Fluid Mechanics 4 (Mechanical)
Tutorial week 5

Question 1

Consider a block of mass 30 kg that is being pulled across a flat plate at a constant velocity of 2 m/s, as shown in Fig. 1. The area of the block's bottom surface is 350 cm^2.

1. Determine the force required to pull the block when there is no oil, assuming the coefficient of kinetic friction is 0.2. This part of the problem is not a fluid problem, but rather a simple dynamics problem to benchmark how a lubricating oil can reduce the force required to move an object.

2. Determine the force required to pull the block if a thin layer of lubricating oil of height 0.25 mm exists between the block and flat plate. Assume the oil to be a Newtonian fluid with dynamic viscosity $\mu = 0.095\,\text{Ns/m}^2$. Assume that the pressure gradient within the travelling direction is negligible.

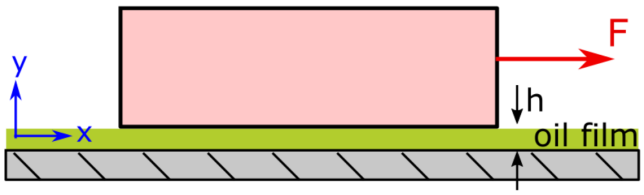


Figure 1: Oil film between a block and a surface.

Exam-style questions

Question 2

A new design for a wind turbine rotor is placed in a wind tunnel to determine the drag it will impose on the tower (see Fig. 2). The tests are performed with a uniform inlet velocity of 30 m/s. The pressure measured in section 1 and section 2 of the wind tunnel are measured to be atmospheric pressure (100 kPa). The velocity distribution at section 2, which is symmetrical about the centreline, is given by:

$$u = 30 - 5\left(1 - \frac{y}{3}\right)\ \text{m/s} \quad |y| \leq 1\,\text{m}$$

$$u = 30\,\text{m/s} \quad |y| > 1\,\text{m}$$

Where y is the distance (in m) on either side of the centreline. Assume that the object's shape does not change in the in-plane direction (i.e., 2D) and that the flow is steady. Calculate the drag force (i.e., the reaction force in the x-direction) per unit width exerted on the air by the object. Assume the air to have ambient density $\rho = 1.2\,\text{kg/m}^3$.

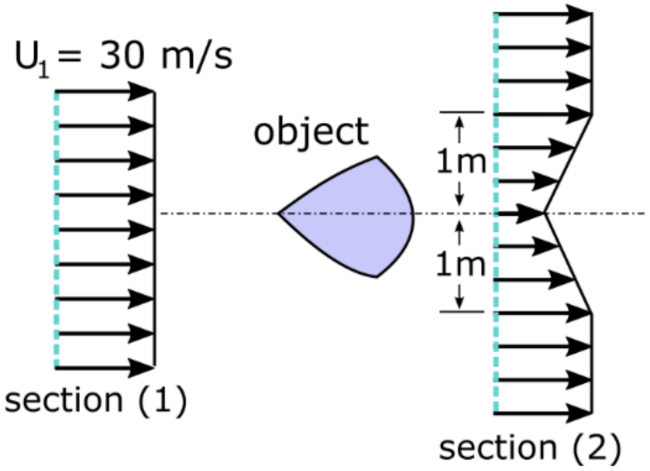


Figure 2: Object in a wind tunnel.