# ENCH 630: Transport Phenomena

# Problem Set 4

## Problem 1:

Assume that the shock wave that results from an explosion and that travels through the surrounding fluid medium has spherical geometry (except where it reflects off a solid surface). Also assume that in the *early* stages of an explosion this shock wave has a radius ($R$) that is a function of time ($t$), the total amount of energy released in the explosion ($E$), and the density of the fluid ($\rho$) that is *in front* of the shock wave (*i.e.,* the density of air before it is disturbed by the explosion).

Use the technique of dimensional analysis and the information given above to find an algebraic relation between $R$, $t$, $\rho$, and $E$ that applies to all explosions in air. If needed, use the concept that if a certain physical phenomenon is described by a single dimensionless number, then that dimensionless number usually has a value approximately of unity.

Use the relation you developed above to estimate the energy released ($E$) in the atomic bomb test at Alamogordo, New Mexico, in 1945 from the photographs of the shock wave produced during that test shown in Figure 1. Note that a length scale is shown in the photographs in Figure 1, and that the photographs were taken at the times 0.006 s, 0.016 s, 0.053 s, and 0.100 s Determine the value of $E$ for the Alamogordo test both in Joules (J) and in kilotons of TNT (where 1 kiloton of TNT equals $4.2 \times 10^{12}$ J). Also compare your result with the commonly quoted value for $E$ of 20 kilotons of TNT for the Alamogordo test.

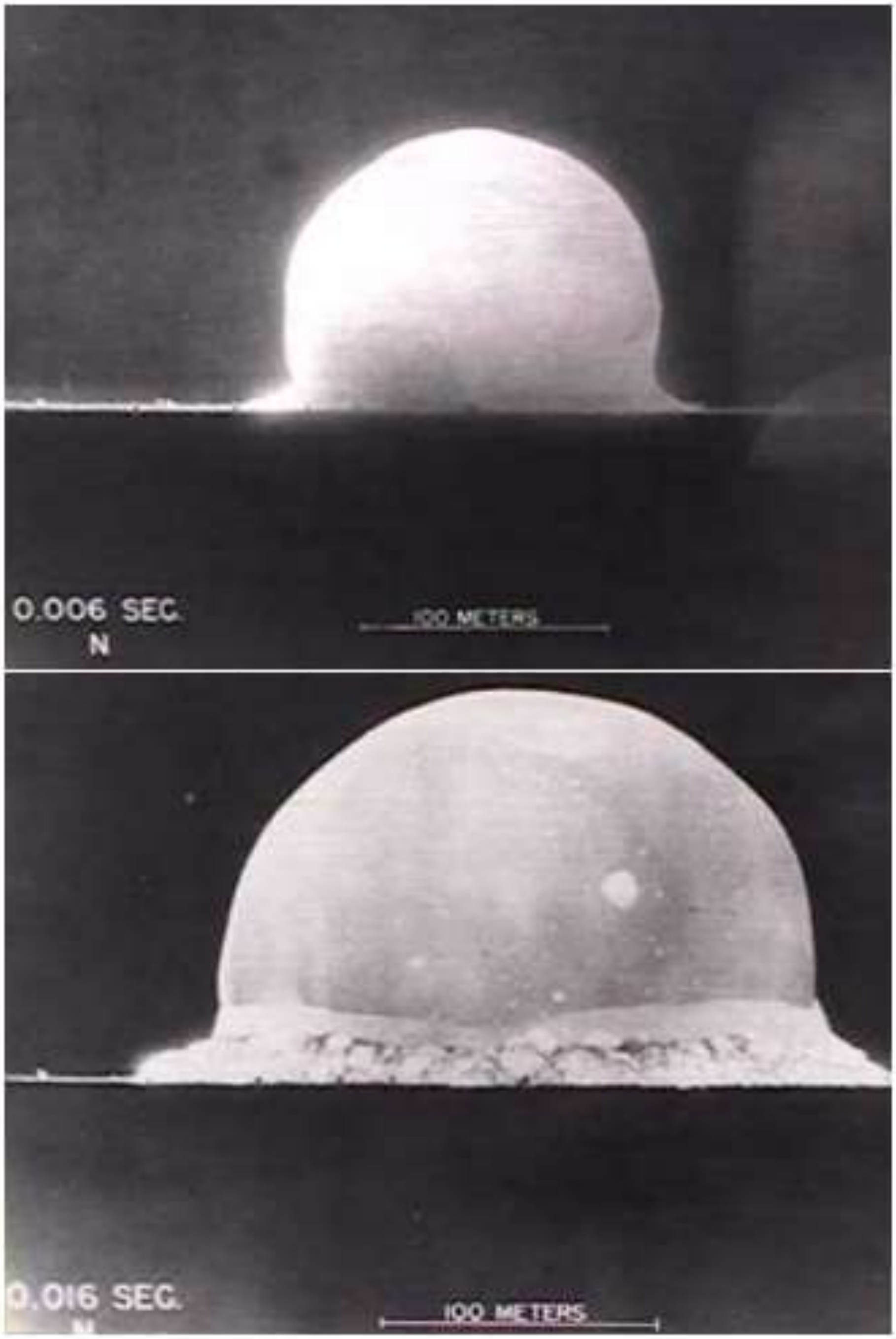


**Figure 1a.** Nuclear explosion data.

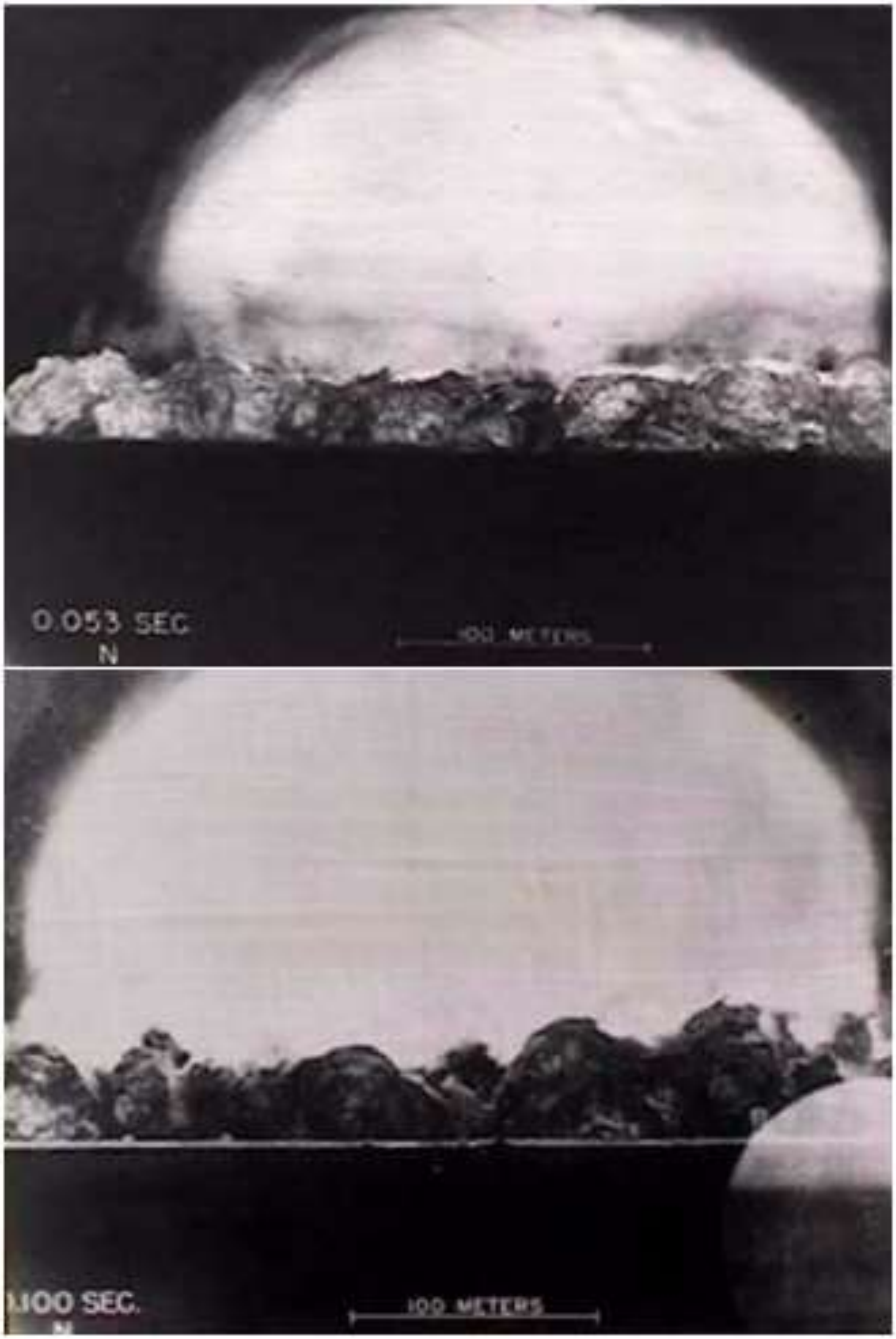


**Figure 1b.** Nuclear explosion data (cont.).

## Problem 2: **Do problem 3A.7 from BSL.**

## Problem 3: **Operation of a pitot tube flow measurement device:**

As shown Figure 2 below, liquid water at 25$^{o}$C flows in a horizontal pipe with a diameter of 2.54 cm. A tube connected to the side of the pipe bends into a U shape and returns to the inside of the pipe. The right end of the tube bends with the open end of the tube facing upstream at the center of the pipe. The tube is filled partially with mercury. The part of the tube connected to a hole in the side of the pipe at point B measures the pressure of the liquid at that point. The other end of the tube is located at the center of the pipe at the stagnation point A, and so point A is at the stagnation pressure of the liquid at that point. The tube is filled with liquid water except for the part filled with mercury. The liquid water flowing in the pipe can be considered to be fully developed laminar flow except for the small region where the tube disrupts the flow profile in the pipe. If the difference in the level of liquid mercury between the two sides of the U tube is 0.79 cm, determine the volumetric flow rate in the pipe. **State clearly all assumptions used to arrive at your answer.**

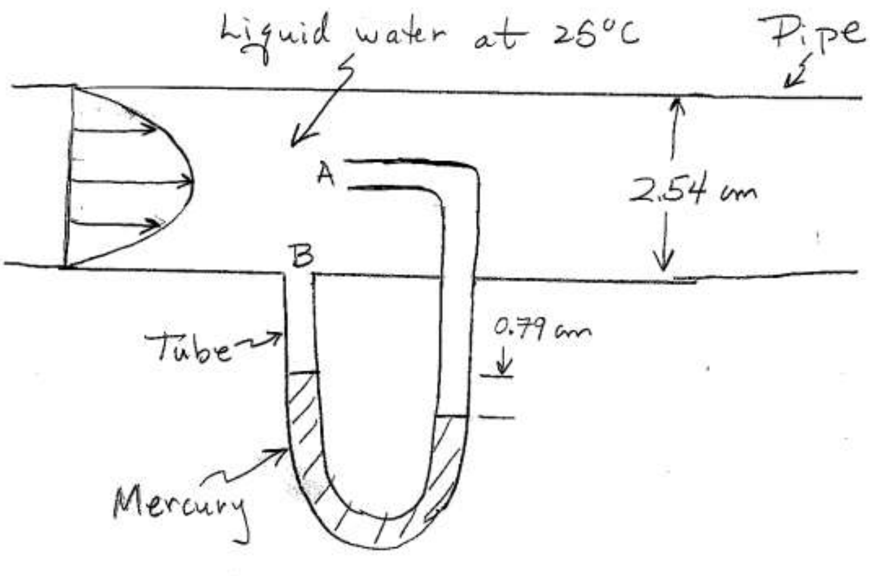


**Figure 2.** Operation of a pitot tube