



**Massachusetts Institute of Technology**  
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**16.01/16.02 Unified Engineering I, II**  
**Fall 2003**

**Problem Set 13**

Name: \_\_\_\_\_

Due Date: 12/2/03

	<b>Time Spent (min)</b>
<b>F16</b>	
<b>F17</b>	
<b>M17</b>	
<b>M18</b>	
<b>Study Time</b>	

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Announcements:

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F16.  $\phi_1(x, y)$  and  $\phi_2(x, y)$  are known to be physically-possible flows (i.e. satisfy mass conservation), and their corresponding pressure fields  $p_1(x, y)$  and  $p_2(x, y)$  are known via the Bernoulli equation.

- a) A third flow is now defined by  $\phi_3(x, y) = \phi_1 + \phi_2$ . Explain how you would obtain its corresponding pressure field  $p_3$ .
- b) Yet another flow  $\phi_4 = \partial\phi_1/\partial x$  is defined. Is this a physically-possible flow?

F17. A vortex flow is given by

$$u_1(x, y) = \frac{y}{x^2 + y^2} \qquad v_1(x, y) = \frac{-x}{x^2 + y^2}$$

A uniform flow in the  $x$ -direction is given by

$$u_2(x, y) = V_\infty \qquad v_2(x, y) = 0$$

Superimpose these two flows, determine the pressure field, and find the  $x, y$  location of the point of maximum pressure.

**Problem M17**

In question M16. You had a state of strain:

Given a state of plane strain:  $\epsilon_{11} = -0.000200$ ,  $\epsilon_{22} = +0.000400$ ,  $\epsilon_{12} = -0.000200$ , do the following:

- a) If a strain gauge rosette, with three gauges at  $60^\circ$  to each other was placed with one of the gauges orientated along the  $x_1$  direction. What strains would the three gauges read?
- b) By representing the strains as a matrix calculate the principal strains and principal directions via the eigenvalue and eigenvectors of the matrix. Show that this is consistent with the values you calculated in M16.
- c) If the state of strain was no longer plane strain, and was now  $\epsilon_{11} = -0.000200$ ,  $\epsilon_{22} = +0.000400$ ,  $\epsilon_{33} = -0.000200$ ,  $\epsilon_{13} = 0.000300$ ,  $\epsilon_{23} = 0$ ,  $\epsilon_{12} = 0$ . What would the principal strains now be?

**Problem M18**

Read Ashby and Jones Chapters 4, 5 and 6. Answer the following short questions (each answer should be one or two sentences only, the important task is the reading, the questions are to focus your attention):

- i) What are the two principal factors that contribute to the Young's modulus of a homogeneous material?
- ii) What is the glass transition temperature of a polymer and what is the underlying cause for this?
- iii) Why do metals tend to have higher densities than ceramics or polymers?
- iv) What is the relationship between the force exerted by an interatomic bond as a function of separation of the atoms and the potential energy associated with the same separation of the atoms?