ME 537 PARTICLE TRANSPORT AND REMOVAL PROJECTS Fall 2024

Part 1: Brownian Diffusion in Micro-Channel

a) Point Source: Consider a laminar flow between two parallel plates. Assume that a point source located at different locations emits particles in the size range of 0.01 to 10 μm. Simulate the motion of particles under the action of Brownian force in the presence and absence of gravity. Assume that the mean air velocity is V= 0.01 m/s, the channel width is h=1 mm, with a length of about 10 mm, and the particle-to-air density ratio is S=2000. Use an ensemble of N=50 to 200 trajectories and evaluate the mean, variance, and other statistics for particle position. Verify your results for dispersion for the source near the duct centerline by comparison with the exact solution. Discuss the importance of gravity and Brownian forces for particles of different sizes. Also, evaluate the deposition rate of panicles for point sources, which are very near the wall (about 20 to 50 μm). (Use FLUENT as well as your own program and compare the results.)

b) Uniform Inlet Concentration: For a uniform inlet concentration of particles in the size range of 0.01 to 10 μm, evaluate the deposition rate for laminar flows between two parallel plates. Plot the results in terms of the Schmidt number. (Use FLUENT as well as your own program and compare the results with those obtained from the diffusion analysis.)

c) Electromagnetic Forces: For the cases studied in parts a) and b), assume that the particles carry the average of the Boltzmann charge distribution. When an electric field in the range of 1000 V/cm is acting perpendicular to the flow direction, evaluate the dispersion and deposition of particles that are emitted from one or more point sources and/or enter the duct with a uniform concentration. Repeat the simulation when a magnetic field in the flow direction is present.

Part 2: Particle Detachment

Develop a computer program for evaluating the critical velocity needed to remove particles in the range of 0.1 to 100 microns from a flat surface in a laminar duct flow. Assume that the duct is two mm wide and use JKR, DMT, and Maguis-Pollock models for two materials of your choice.

Part 3: Applications

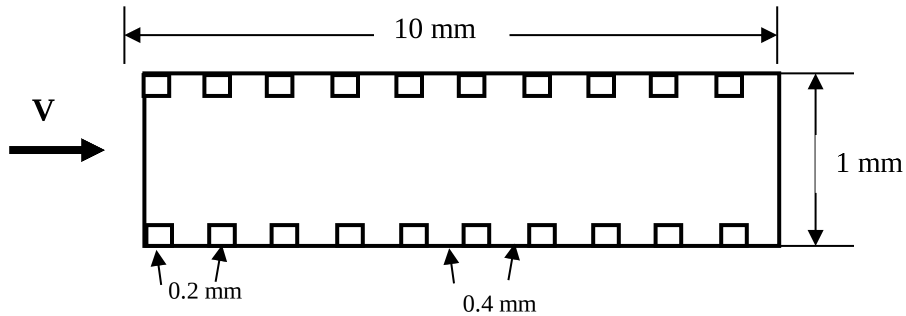
Solve the attached projects, or alternatively, select three industrial/environmental examples and perform two and three-dimensional analyses of the flow and particle transport analysis.

Report and Due Dates: The reports should include hard copies and electronic copies of the programs, including FLUENT CAS and DAT files, figures, and discussions of the results. The due dates for **Parts 1 and 2 are October 22, 2024, and Part 3 is November 26, 2024.**

ME 537 PART III PROJECT Fall 2024

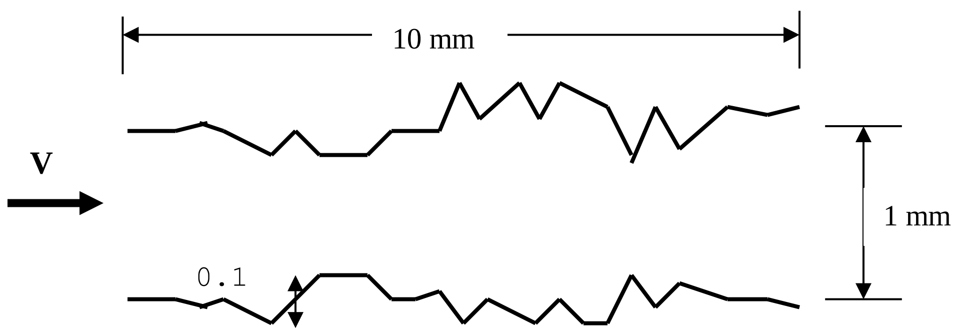
Electronic Cooling

For a duct, assume that there are rectangular roughness elements with a width of 0.2 mm and a height of 0.1 mm mounted on the duct walls with a spacing of 0.4 mm. Evaluate the flow fields for the inlet velocities of 0.01 and 0.1 m/s. Also, evaluate the dispersion and deposition of particles in the range of 0.01 to 10 μm from point sources located at three locations in the duct inlet. In addition, evaluate the deposition of particles for a uniform inlet concentration. (The flow is in the laminar regime.)



Rough Ducts

For a rough duct with a roughness of 0.1 mm and 0.2 mm, evaluate the flow field for inlet velocities of 0.01 and 0.1 m/s. Also, evaluate the deposition rate of particles from a point source at different locations and deposition velocity for uniform particle concentration.

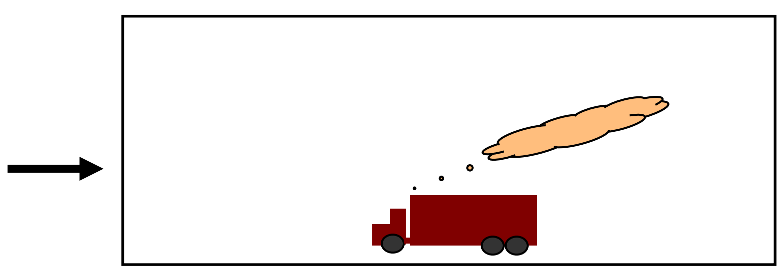


Flow in a Room

For a typical classroom, assume that the ventilation air velocity is V=0.2 m/s. Assume that a student is sneezing. Find the trajectory of the respiratory droplets containing viruses and the chance for other students to get infected. (Use a three-dimensional model.)

Truck Emission

Simulate the flow around a truck moving on a road. Study the dispersion of particulate emission from the truck exhaust. Describe the conditions you have assumed and discuss the results. (Use a three-dimensional model.)



Guideline for Technical Report Writing

First page

Title of the project.

Names of the authors and their affiliations.

Abstract

Describe what is in the report, the key points, and significant findings.

Second Page

Introduction

Introduce the topic and give the background. Review the related works. In the literature survey, point to the gaps in the literature and set the stage for this work. Also, give a summary of the main findings.

Technical Report

Formulation or Experimental setup

Experimental procedure

Results and Discussion

Note that all equations should be numbered consecutively. All assumptions should be clearly stated.

Note that all figures need to be numbered consecutively, and each figure should be discussed.

Conclusions

State the conclusions of the study.

References

All references should be listed. All listed references should be referred to in the text. Make sure to keep the same style in the references. References are given either by year or are numbered. e.g.,

Smith, J.D. (2000). Title of the paper. Journal of Probabilistic Mechanics, Vol. 4, pp. 345-356.

1. Smith, J.D., Title of the paper. Journal of Probabilistic Mechanics, Vol. 4, pp. 345-356 (2000).