Ö. Savaş NAME: _____

8:10-9:30, Thursday, October 2, 2003

ME 106.2
FLUID MECHANICS
EXAM 1 – open book

1.(25%) Consider the steady two-dimensional flow field with Cartesian velocity components

$$(u, v) = (2ax, -ay)$$

where a is a positive constant.

(a) [10] Determine and sketch the streamlines of the flow.

(b) [5] Calculate the divergence of the field. What can you say about the compressibility of the flow field?

(c) [10] Assuming that the density field is uniform (no spatial dependence), determine the density as a function of time using the differential continuity equation.

2.(25%) A closed rigid cylindrical container of diameter $2a$ and height H contains equal volumes of two immiscible liquids of densities ρ_1 and ρ_2 such that $\rho_1 > \rho_2$. The container and its contents are rotating at a constant angular velocity of Ω in the presence of gravity. Let us determine the equation for shape of the interface $h(r)$ between the two liquids. Assume that the pressure at the top center is *zero*.

(a) [10] Determine the pressure fields in each of the liquids. Leave the interface location H_o as a free parameter.

(b) [5] Obtain the equation for the interface shape $h(r)$ by using the continuity of pressure at the interface.

(c) [5] Finally, determine H_o by using the volumetric information.

(d) [5] What would the interface shape be if the gravity were absent?

3.(25%) Consider the wind coming off shore and blowing over Mount Temelpais which is 700m high where pressure is 0.92 atmosphere. The atmospheric conditions at sea level are $1atm$, $288K$ and the wind speed is 20 m/s. Let us assume that the flow is steady and there are no loses. Do not ignore the elevation change.

(a) [10] Assuming the flow to be incompressible, determine the wind speed at the mountain peak.

(b) [10] Allowing for the compressibility of the flow, determine the wind speed at the top.

(c) [5] Compare the two results and comment on their difference.

4.(25%) Consider a *lawn sprinkler* with unequal arms L_1 and L_2 as shown in the figure. The water jets have identical mass flow rates $\dot{M}$ and velocities U and discharge azimuthally. Determine the relation between the torque T on the sprinkler and its angular velocity Ω.