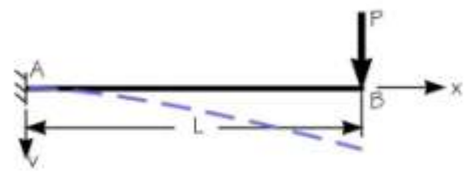
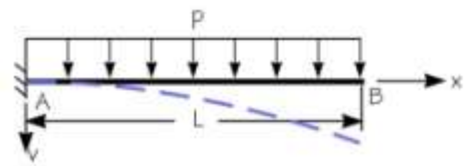
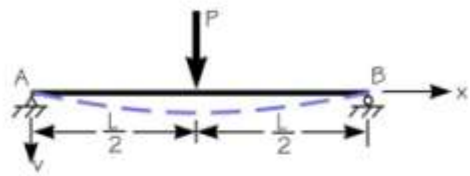
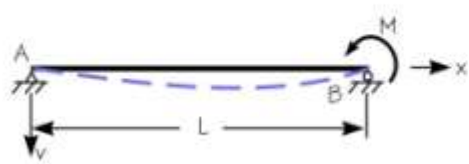
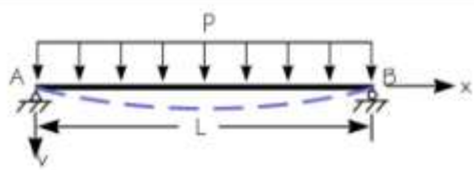
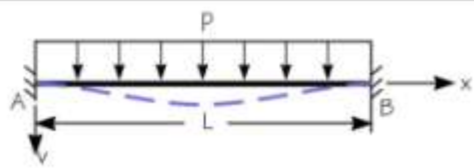
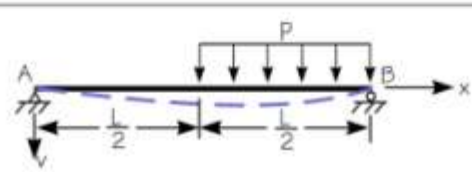
$m = \int yt\,ds$

Torque: $Mx = 2qA$

Fixed End Loads



Deflection and Slopes of Beams

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