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Cadeira: MECÂNICA DOS MEIOS CONTÍNUOS **Época: Normal**

Ano lectivo: 2018/2019 (1º Semestre) **TESTE 3** (2019/01/11) **Duração:** 1,5 horas

Nome: ________________________________ Número: ___________ Curso: **EC**

Questions 1 to 4 should be answered in this sheet. Please do not write derivations or calculations in these questions; they will not be rated anyway. It is not worth presenting several variants of the answer (if they are contradictory, the answer will be considered incorrect). The remaining questions should be answered on the examination sheets with appropriate derivations and calculations.

1. [4] Consider the motion

$$u_1 = \alpha \sin \frac{2\pi}{l}\left(X_1 - c_L t\right) + \beta \cos \frac{2\pi}{l}\left(X_1 - c_L t\right), \quad u_2 = u_3 = 0$$

in the half-space $X_1 \geqslant 0$. Write expressions for the constants α, β, l in terms of all the other parameters assuming the boundary condition in the plane $X_1 = 0$ is the following:

(a) the displacement is specified,

$$\mathbf{u} = (b \sin \omega t)\ \mathbf{e}_1$$

Answer:

(a) the surface traction is specified,

$$\mathbf{t}_{ext} = (d \sin \omega t)\ \mathbf{e}_1$$

Answer:

2. [3] Consider a flow of incompressible fluid in a cylindrical tube. The tube diameter is d, the flow rate is G, the density of the fluid is ρ and the viscosity of the fluid is μ.

(a) What is the condition to be satisfied by the above parameters so that the flow is laminar?
Answer:

(b) Assume that $d = 15\,\mathrm{mm}$, $G = 1\,\mathrm{l/\,min}$, the fluid is water ($\rho = 1.0\,\mathrm{g/\,cm^3}$, $\mu = 1.0\times 10^{-3}\,\mathrm{Pa}\times\mathrm{s}$). Determine if the flow in these conditions is or is not laminar and justify the answer on the basis of the condition formulated in the previous paragraph.

3. [2] Consider an irrotational flow of an ideal incompressible fluid in the field of a body force $\mathbf{B}$ given by the expression (in dimensionless variables) $\mathbf{B} = (9x_1x_2, Ax_1^2, 0)$, where A is a constant. Determine the value of the constant A.

Answer ___

4. [2] Potential of an irrotational flow is $\Phi = x_1^3 - 3x_1x_2^2(x_3^3 - 3x_2^2x_3)$ (in dimensionless variables). Determine the velocity field.

Answer:

5. [4] A cylindrical bar made of steel ($E_Y = 207\,\mathrm{GPa}$) $3\,\mathrm{m}$ long will be designed to withstand a traction force of $445\,\mathrm{kN}$ at one of its extremities. What should be the minimum radius of the bar:

   (a) if the maximum shearing stress should not exceed $100\,\mathrm{MPa}$ and the maximum normal stress should not exceed $140\,\mathrm{MPa}$?

   (b) if it is further required that the elongation should not exceed $0,12\,\mathrm{cm}$?

6. [5] Assume that the air temperature in the atmposphere varies linearly with altitude: $T = T_0 - \alpha x_3$, where T_0 is ground level temperature and x_3 measures height above the earth. Consider that p_0 is the pressure at ground level, which is known, and that air is an ideal gas. (Recall that the equation of state of an ideal gas can be written as $p = \frac{R}{M}\rho T$, where p is hydrostatic pressure, M is the molar mass of the gas which is a known characteristic of each gas, ρ is the gas density, and R is a given constant.) Determine the air pressure in the atmosphere as a function of x_3 under hydrostatic conditions.