APL106
Minor 2A

Time: 30 minutes
+ 10 minutes uploading

22-12-2020

Name

Entry No.

Please answer all the questions. All bold letters indicate vector quantities. Standard symbols have their usual meanings.
If required use the data as follows: a) $\rho_{air} = 1.25$ kg/m^3, b)) $\rho_{water} = 1000$ kg/m^3, c) $g = 9.81$ m/s^2.

Total 3 pages in Question paper including this page. 1 question on each page from page 2 to page 3.

Maximum Marks

Q1. 15 marks
Q2. 15 marks

Total 30 marks

All parts of the same question must be answered together.

Please sign the after writing the following statement:

I hereby declare that I have neither given nor taken any help from anyone in solving this examination.

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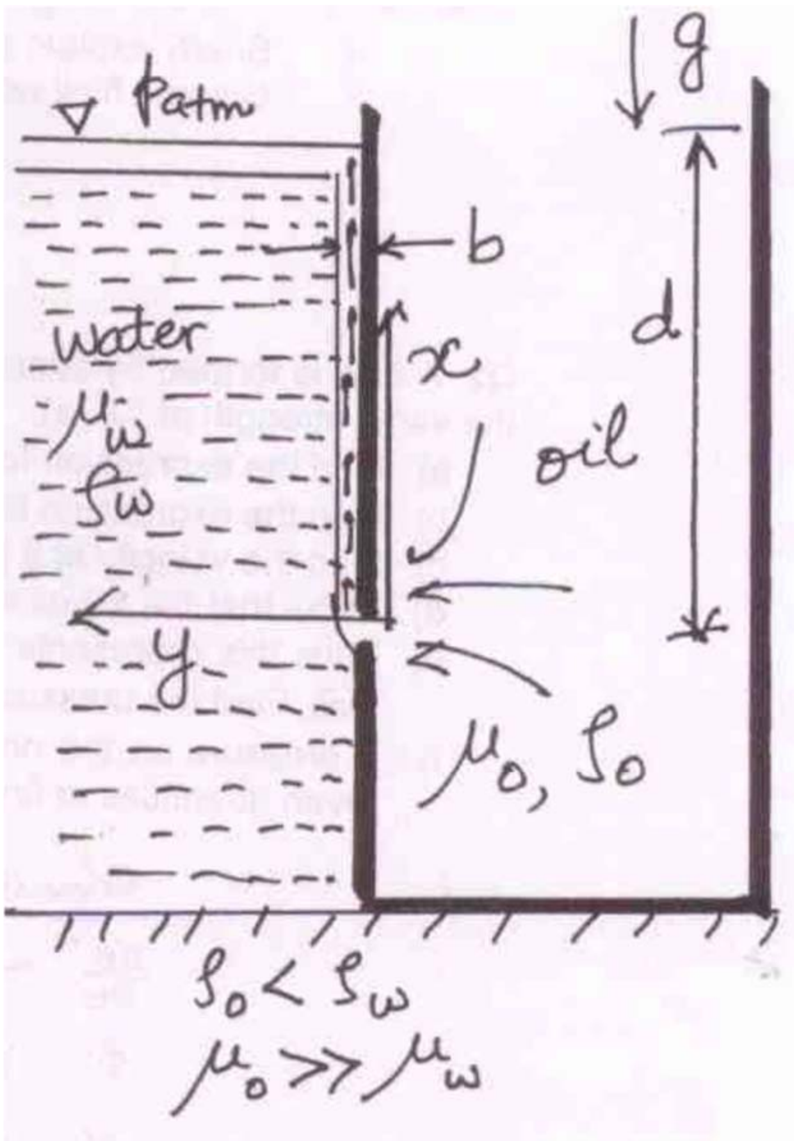
(Signature)

Q1. An ONGC oil tank located in Bombay High region of the sea has developed a fine crack on its side located at a depth d from the surface. Oil leaks from the crack and runs up the side of the tank in a thin layer of dimension *b* as shown. Assume that the oil flow is very highly viscous and less dense than surrounding water i.e. $\rho_o < \rho_w$ and $\mu_o >> \mu_w$. We wish to find the flow rate of oil per unit width, Q in terms of the given parameters. Assume that the flow is steady, 2 dimensional and fully developed, i.e. velocity is not a function of x. (Please see x and y as marked in the problem). Also assume hydrostatic pressure distribution in the water.

a) State the boundary conditions on V_x, V_y and p.

b) Simplify the continuity and N.S. equations and solve for V_y, p and V_x.

c) Find Q. (15 marks)



Q2. A circular thrust bearing is shown in the figure. Incompressible oil (density ρ and viscosity μ) with gauge pressure p_0 is pumped from the bottom and flows outwards in the region $R_1 < r < R_2$. At $r = R_2$, the pressure is atmospheric. The gap between the upper and the lower plates is constant and equal to h. The upper plate rotates with a constant angular velocity ω, while the lower plate is fixed. The following assumptions may be made.

i) $V_z = 0$.

ii) Axisymmetric flow so velocity and pressure do not vary with θ.

iii) Gravity can be neglected.

iv) ***Inertial terms can be neglected***, i**.e. assume that acceleration = 0**.

v) The flow is steady.

a) State the boundary conditions on V_r , V_θ and p.
b) Show that $V_r = f(z) /r$.
a. Simplify the r, θ and z components of the Navier-Stokes equations.
c) Substitute the form of V_r in a) above in the r direction equation to obtain the pressure distribution p(r). Use boundary conditions on p to obtain the constants.
d) Find f(z). You will have to use the boundary conditions on V_r.
e) Set up an integral expression for calculating the total load which the bearing can take. ***Do not calculate the integral***.