MEMORIAL UNIVERSITY OF NEWFOUNDLAND

Faculty of Engineering and Applied Science

Engineering 5003 - Ship Structures

MID-TERM EXAMINATION

Date: Fri., Feb. 17, 2012 **Professor: Dr. C. Daley**
Time: 9:00 - 9:50 pm

Answer all questions on the question paper. If you must, use the back of the page, Total 20 marks. Each question is worth marks indicated **[x].**

SOLUTIONS

Name: ______________________________

Student No: ______________________________

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

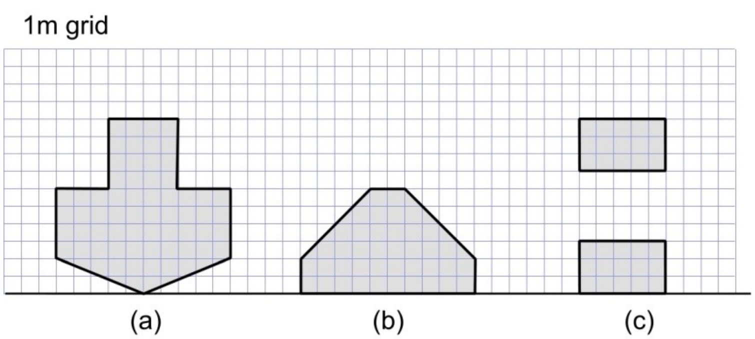
Good luck.

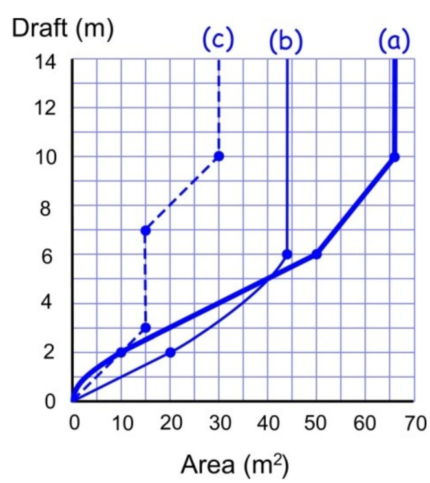
1. Discuss the issue of 'scale' (ie structures may be local, global, small, large, simple, complex etc.) in ship structures. **[4]**

Example Answer:

Ships structures are affected by physical behavior on a variety of scales. At the smallest scales there is material behaviour. The relationship between stress and strain (Hooke's Law) applies to very small parts of material which are treated with continuum mechanics. Yielding and fracture are likewise very small and localized processes. The next larger scale involves single structural components (single plates, single frames and beams). These behaviors employ material models, but add simple bending and axial behaviors. At the next larger scale are structural assemblages (such as a double bottom or a whole bulkhead). At the next larger scale is the entire hull. Depending on the goals of an analysis, the entire hull may be modeled as a simple beam, or may be considered as a complex multi part structure. At scales larger than a ship, there are no structural issues per se, but the loads on a ship arise partly from the behavior of the ocean, vessel routing and global economics, which all have processes at very large scales.

2. For the three station profiles shown below, sketch the corresponding bonjean curves **[4]**

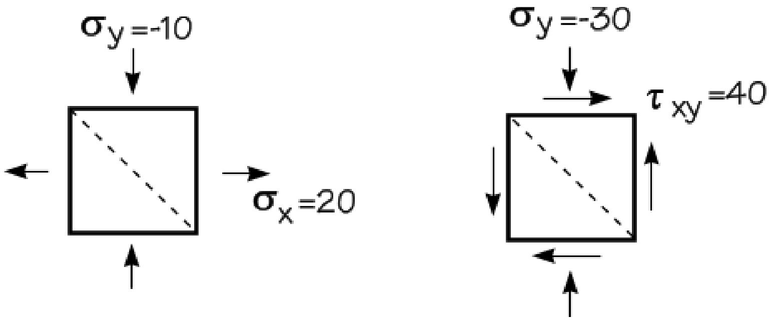


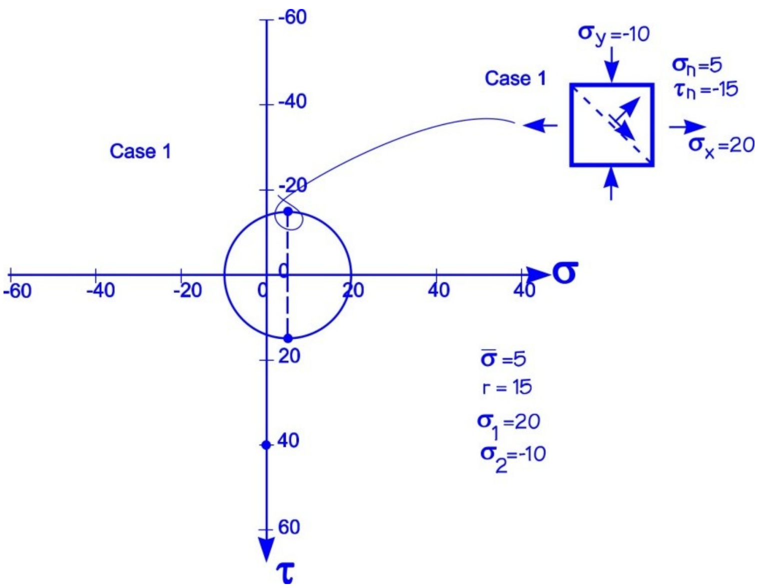


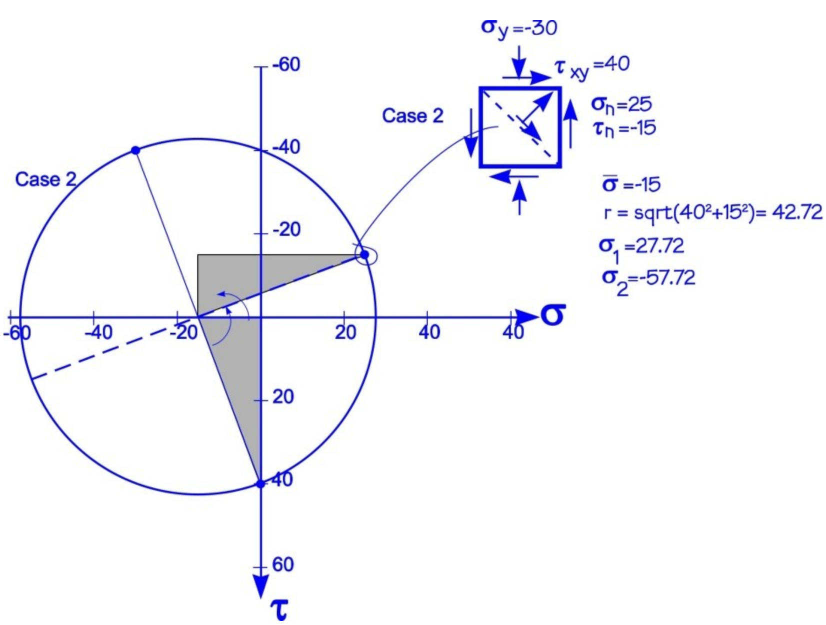
3. For the two cases of stress shown below,

a) draw a Mohr's circle.

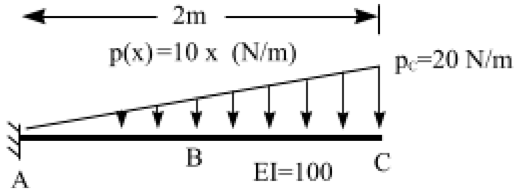
b) What are the stresses on a 45deg diagonal plane (the dashed lines in the sketch). **[5]**







4. Beam Mechanics. For the beam sketch below:



a) Solve the problem above using direct manual integration (use Macaulay notation if you wish, but that is not required). Give the equation for shear, moment, slope and deflection as a function of x. **[5]**

Manual

$R_A = 20\ 2/2 = 20$ N

$Q(x) = R_A - 10/2\, x^2 = 20 - 5x^2$

$Q(0)=20$
$Q(2)=0$ OK

$M_A = 2/3\, L\, R_A = -80/3 = -26.67$

$M(x) = M_A + 20x - 5/3\, x^3$
$= -80/3 + 20x - 5/3\, x^3$

$M(0)=-26.67$
$M(2)=0$ OK

$\theta(x) = \theta_0 + \frac{1}{100}(-80/3x + 10x^2 - 5/12\, x^4)$
$= -4/15\, x + 1/10\, x^2 - 1/240\, x^4$

$\theta(0)=0$
$\theta(2)=-1/5$ OK

$v(x) = v_0 - 2/15\, x^2 + 1/30\, x^3 - 1/1200\, x^5$

$v(0)=0$
$v(2)=-.2933$ OK

Macaulay:

$p(x) = M_A\langle x-0\rangle^{-2} + R_A\langle x-0\rangle^{-1} - 10\langle x-0\rangle^{1}$

$p(x) = -26.67\langle x-0\rangle^{-2} + 20\langle x-0\rangle^{-1} - 10\langle x-0\rangle^{1}$

$Q(x) = -26.67\langle x-0\rangle^{-1} + 20\langle x-0\rangle^{0} - 5\langle x-0\rangle^{2}$

$Q(0)=20$
$Q(2)=0$ OK

$M(x) = -26.67\langle x-0\rangle^{0} + 20\langle x-0\rangle^{1} - 5/3\langle x-0\rangle^{3}$

$M(0)=-26.67$
$M(2)=0$ OK

$\theta(x) = \theta_0 + 1/EI\,(-26.67\langle x-0\rangle^{1} + 10\langle x-0\rangle^{2} - 5/12\langle x-0\rangle^{4})$

$\theta(x) = 1/100\,(-26.67\langle x-0\rangle^{1} + 10\langle x-0\rangle^{2} - 5/12\langle x-0\rangle^{4})$

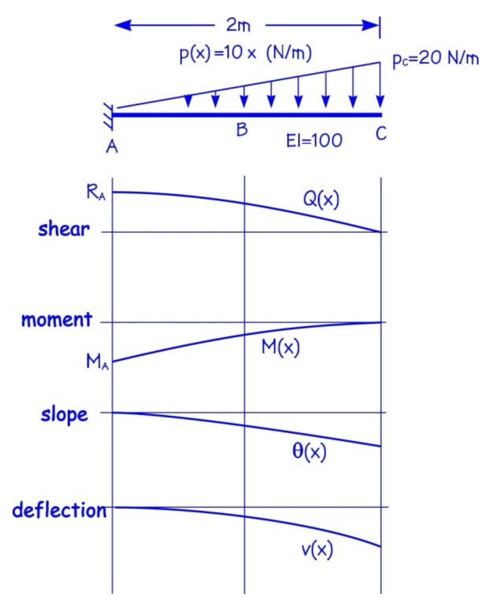
$\theta(0)=0$
$\theta(2)=-1/5$ OK

$v(x) = v_0 + 1/EI\,(-13.33\langle x-0\rangle^{2} + 10/3\langle x-0\rangle^{3} - 5/60\langle x-0\rangle^{5})$

$v(x) = (-.133\langle x-0\rangle^{2} + .033\langle x-0\rangle^{3} - 1/1200\langle x-0\rangle^{5})$

$v(0)=0$
$v(2)=-.2933$ OK

b) sketch by hand the shear, moment, slope and deflection diagrams **[2]**



Formulae

Family of Differential Equations Beam Bending

v = deflection [m]

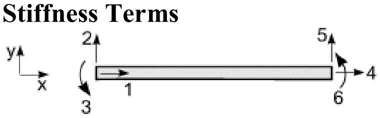
$v' = \theta =$ slope [rad]

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

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

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

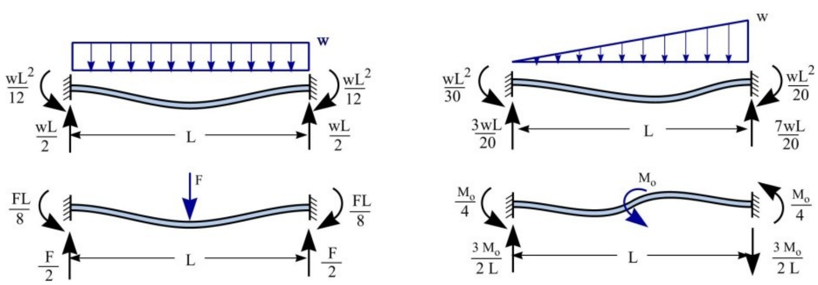
Stiffness Terms



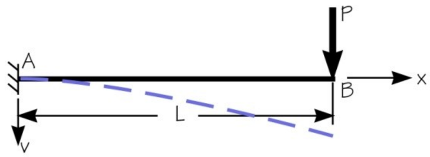
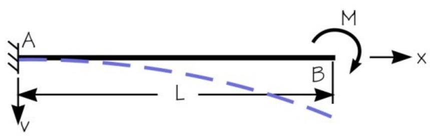
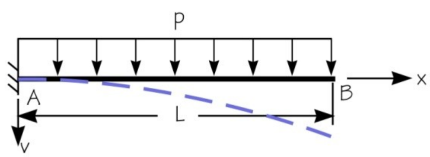
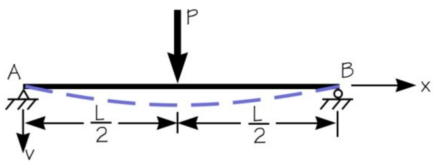
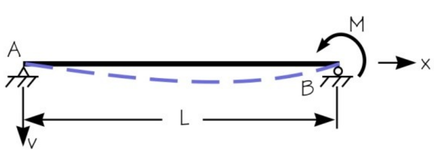
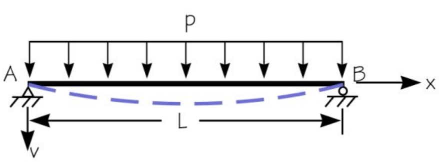
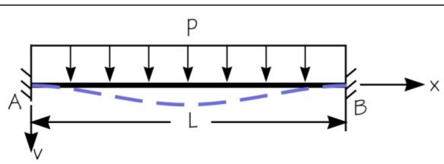
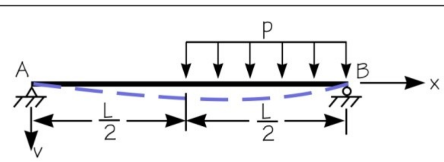
2D beam = 6 degrees of freedom

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

Fixed End Reactions



Deflection and Slopes of Beams

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