Name: _____CM Box: _____

Circle your section:

Lui – 01 Lui – 02 Mech – 07

ES 202
Fluid & Thermal Systems

Examination I
December 20, 2006

Problem	Score
1	/ 50
2	/ 50
Total	/ 100

Clearly show all work for credit.

Open table ONLY

One side of an 8.5" x 11" equation sheet is allowed.
Laptops allowed
No EES allowed

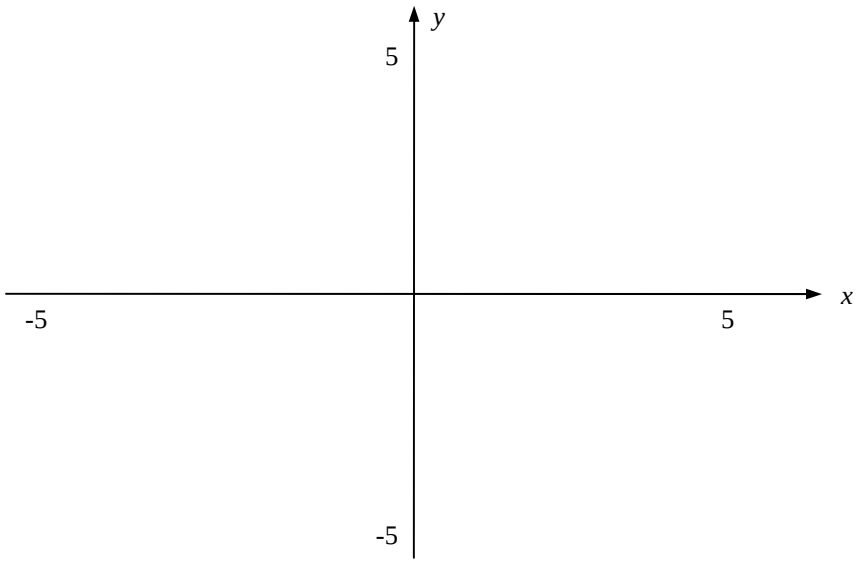
Density of water at standard conditions is assumed to be 1000 kg/m^3 in this exam.

Problem 1 (50 points)

a) A given flow has a stream function of the following form:

$$\psi = x^2 + 4\,y^2$$

i) Sketch a representative streamlines of the flow over the region $-5 \le x \le 5$ and $-5 \le y \le 5$.



ii) Define V_x and V_y in terms of x and y.

iii) Is this flow incompressible? Explain your answer.

iv) Is this flow irrotational? Explain your answer.

b) The continuity equation expressed in the Cartesian coordinate system is

$$\underbrace{\frac{\partial \rho}{\partial t}}_{\text{Term A}} = \underbrace{-\frac{\partial (\rho V_x)}{\partial x}}_{\text{Term B}} \underbrace{-\frac{\partial (\rho V_y)}{\partial y}}_{\text{Term C}}$$

Explain the physical meaning of the following terms in the continuity equation:

Term A:

Term B:

c) On a windy day, we may hear the electricity cable hanged between the wooden poles "sings" at different pitches. Out of curiosity, an engineering student attempt to identify the relationship between the "singing" frequency, ω, and other system parameters. In his first model, he assumes the mechanism to be frictionless. Hence, the proposal takes the form of

$$\omega = \text{function}\left(V_{\text{wind}}, D_{\text{cable}}, \rho_{\text{air}}\right)$$

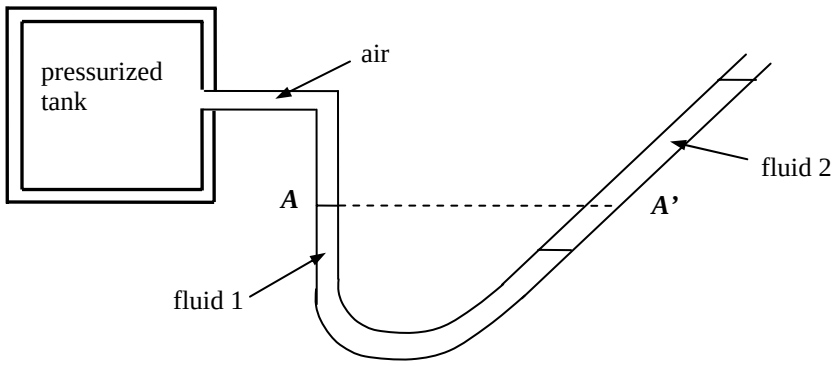
where V_{wind} is the wind speed

D_{cable} is the cable diameter

ρ_{wind} is the air density

How many non-dimensional group(s) can he find? What are they?

d) Consider the following inclined manometer setup.



Which one of the following statements is correct if all fluids in the setup are stationary?

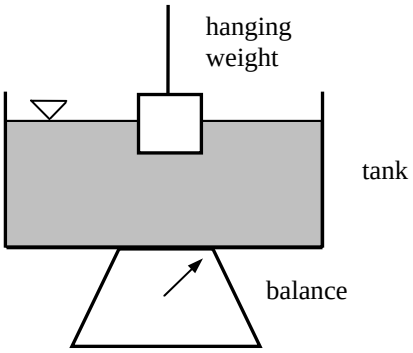
i) $P_A > P_{A'}$

ii) $P_A = P_{A'}$

iii) $P_A < P_{A'}$

iv) insufficient information to determine

e) Consider the following setup and circle the correct answer.



i) Assume the tank is large enough that no over-flowing occurs. As the hanging weight is gradually lowered into the water tank without touching the base, the balance reading will

a. increase

b. decrease

c. remain constant

d. insufficient information to determine

ii) Assume the tank is completely filled initially. As the hanging weight is gradually lowered into the water tank without touching the base, the balance reading will

a. increase

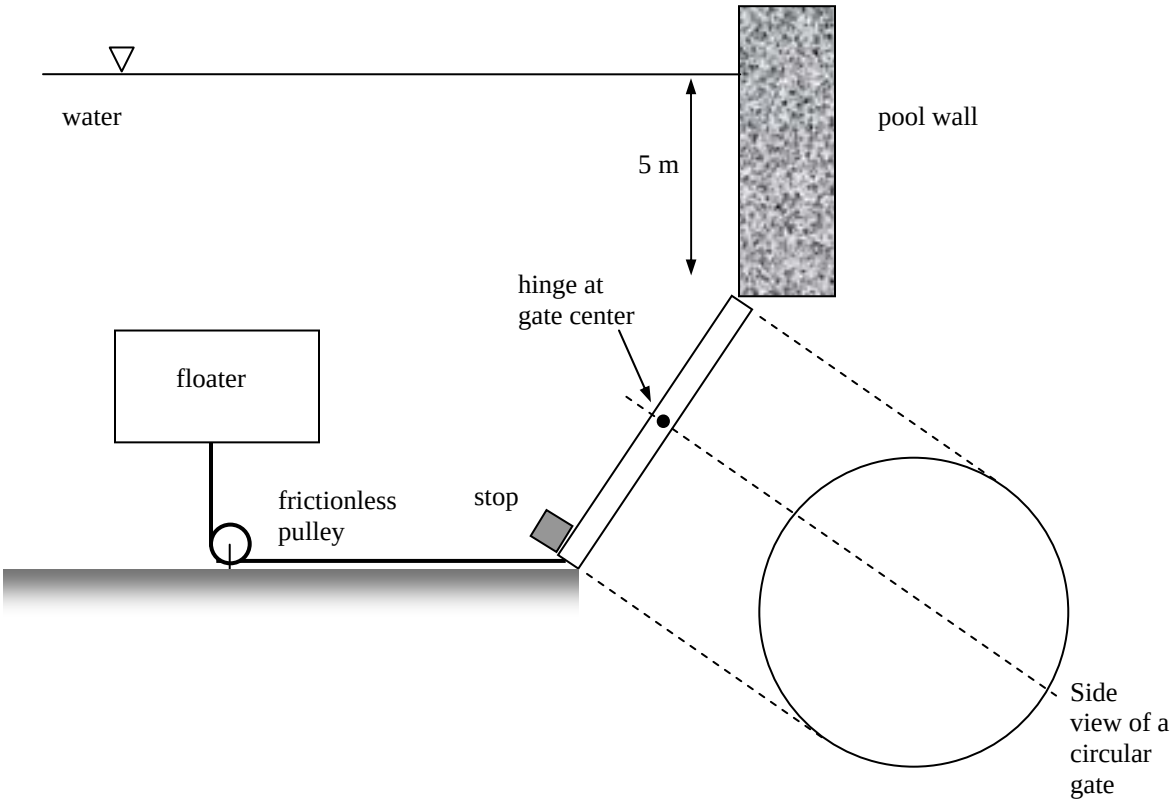
b. decrease

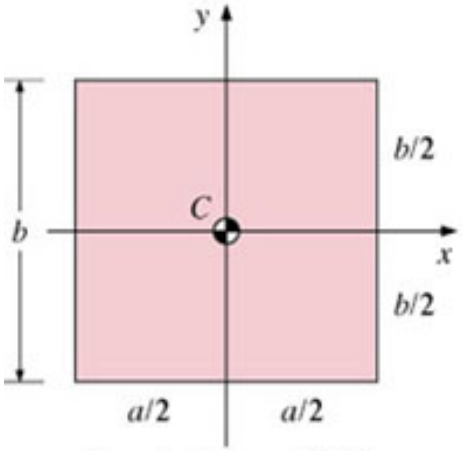
c. remain constant

d. insufficient information to determine

Problem 2 (50 points)

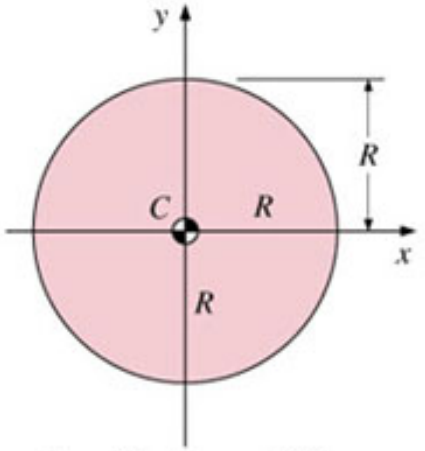
A circular gate of 1.5 m diameter is positioned at an angle of 60^o with the horizontal axis. It can freely rotate about an axis through its center. However, its motion is restrained by a stop at the bottom of a pool. Determine the <u>volume of the floater</u> (specific gravity of 0.65) necessary to open the circular gate with a water depth of 5 meters above the top edge of the gate.





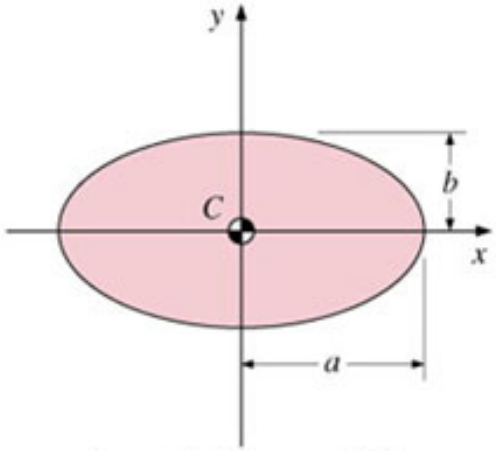
$A = ab,\ I_{xx,C} = ab^3/12$

(*a*) Rectangle



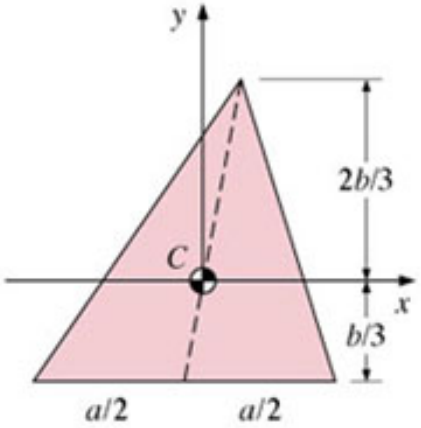
$A = \pi R^2,\ I_{xx,C} = \pi R^4/4$

(*b*) Circle



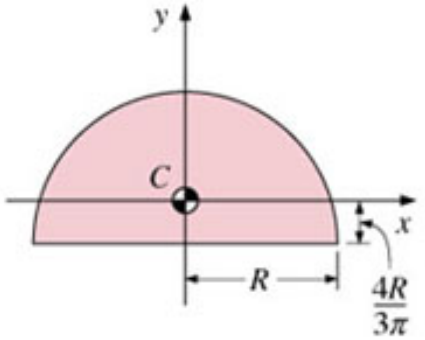
$A = \pi ab,\ I_{xx,C} = \pi ab^3/4$

(*c*) Ellipse



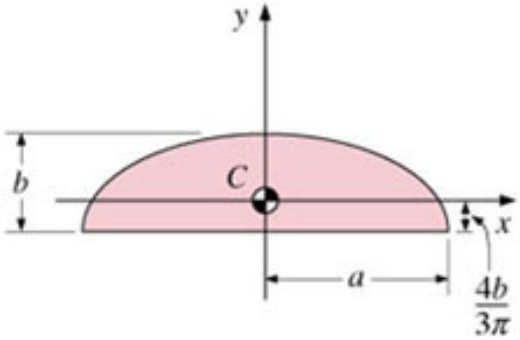
$A = ab/2,\ I_{xx,C} = ab^3/36$

(*d*) Triangle



$A = \pi R^2/2,\ I_{xx,C} = 0.109757R^4$

(*e*) Semicircle



$A = \pi ab/2,\ I_{xx,C} = 0.109757ab^3$

(*f*) Semiellipse

Source: Cengel & Turner, Figure 11-6