MEMORIAL UNIVERSITY OF NEWFOUNDLAND

Faculty of Engineering and Applied Science

Engineering 5003 - Ship Structures

MID-TERM EXAMINATION

WITH SOLUTIONS

Date: Fri., Feb. 22, 2013 **Professor: Dr. C. Daley**
Time: 9:00 - 10:00 pm

Answer all questions. Total 20 marks. Each question is worth marks indicated **[x].**

Name: ______________________________

Student No: ______________________________

Watch your time. 60min
Think through your answers, then write and sketch clearly.

Good luck.

1. Answer the following questions in the space provided. **[4]**

a) Give examples each of the three levels of ship structure: i. Primary, ii., Secondary and iii. Tertiary, and for each case give an example of loads (causes of loads) and responses that might occur.

i) Primary: The hull girder, bends due to wave loads, might fracture in two.

ii) Secondary: a bulkhead, loaded by cargo on one side, might fail by corrugation buckling

iii) tertiary: deck plating, loaded by pressures from green water on deck, may fail by plastic yielding on edges.

(wide variety of possible answers)

b) Discuss the difference between material behavior and structural behavior (in ships).

Material behaviour is the behaviour of the steel at a very small local level, (say a small cube of material much smaller than the plate thickness). At this scale we view the behaviour as 'continuum' behaviour. We apply laws such as Hooke's Law (relationship of elastic stresses and strains) and Von-Mises failure criteria (model of maximum state of stress that can be withstood prior elastically)

On the other hand, structural behavior considers the behavior of structural components (members) and assemblages. Structural behavior must account for the discrete components and how they interact.

c) Define the 3 terms: i. Scantlings, ii. Quasi-static, iii. Design Criteria

Scantlings: structural dimensions (or casually - the structural components of a ship)

Quasi Static: low frequency time varying loads that do not cause significant dynamic (inertial) effects - can be treated as if static.

Design Criteria: The rules that establish which behaviors are acceptable vs those that are unacceptable.

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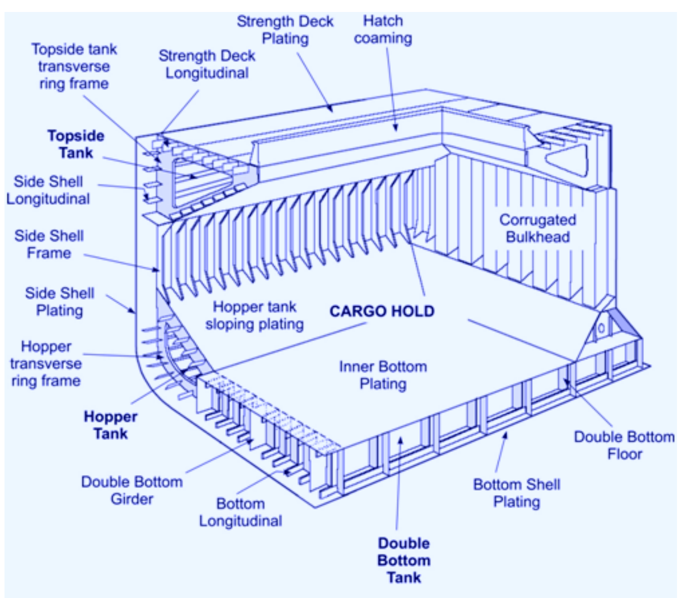
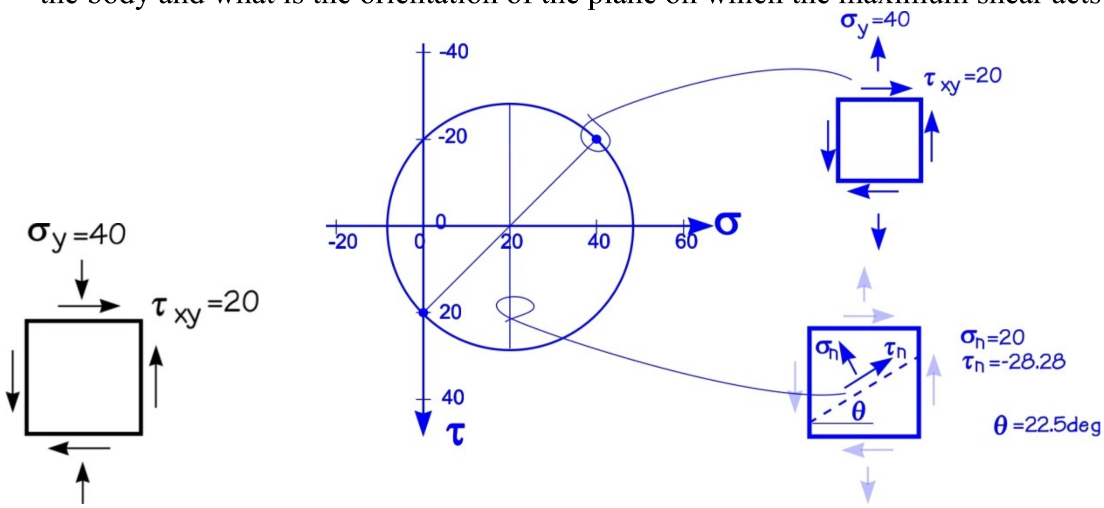
2. Sketch in the space below, a free hand oblique view drawing of the structure of a single sided, double bottom bulk carrier. Keep it neat and label the elements **[3]**



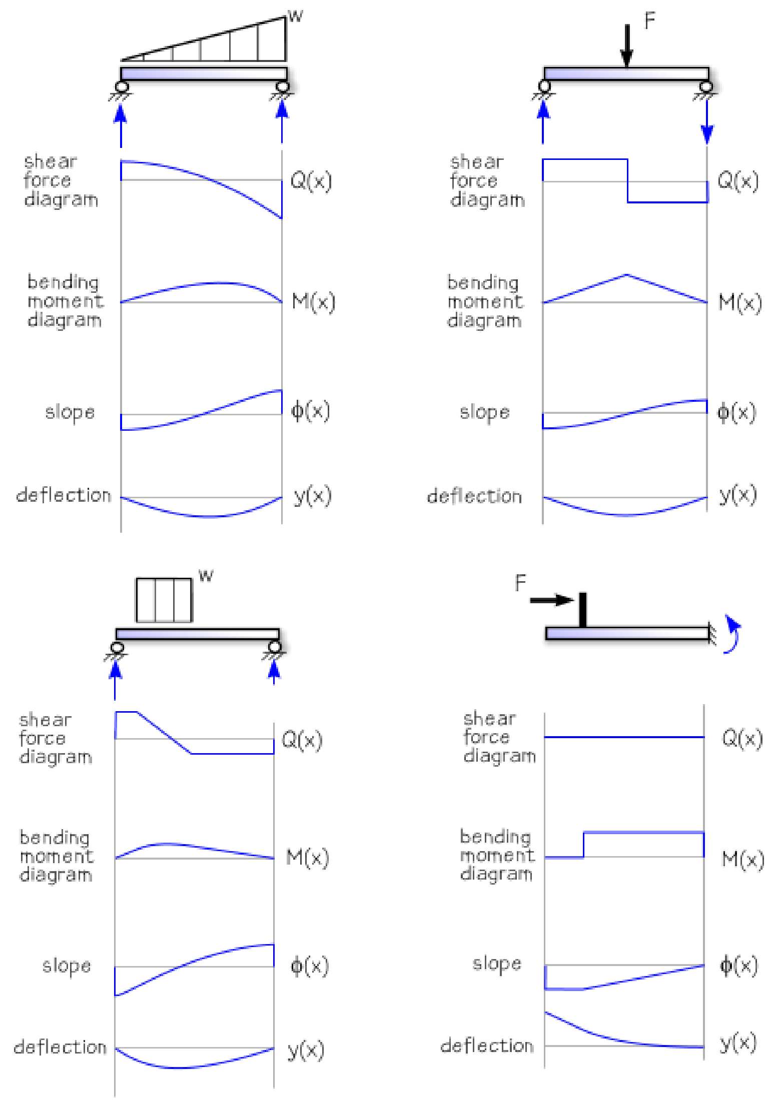
Single Side - Double Bottom Bulk Carrier

3. For the state of stress shown, draw the Mohr's Circle. What are the maximum shear stress in the body and what is the orientation of the plane on which the maximum shear acts? **[4]**

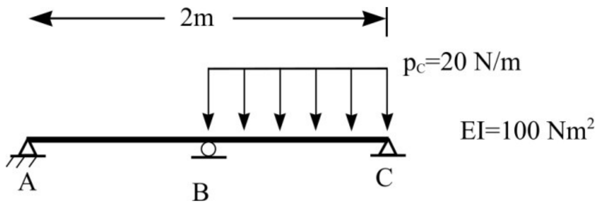


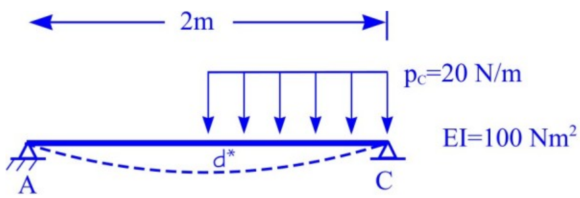
4. Beam Mechanics. For the beam sketch below:

a) sketch by hand the shear, moment, slope and deflection diagrams for each of the 4 problems shown below **[5]**



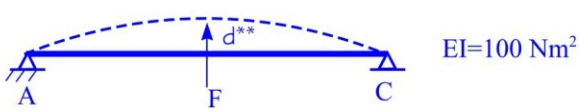
b) There is a beam supported at 3 points, with a load over the right side. Using the table of solutions on page 6, find the value in N of the reactions at B in the problem below. (Use the concept of the Force method to combine the solutions in the table). **[4]**





$$d^* = \frac{3\,pL^4}{256\,EI} \quad @\ x=L/2$$

$$= \frac{3\;20\;2^4}{256\,EI} = \frac{3.75}{EI}$$



$$d^{**} = \frac{-FL^3}{48EI} \quad @\ x=L/2$$

$$= \frac{-F}{6\,EI}$$

$d^*+d^{**}=0 \qquad \frac{3.75}{EI} + \frac{-F}{6\,EI} = 0 \qquad F = 22.5\text{ N}$

Reaction at B = F = 22.5 N <= ANSWER

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

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

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

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;

$$a = .239 - T/L$$
$$b = .1.1T/L - .003$$

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]

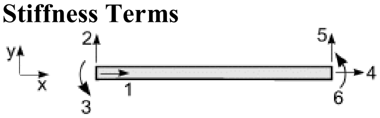
$v' = \theta =$ slope [rad]

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

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

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

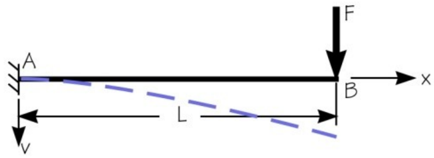
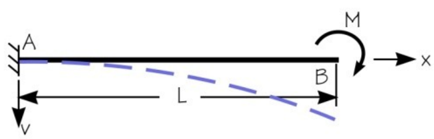
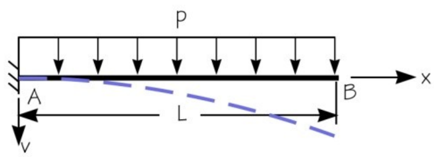
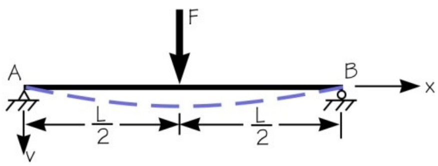
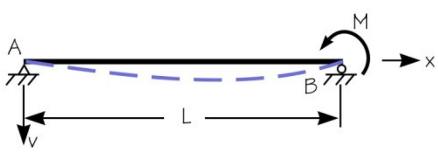
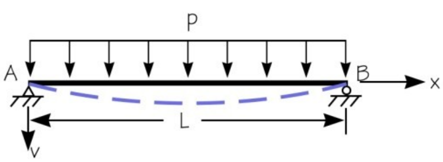
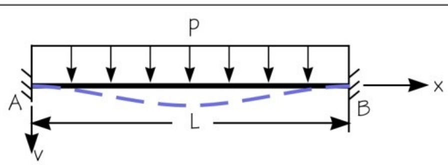
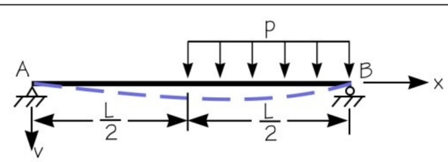
Stiffness Terms



2D beam = 6 degrees of freedom

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

Deflection and Slopes of Beams

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