MEMORIAL UNIVERSITY Faculty of Engineering and Applied Science

Engineering 5003 - Ship Structures

MID-TERM EXAMINATION

SOLUTIONS
(detailed expl.)

Date: Fri., Feb. 12, 2016 **Professor: Dr. C. Daley**
Time: 10:00 - 11:00 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].**

Name: _____

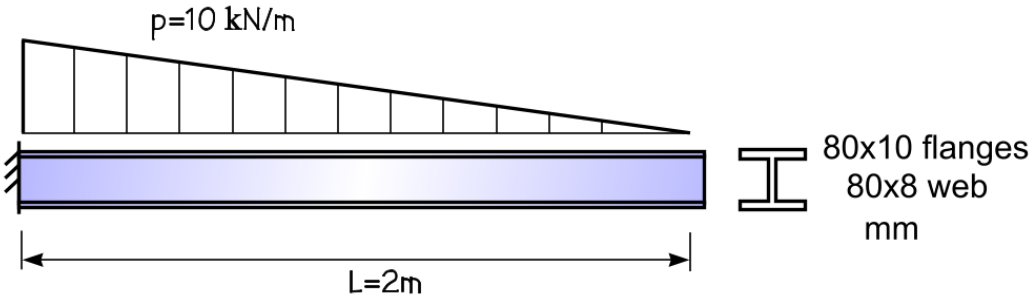
Student No: _____

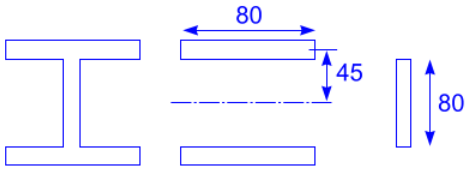
Watch your time. 60min
Think through your answers, then write and sketch clearly and concisely.

Good luck.

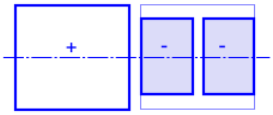
1. Consider the cantilever beam as sketched below.

a) What is the moment of inertia for the beam? **[2]**
b) What is the maximum bending moment in the beam? **[1]**
c) Sketch a 'state of stress' in the top flange, near the support (left end) **[1]**
d) Sketch a 'state of stress in the web, near the top flange, near the support **[1]**





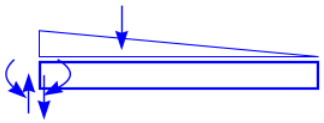
$I = 2 \times (1/12 \times 80 \times 10^3 + 80 \times 10 \times 45^2) + 1/12 \times 8 \times 80^3$
$= 3{,}594{,}667 \text{ mm}^4$
or
$I = 1/12 \times 80 \times 100^3 - 1/12 \times 72 \times 80^3$
$= 3{,}594{,}667 \text{ mm}^4$



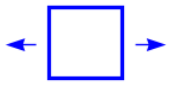
(a) $I = 3{,}594{,}667 \text{ mm}^4$ **<= ANS.**

$F = 10 \times 2 / 2 = 10 \text{ kN}$

(b) $M = 10 \times 2 \times 1 / 3 = 6.667 \text{ kN-m} = 6{,}667{,}000 \text{ N-mm}$ **<= ANS.**



(c) $\sigma = 6{,}667{,}000 \times 50 / 3{,}594{,}667 = 92.7 \text{ MPa}$



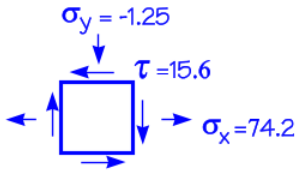
The top of the flange near the support feels only stress in x of 92.7

<= ANS.

(d) $\sigma_x = 6{,}667{,}000 \times 40 / 3{,}594{,}667 = 74.2 \text{ MPa}$ tension
$\sigma_y = -10 / 8 = -1.25 \text{ MPa}$ compression (N/mm /mm = MPa)

$\tau = 10{,}000 / (80 \times 8) = 15.6 \text{ MPa}$

The top of the web near the support feels stress in x of 74.2 as well as a shear stress estimated at 15.6 MPa. There is also a y direction stress from the load of 1.25 MPa (might ignore !)

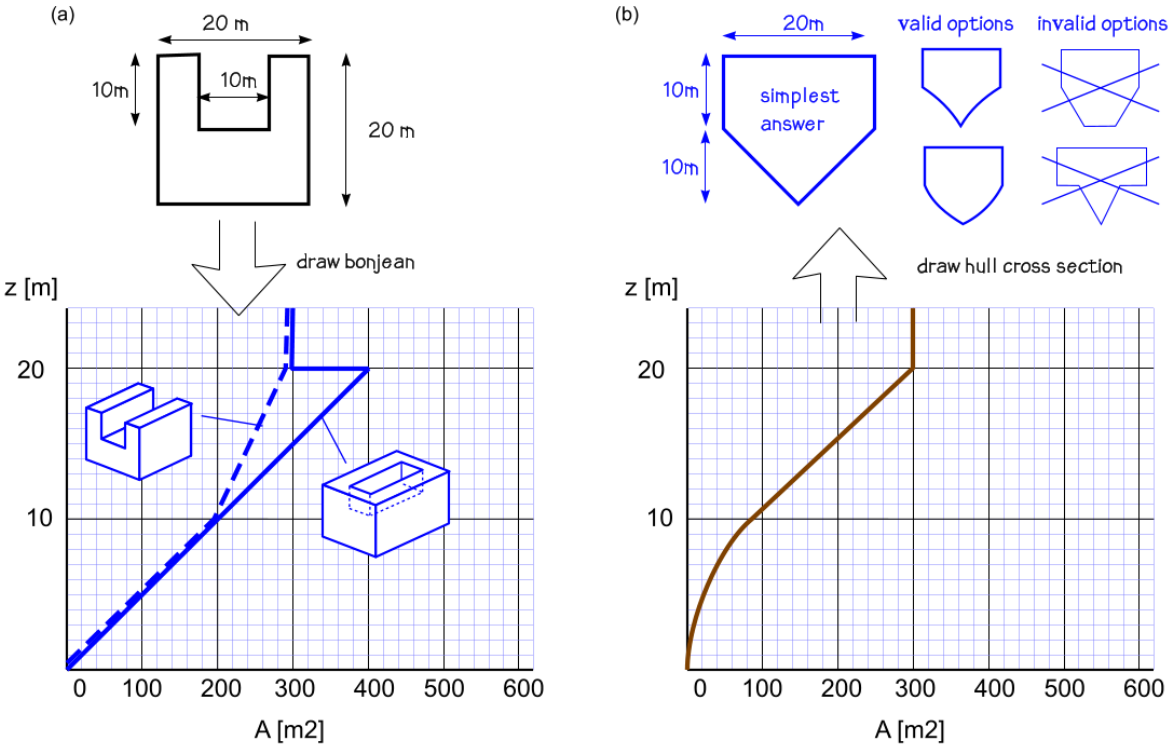


<= ANS.

2. For part (a) shown below, sketch the bonjean curve. For part (b) draw the hull cross section. **[5]**

There are two options for case (a). If the center 'hole' is free to flood from the ends then we get the dotted line case below. If the center only floods when water comes over the deck, then we get the solid line case. In either case the max submerged area is 300 m2.

For case (b), we have a rectangle sitting on top of a triangle. The bonjean starts from 0 going straight up, so the initial width is zero. At the 10m draft, the lower curve is tangent to the upper straight line, indicating no abrupt change in beam.
Options: the lower part of the hull could be curved a bit.



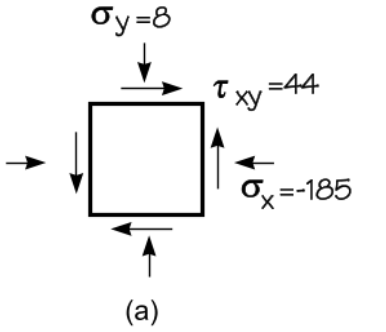
3. States of stress

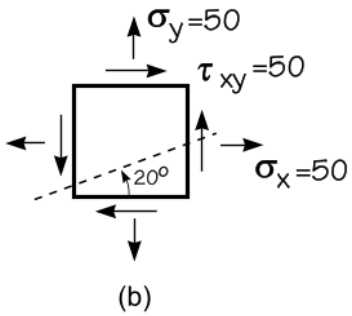
a) For case (a) draw a Mohr's circle. **[2]**

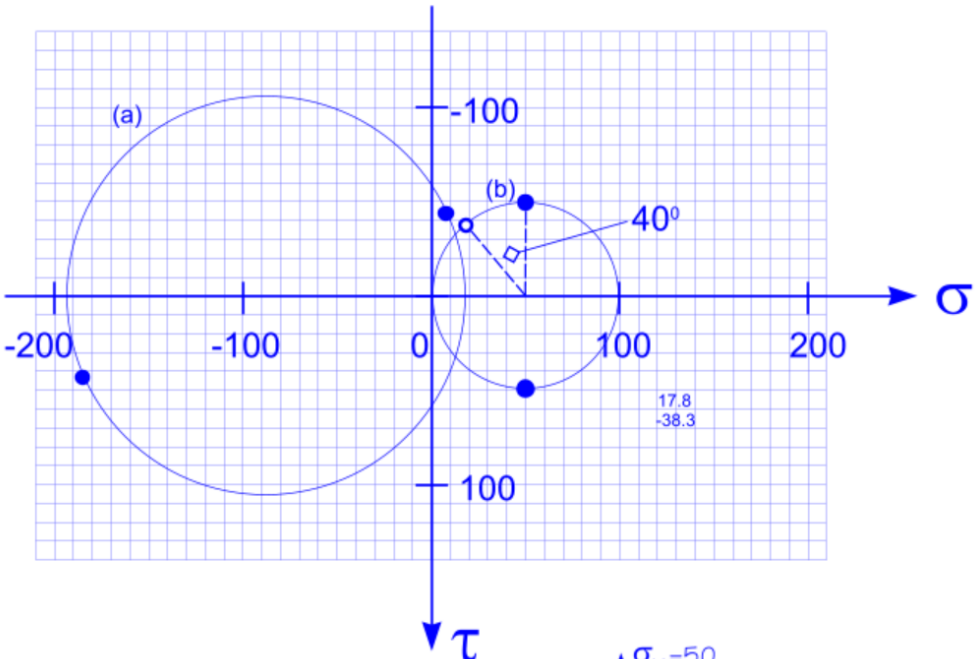
b) For case (b) draw the Mohr's circle and then indicate what are the stresses on a plane 20deg up from horizontal (the dashed lines in the sketch). **[3]**

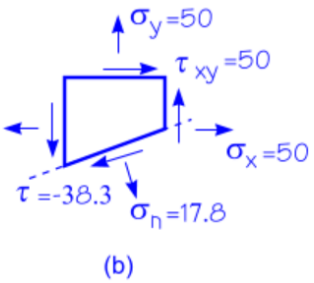
The (a) case starts with points at (-185, +44) and (+8, -44). Center of circle is at (-88.5,0) with radius 106.06.

Case (b) starts with points at (50, 50) and (50, -50). Center of circle is at (50,0) with radius 50. The cut line is rotated 20deg (real) in a counterclockwise sense from the (50,-50) point (which is near the (b) in the plot). The stresses on the cut plane are at the open circle, which is 40 deg counterclockwise, with values (17.8, 38.3). (= 50 – 50 sin 40^0, -50 cos 40^0)

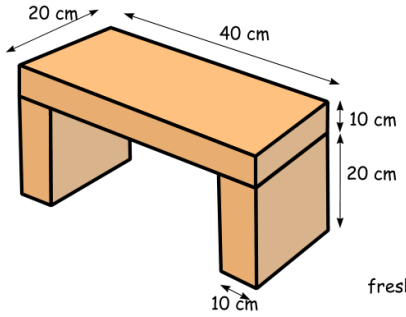








4. A floating object is sketched below. Its made of 3 blocks all glued together. It is placed in water in the orientation as shown. (Assume that it is stable)

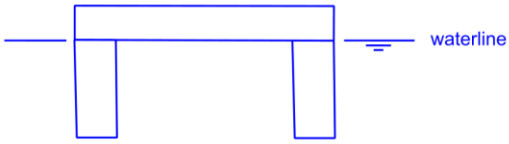


40 x 20 x 10 cm + 2@ 10 x 20 x 20 cm blocks
(uniform density of 0.5 t/m³)

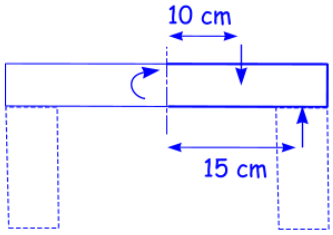
fresh water (1 t/m³)

a) Where would the waterline be on the body? **[1]**
b) What would the highest compressive bending stress be in the top block? **[3]**
c) Considering all weight and buoyancy effects, where in the body would there be material with zero stress? **[1]**

a) Water line is at the lower edge of the top block, because the top block is half the total volume and the block is half the density of water. This submerging the tow lower blocks are sufficient to support the whole thing.



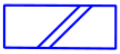
b) To find the moment at the middle, just make a f.b.d. of half the body. The upper block is supported by the lower, so the upper block has half its weight acting at the middle of the half (10cm from cl) and is supported by the same force pushing up from the middle of the submerged block. This creates a couple which must be resisted by the moment at the middle.



Displacement total = .2 x .2 x .2 = .008 m³

Total Wt = .008 t = 8 kg = 78.4 N
Half Wt of top block = 19.6 N
Moment = 19.6 x .05m = 0.98 N-m

Top Block - cross section .2 x.1 m



I = 1/12 .2 x .1³
= .00001667 m⁴

Z = I / .05 = 0.000333 m³

σ = M / Z = 0.000333 m³ = 2940 Pa

c) Only the material in the top four corners would have zero stress. Everywhere else feels some kind of stress (bending, shear, gravity).