# see belowPart 1 Convergent - Divergent Nozzle

## Orifice Calibration

With the given properties of the orifice plate, and the assumptions stated in the handout, the velocity and mass flow in the orifice plate are found by using Bernoulli's and the continuity equations respectively. The values are given in Table 1.

We can use Bernoulli's equation until the entrance to the orifice plate because we have assumed that the air is inviscid and also irrotational. In the mass flow calculation, we have included the contribution of the discharge coefficient Cd. This is defined as the ratio of actual mass flow rate to the theoretical mass flow rate.

Although we have assumed inviscid flow until the orifice, the actual orifice itself creates viscous effects which alter the real mass flow rate through the plate.



*Table 1*

## Pressure Distributions

The four distributions of pressure ratios are plotted on a single graph in Appendix B. The estimated throat location was at (just after) tapping 9, and the expected pressure ratio was found from the CUED tables to be 0.528.

## Run 3 Shock

In run 3, a shock is expected in the nozzle divergence, and the pressure distribution should show a sudden jump. This is not the case however due to the boundary layer which forms. A good approximation is to assume that the shock location is where there is the same pressure ratio as at the throat (M=1), leading to the conclusion that the shock wave is at pressure tapping 16.

From the Mach number at this tapping for *run 4* where M = 1.37, the CUED tables give Ms = 0.75. The expected pressure jump Ps/P is 2.023, whereas from my results comparing the pressure at tapping 15 and and tapping 17, the value for Ps/P is 1.422.

However, using the approximation shown on the graph by a dotted line, the ratio of Ps/P = 1.78 (using Ps = Pressure at 17th tapping for run three, and P = Pressure at 16th tapping for run 4), which approaches the theoretical value.

# Part 2 - Supersonic Wind Tunnel Shockwave

## Pressure Plots

The pressure plots for Non-dimensionalised pitot and static pressures are annotated as requested in the handout.

## Flow Mach Number

The ratio of static pressure to inlet stagnation pressure when the shock has passed downstream (Ps/Po) was used to determine the tunnel Mach number. The pressure plots give a value of P/Po after the shock has passed downstream to be 0.267, and this corresponds to a Mach number of 1.51. This is reasonable as the tunnel is designed to operate at a Mach number of 1.50.

## Static Pressure Measurements

The above Mach number and shock tables were used to calculate theoretical values for the static pressure ratio across the shock (Ps/P) to be 2.494. The jump seen in the measurements however gives a value of 2.140, which is 86% of the theoretical value.

## Pitot Pressure Measurements

The expected non-dimensional pitot pressure ratio should be 0.9266 at this Mach number, however the experiment shows this ratio to be 0.945.