

MECH0011 Topic Notes

UCL

HD

October 4, 2020

Contents

| | | |
|-----------|---|----------|
| I | Fluids | 3 |
| 1 | Differential equations of mass, momentum and energy | 4 |
| 1.1 | Differential analysis of fluid flow | 4 |
| 2 | Flow Past a Body (lift and drag) | 6 |
| 3 | Flow in Pipe | 7 |
| 4 | Boundary-Layer Theory | 8 |
| II | Thermodynamics | 9 |

Part I

Fluids

Chapter 1

Differential equations of mass, momentum and energy

1.1 Differential analysis of fluid flow

What do we want to know? The velocity field, pressures, densities and temperature everywhere and anytime. Hence, these will be a function of (x, y, z, t).

List of variables

| Variable | Type | Units |
|---|--------------------|--------------------|
| $\vec{U} = u\hat{i} + v\hat{j} + w\hat{k}$ $\vec{U} = u_1\hat{i}_1 + u_2\hat{i}_2 + u_3\hat{i}_3$ | Velocity/Vector | m s^{-1} |
| p | Pressure/Scalar | N m^{-2} |
| T | Temperature/Scalar | $^{\circ}\text{C}$ |
| ρ | Density/Scalar | kg m^{-3} |
| $T = \begin{bmatrix} \tau_{xx} & \tau_{xy} & \tau_{xz} \\ \tau_{yx} & \tau_{yy} & \tau_{yz} \\ \tau_{zx} & \tau_{zy} & \tau_{zz} \end{bmatrix}$ | Stress Tensor | N m^{-2} |

Since we have 12 variables, we need 12 equations to describe the fluid!

From last year, we have our conservation of mass equation

$$\frac{\partial}{\partial t} \int_V \rho dV + \oint_S (\rho \vec{V} \cdot \hat{n}) dS = 0$$

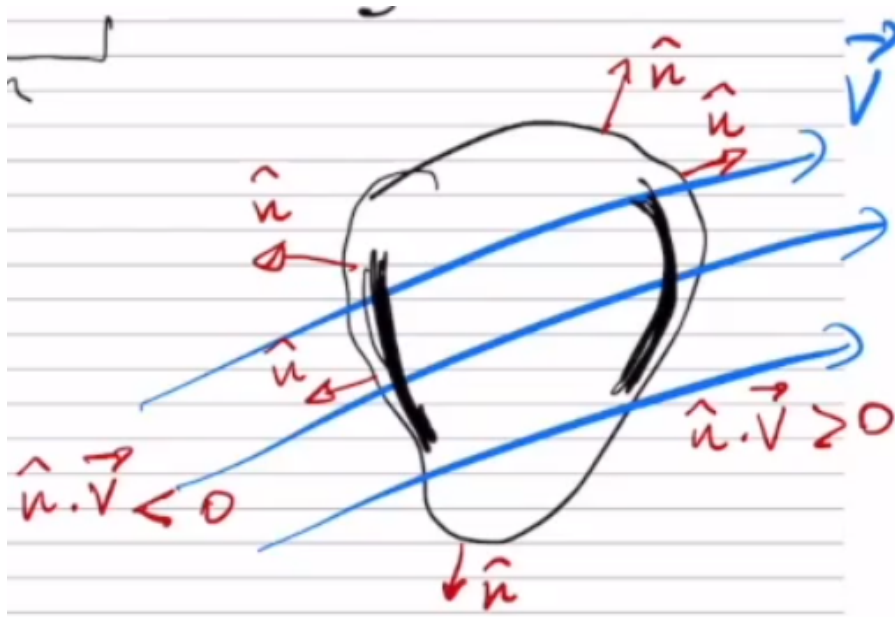


Figure 1.1: Consider \hat{n} to be a vector coming out of the control volume. Depending on where \hat{n} is, our dot product will either be greater than or less than 0.

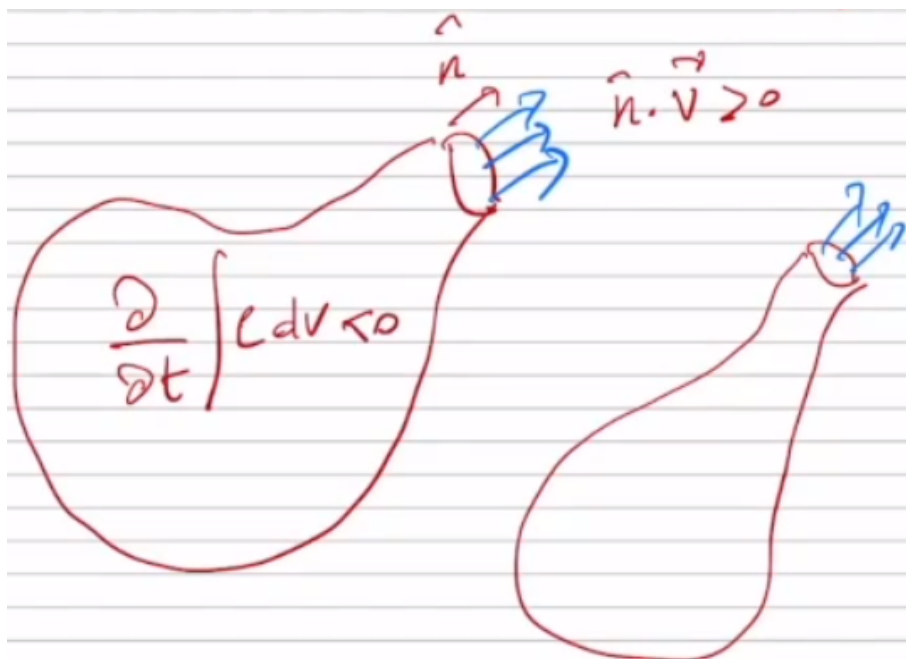


Figure 1.2: There is a velocity exiting the balloon. The amount of mass inside will decrease with time. The volume of the balloon will become smaller. This will be equal to the amount of mass which came out of the control volume (the balloon). If the second term of the continuity equation is positive, the first term must be negative.

Chapter 2

Flow Past a Body (lift and drag)

Chapter 3

Flow in Pipe

Chapter 4

Boundary-Layer Theory

Part II

Thermodynamics