Faculty of Maritime Engineering and Marine Sciences

Ship's Structure

Exam #2 – Plate bending & Hull structure analysis **August, 24th, 2026**

Student: ……………………………………………………. **ID:** ……………………. **Completion time**: ………..…

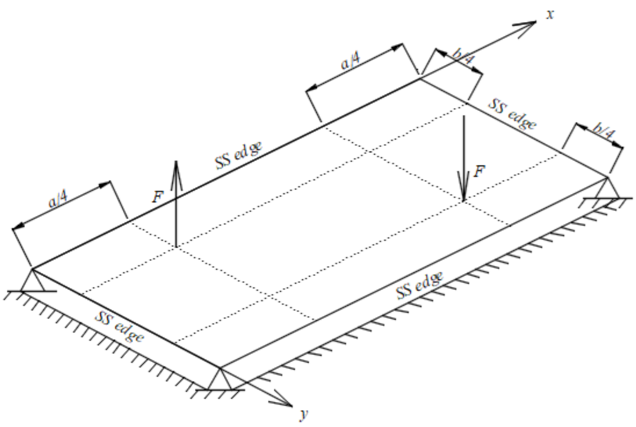
Part 1. Closed books

1.- A rectangular steel plate *a*: 1.5 m, *b*: 0.5 m, and *t*: 8 mm, is supporting a hydrostatic loading from a 2 meters height sea water column. The deflection function is approximated as: $0.178\left(1-cos\left(\frac{2\pi x}{a}\right)\right)\left(1-cos\left(\frac{2\pi y}{b}\right)\right), [mm]$. Determine the maximum value of strain in y-direction. (10)

c. $\mu\varepsilon_y = 225$	**c.** $\mu\varepsilon_y = 235$	**c.** $\mu\varepsilon_y = 110$	**c.** $\mu\varepsilon_y = 85$

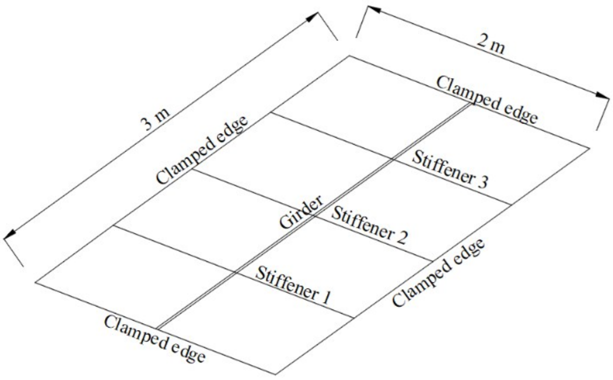
2.- On a aluminum alloy rectangular plate (*a*: 1.30, *b*: 0.60, *t*: 0.008 m) two concentrated forces are acting as shown in the figure. If want to represent this load using one term, what combination is the best for this case? (10)

$$p_{mn} = \frac{4}{a\,b}\iint dx\,dy\,p(x,y)\,sin\,\frac{m\pi x}{a}\,sin\,\frac{n\pi y}{b}$$



a. *m*=1, *n*=1	**b.** *m*=2, *n*=2	**c.** *m*=1, *n*=2	**d.** *m*= 3, *n*=1

3. A steel plate is reinforced with one girder and three stiffeners, to support a uniform load of 15 KN/m^2. The effective inertia of the girder is 300 cm^4 and the stiffeners are 5 times less rigid. Solving the combination of beams representing girder and stiffeners, reaction on the ends of stiffener 1 is 7757 N. Considering the flexibility of the girder, what is the contact force between girder and stiffener 1? (10)



5540 N	7500 N	1130 N	6986 N

4.- In a transversely framed ship navigating in waves, you are asked to analyze the hull beam behavior and the bending of a bottom plate. If at a certain instant of time, the vessel is in Sagging condition, which of the following combinations produces the most important state of stress (x-axis points in forward-aft direction, and y-direction points in the direction of the beam)? (10)

a. σ_x^1 is (+), σ_y^3 (-)	**b.** σ_x^1 is (-), σ_x^3 (-)	**c.** σ_x^1 is (-), σ_y^3 (-)	**d.** σ_x^1 is (+), σ_x^3 (-)

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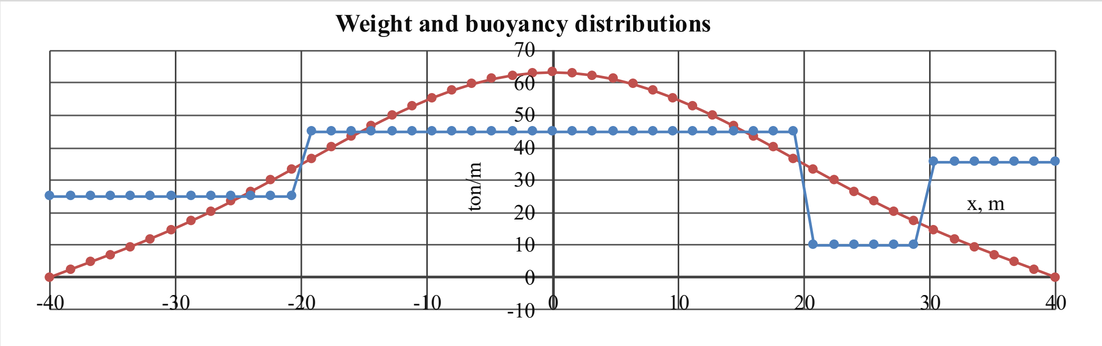
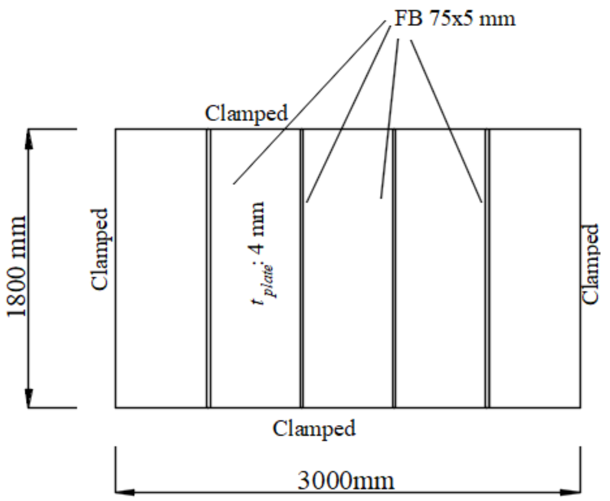
Part 2. Closed books. Identify your steps with the parameter you are going to calculate and write only on one side of the pages.

1. A steel cargo ship with quadratic distribution of beam: $B(x) = B_o(1 - (2x/L)^2)$, $-L/2<x<L/2$, along its length is to be analyzed in waves. Main dimensions are L: 80 m, B: 10 m, and T: 4.550 m, and she has vertical sides. Weight distribution includes four items, each one uniformly distributed: hull weighs 800 tons, cargo in the central region 1400 tons, superstructure and propulsion machinery abaft of vessel 300 tons, and forward anchoring machinery: 257 tons. Waves are acting on the ship in hogging condition with amplitude of 1.625 m.

After quasi-equilibrating the ship in a wave, the following distributions of weight and buoyancy are obtained. Considering an allowable normal stress of 150 MPa, calculate the minimum section modulus that the ship hull structure must have in the midship area. (30)



2. A stiffened panel built with standard steel, of external dimensions 3x1.8 m, has four stiffeners in the transverse direction. The steel plate is 4 mm in thickness, the stiffeners are 75x5 mm flat bars and following the rules of a ship classification society the plate is 60% effective. Uniformly distributed load of 10000 N/m^2 is acting over the panel. Determine the safety factor of the reinforced panel, applying the Maximum Distortion energy theory, considering allowable stress of 150 MPa and all edges of the panel as clamped; you may neglect shear stresses. (30)



If you use this figure, you must clearly show your selected values.

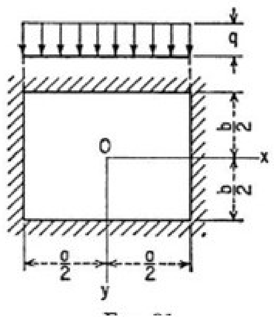


TABLE 35. DEFLECTIONS AND BENDING MOMENTS IN A UNIFORMLY LOADED RECTANGULAR PLATE WITH BUILT-IN EDGES (FIG. 91)
$\nu = 0.3$

b/a	$(w)_{x=0,y=0}$	$(M_x)_{x=a/2,y=0}$	$(M_y)_{x=0,y=b/2}$	$(M_x)_{x=0,y=0}$	$(M_y)_{x=0,y=0}$
1.0	$0.00126qa^4/D$	$-0.0513qa^2$	$-0.0513qa^2$	$0.0231qa^2$	$0.0231qa^2$
1.1	$0.00150qa^4/D$	$-0.0581qa^2$	$-0.0538qa^2$	$0.0264qa^2$	$0.0231qa^2$
1.2	$0.00172qa^4/D$	$-0.0639qa^2$	$-0.0554qa^2$	$0.0299qa^2$	$0.0228qa^2$
1.3	$0.00191qa^4/D$	$-0.0687qa^2$	$-0.0563qa^2$	$0.0327qa^2$	$0.0222qa^2$
1.4	$0.00207qa^4/D$	$-0.0726qa^2$	$-0.0568qa^2$	$0.0349qa^2$	$0.0212qa^2$
1.5	$0.00220qa^4/D$	$-0.0757qa^2$	$-0.0570qa^2$	$0.0368qa^2$	$0.0203qa^2$
1.6	$0.00230qa^4/D$	$-0.0780qa^2$	$-0.0571qa^2$	$0.0381qa^2$	$0.0193qa^2$
1.7	$0.00238qa^4/D$	$-0.0799qa^2$	$-0.0571qa^2$	$0.0392qa^2$	$0.0182qa^2$
1.8	$0.00245qa^4/D$	$-0.0812qa^2$	$-0.0571qa^2$	$0.0401qa^2$	$0.0174qa^2$
1.9	$0.00249qa^4/D$	$-0.0822qa^2$	$-0.0571qa^2$	$0.0407qa^2$	$0.0165qa^2$
2.0	$0.00254qa^4/D$	$-0.0829qa^2$	$-0.0571qa^2$	$0.0412qa^2$	$0.0158qa^2$
∞	$0.00260qa^4/D$	$-0.0833qa^2$	$-0.0571qa^2$	$0.0417qa^2$	$0.0125qa^2$

Von Mises equivalent stress: $\sigma_{eq} = \sqrt{{\sigma_x}^2 + {\sigma_y}^2 - \sigma_x\sigma_y + 3{\tau_{xy}}^2}$

jrml/2026