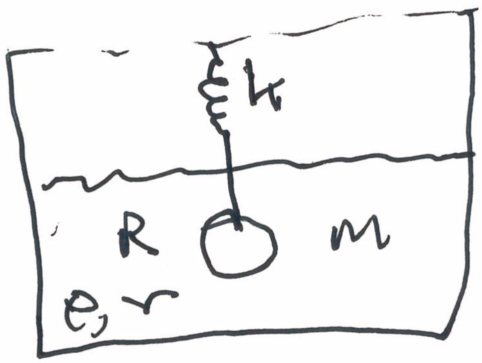
Physics 216/116 Winter 2020

Problem Set V: Not graded

- ⇒ These problems are typical of the oral Final. You should be able to do them **closed book**.
- ⇒ No lengthy calculations are required.

1) 

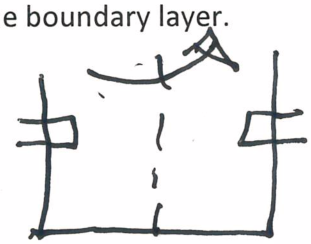
A mass m of radius R is immersed in a viscous fluid of viscosity v, density ρ.

- Take the Reynolds # $\ll 1$.
- Calculate the frequency and damping rate for the system.

2) Estimate the size of a raindrop in a turbulent atmosphere. Take the outer scale velocity and scale to be v_o, l_o.

3) A sphere of radius R moves a U through a viscous fluid, leaving a turbulent wake. Estimate the profile of the wake and how far downstream of the sphere it persists.

4) A viscous fluid is impelled to rotate at high angular velocity over a plate, as shown. What is the width of the boundary layer? Give the perpendicular velocity of the fluid outside the boundary layer.



5) Consider a discontinuity in flow, as shown.

$v = v$ ρ

ρ

$v = o$

Determine its stability.

6) a) Define precisely what incompressible convection entails. List all constraints.

b) What dimensionless parameters characterize Rayleigh–Benard convection? What do they mean?

7) Derive the profile of turbulent flow in a pipe of radius R, with pressure drop $\Delta p/l$. How does boundary layer flow velocity scale with Δp?

8) Discuss the structure of potential flow around a body which leaves a wake. What would a far field observer expect to see? How would you convince a skeptic of the result — i.e. prove it?

9) Explain how one could determine the s_2 structure function of a turbulent velocity field by measuring the evolution of the separation of two test particles in a turbulent flow.

10) Show that $\underline{\omega} + 2\underline{\Omega}$ is 'frozen in' to a rotating, incompressible fluid, up to viscosity. What does the freezing-in law imply about the structure of the flow for large $|\Omega|$?