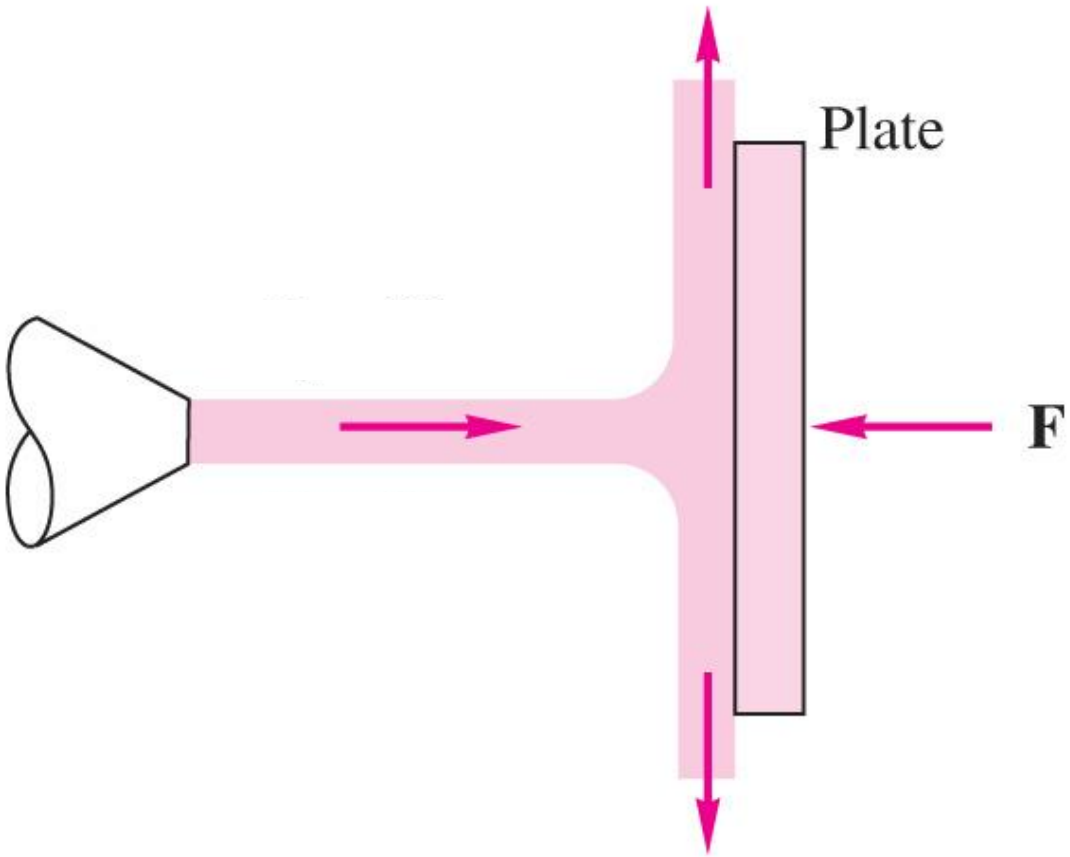
Lab X3 – Jet Impact Forces

Water, Wind, and Weather Forces

Problem Figure 3.40



The simplest case of the momentum force on an object

$$F = - mV = -(\rho A V) V = - \rho A V^2$$

Straight forward on paper.

But what is A? (area of impact)

Is the jet straight and smooth?

Does it expand or contract before hitting plate?

First approximation: Equals orifice size

Water Hammer – (Not a tool from Lowe's)

Water flow inside of a pipe can also exert forces on fittings.

When a pipe is initially empty and a pump starts, the slug of water can break fittings like elbows, or end caps.

In a closed fluid system:

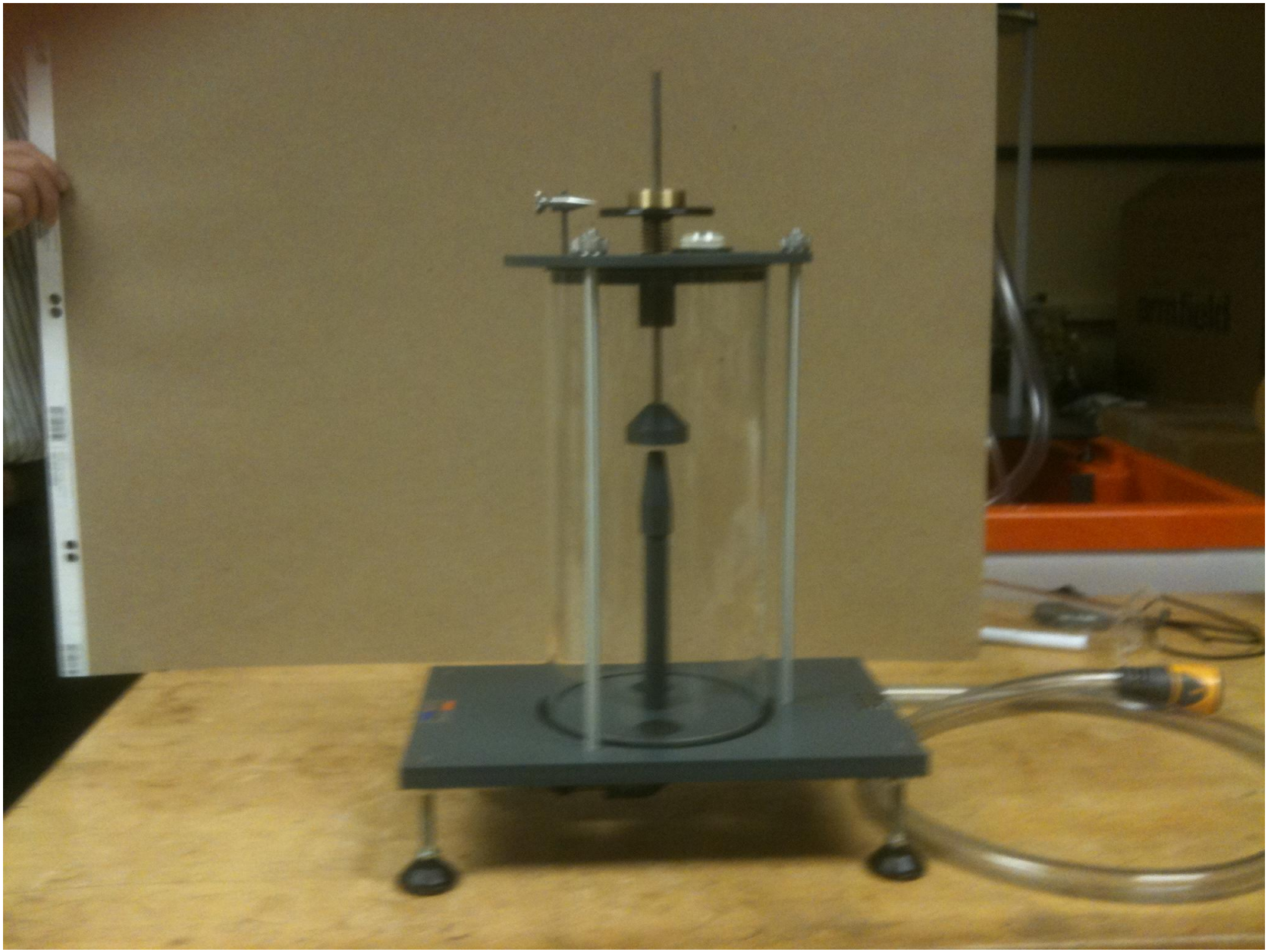
- The moving fluid is the “hammer”
- A valve, orifice, or pipe fitting is the “nail”

Unlike a hammer and nail:

- Water is compressible
- Pipe walls are elastic.

With this constraint, forces pipe can be very large.

We will be working with an open system.



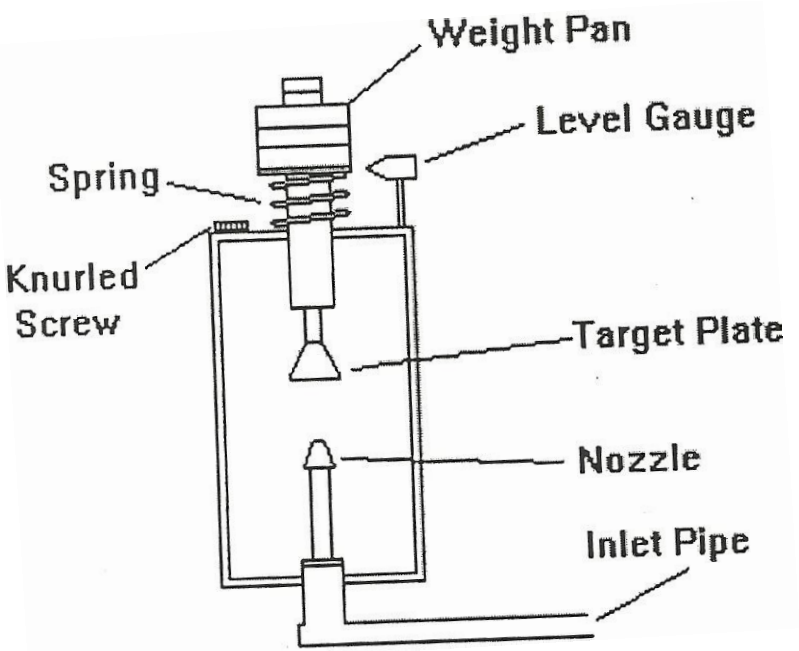


Diagram of the apparatus.

The impact force is measured directly by the weights place on the weight pan. No levers involved.

The calculated force is the momentum impact equation

For weights on pan from 100 g to @1 kg:

Measure and record water flow rate to balance.

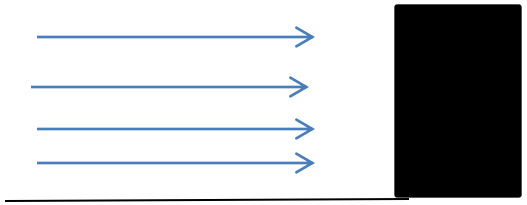
Calculate the expected Force from change in momentum

Plot Force (=m*g) of weights versus calculated Force.

Uncertainty Analysis:

Perform a Propagation of Error analysis to obtain the Fractional error ($\Delta F/F$)

1. Calculate forces on the block wall for range of water and of air velocities



Waves different from a surge, but same order of magnitude

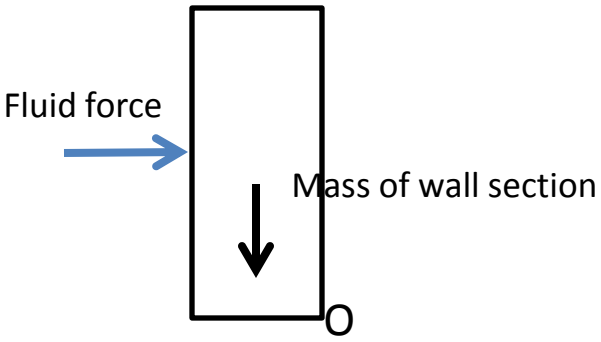
dens=	1030kg/m3	seawater
g=	980m/s^2	Vavg

3	m high
10	m long
30m^2	

1

2. Calculate the “tipping” point for each force.

(This is worst case; buried foundations would help)



Uncertainty analysis:

$F = - mV = -(\rho A V) V = - \rho A V^2$

Consider sources of uncertainty

$$\Delta M = \sqrt{\left(\frac{\partial f}{\partial x}\Delta x\right)^2 + \left(\frac{\partial f}{\partial y}\Delta y\right)^2 + \left(\frac{\partial f}{\partial z}\Delta z\right)^2 + \cdots}$$

Propagation of Error expression…WHAT'S THAT?