

ENCH 630: Transport Phenomena – Problem Set 2

Problem 1.

Show that $-\nabla P$ can be interpreted to be the pressure force vector per unit volume in a fluid. Note that ∇ is the del operator and P is the pressure in the fluid.

Problem 2. Do Problem 2.B.7 from BSL (skip part d)

Problem 3. Do Problem 3.B.10 from BSL (skip parts e and f)

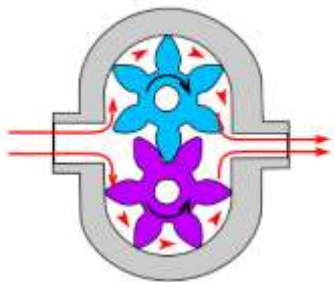
Problem 4. Fluid Mechanics of a Gear Pump

The left figure below illustrates a gear pump and the right figure below illustrates an idealized representation of the fluid flow behavior that takes place between the teeth of the gear pump. In the idealized fluid flow representation the fluid is contained between a moving top surface and a stationary cuboid container. When analyzing the fluid motion for the right figure below, you may assume $H \ll L$ so that the fluid flow reversal near the teeth can be ignored and only the region where the flow is parallel to the top and bottom surfaces needs to be analyzed. The fluid under consideration has a viscosity and density of μ and ρ , respectively. You may neglect the effects of gravity. You may also assume laminar and steady-state flow and that the pressure varies only in the x direction in the idealized fluid flow representation. State any other assumptions used in your analysis.

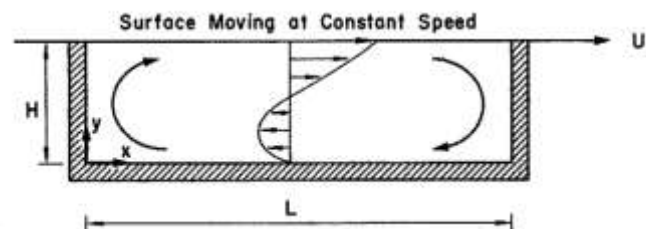
4.a. Explain why the net volume flow rate is zero in the idealized fluid flow representation.

4.b. Compute the velocity profile, the pressure gradient, and the shear stress on the moving surface for the idealized fluid flow representation.

4.c. Describe how your results from 5.b can be used to estimate the torque needed to rotate the gears in the gear pump.



Gear Pump



Idealized fluid flow representation