



**UNIVERSITY OF BRITISH COLUMBIA
FACULTY OF APPLIED SCIENCE
DEPARTMENT OF MECHANICAL ENGINEERING**

TEST #1, February 9th, 2017

MECH 222

Suggested Time: 75 minutes

Allowed Time: 110 minutes

Materials admitted: Pencil, eraser, straightedge, Mech 2 Approved Calculator (Sharp EL-510), one 3x5 inch sheet of paper for hand-written notes.

All questions must be answered. Provide **all** work and solutions **on this test**. Orderly presentation of work is required for solutions to receive full credit. **Illegible work, or answers that do not include supporting calculations and explanations will NOT BE MARKED.**

FILL OUT THE SECTION BELOW AND WRITE YOUR NAME ON THE TOP OF ALL TEST PAGES. Do this during the examination time as additional time will not be allowed for this purpose.

NAME: _____ Section _____

SIGNATURE: _____ *

STUDENT NUMBER: _____

* By your signature you are affirming that you have neither given nor received aid on this examination

Question	Domain	Maximum Mark	Mark Received
1	Fluids	5	

Name:_____ Section:_____

2	Math	10	
3	Fluids	5	
4	Math	10	
5	Fluids	10	
6	Math	10	
7	Fluids	15	
8	Thermodynamic s	10	
TOTAL	-	75	

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Name:_____ Section:_____

Name:_____ Section:_____

Problem 1 – 5 marks

An object is supported in mid-air inside a submarine by a helium balloon. The submarine, in turn, is neutrally buoyant (that is, it displaces exactly its own mass of water) and is stationary at a constant depth below the surface. As the helium leaks out of the balloon into the air inside the submarine, the object settles to the deck inside the submarine. Will the submarine rise or sink in the water, and by how much? Why?

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Problem 2 – 10 marks

Let D be the triangular region with vertices $(-1,0)$, $(3,2)$ and $(3,0)$, and consider the function

$$f(x,y)=1-xy-y^2$$

(a) [2 marks] Sketch the region D .

(b) [2marks] Write the integral $\iint_D f(x,y) dA$ as an iterated integral of the form:

$$\int_a^b \int_{g_1(x)}^{g_2(x)} f(x,y) dy dx$$

Name:_____ Section:_____

(c) [2 marks] Write the integral $\iint_D f(x, y) dA$ as an iterated integral of the form:

$$\int_c^d \int_{h_1(y)}^{h_2(y)} f(x, y) dx dy$$

(d) [4 marks] Compute the integral $\iint_D f(x, y) dA$.

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Problem 3 – 5 marks

A deep tank with vertical sides is filled with liquid and has two identical square holes in its side, as shown in the figure, each covered by a hinged plate. For each hole, one horizontal edge (AB or GH) of the square is hinged (dark line in the figure) and a force is applied perpendicular to the side of the tank at the other horizontal edge (CD or EF) to hold the plate in place. For which plate is the required force higher, or are the forces equal, and why?

■

Name:_____ Section:_____

Alternative solution to 2(d)

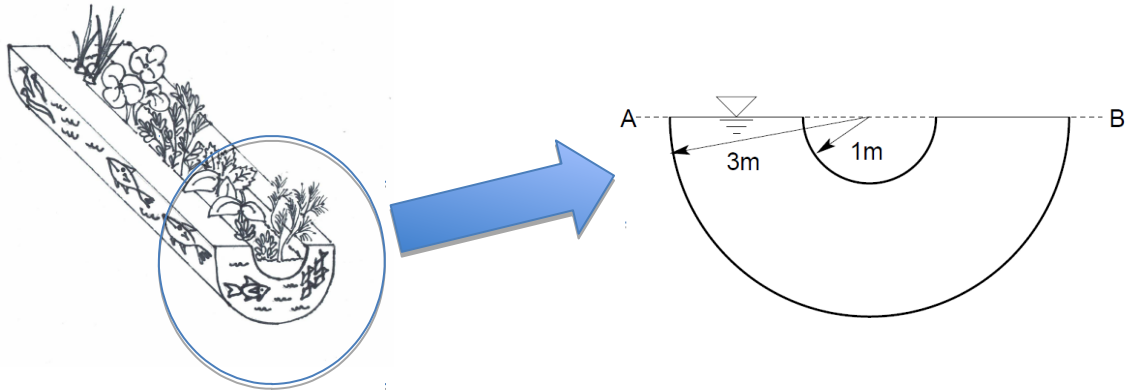
Problem 4 – 10 marks

Find the center of mass of the lamina covering the region D located inside the circle $x^2+y^2=4$ and outside the circle $x^2+y^2=1$, with density $\rho(x,y)=3-x$.

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Problem 5 – 10 marks

The sketch shows the end view of an unusually shaped aquarium, which is filled with salt water (density $\rho = 1025 \text{ kg/m}^3$). Determine the magnitude of the hydrostatic pressure **force** and the moment that hydrostatic pressure produces about the line AB.



Name:_____ Section:_____

Problem 6 – 10 marks

Compute the integral

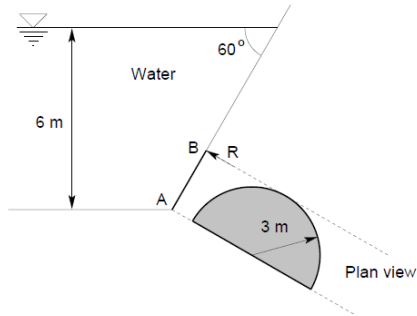
$$\iint y^2 \sqrt{1+x^4} dA$$

over the region D bound by the lines $y=x$, $y=-x$ and $x=1$.

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Problem 7 – 15 marks

The sketch shows a side view of a tank filled with fresh water. The gate AB is semi-circular, with a radius of three meters. This gate is hinged at A and held closed by a force R applied at B, perpendicular to the tank wall.



- (a) (5 marks) On the sketch, draw in the pressure distribution on the gate. Indicate the magnitude by labeling at least one of the arrows that you draw. [See above](#)
- (b) (10 marks) Find the magnitude of the net pressure force on the gate.

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Problem 8 – 10 marks

Consider a cylinder/piston assembly containing 4 g of air. The piston is frictionless and weightless. Assuming for the given conditions provided on the accompanying figure the system is in equilibrium with its surroundings; find

- The absolute pressure of the air inside the cylinder (5 Marks)
- The temperature of the air inside the cylinder (5 Marks)

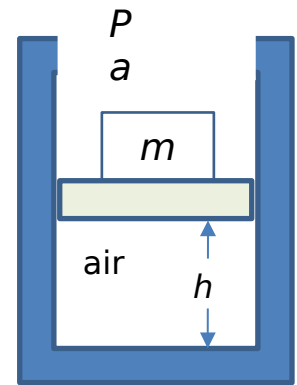
The local atmospheric pressure is $P_a = 100 \text{ kPa}$

Piston diameter, $d = 30 \text{ cm}$

Mass on top of the piston, $m = 5 \text{ kg}$

Piston height, $h = 5 \text{ cm}$

Air gas constant is 0.287 kJ/kg-K



Please write your final answers in the Table below:

Part a	$P=$	
Part b	$T=$	