# Forced vortex flow

**(AS2100: Basic Aerospace Engineering Lab)**


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The experiment is carried out to study the relationship between the surface shape of a forced vortex flow and the angular velocity ($\omega$) of the rotating fluid . The height ($h$) of the free surface from the bottom of the container at different radial distances 'r' was measured using a set of electrical probes. Due to some unknown source of vibration in the setup the free surface of the fluid was found to have a wavy motion. This induces a periodically fluctuating error of frequency of about 30Hz in the measurement of free surface height along with the random errors. In order to remove the fluctuating component of error, readings from each probe was recorded for 2s with a sample frequency of 500Hz (each probe takes 1000 readings per $\omega$ value). The experiment is repeated for 5 sets of $\omega$ values The value of $r$, $R$, $\omega$ etc are known exactly unless specified.
The values of parameters are:

- Radius of the Cylinder, R = 0.05m
- Acceleration due to gravity, g = 9.8 $m/s^2$

The data set `P11_ForcedVortex.mat` contains,

- The angular velocity of the cylinder in $rad/s$ (each variable is an array of size 5, as the experiment is performed for 5 $\omega$ values)

  $\Longrightarrow$ `"w"`

- Corresponding values of free surface height in meters (each variable is a $20 \times 1000$ matrix, as there are 20 probes and the total number of taken by each probe over 2s is 1000)

  $\Longrightarrow$ `"h_w1","h_w2","h_w3","h_w4","h_w5"`

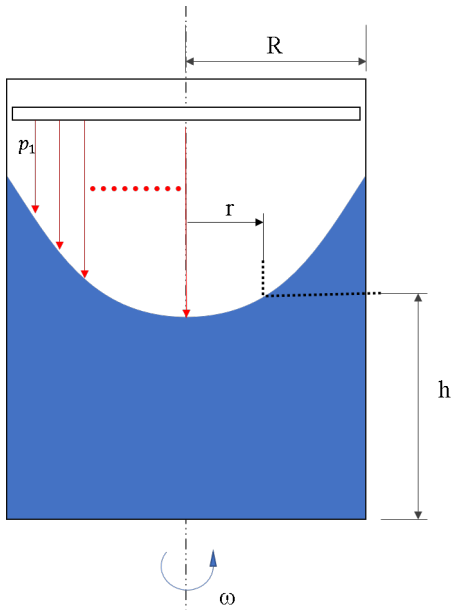


Figure 11: Forced vortex apparatus

1. Explain the theory behind the experiment
2. What are the possible sources of errors in the experiment and how to minimize them?

   Discuss a method and use it to remove periodically fluctuating components of error from strain readings given in the data set `P11_ForcedVortex.mat`.

3. Plot normalised histograms of resultant value of $h$ for $r = 0.0m$ for all the 5 $\omega$ values.Also plot the smoothened probability density function trends over the corresponding histograms.

4. Does the smoothened probability density curve obtained in the previous question resemble a normal probability density function? Determine the statistical quantities $\mu$ and $\sigma$ for each histogram and plot Gaussian probability density functions using these values. Compare it with corresponding smoothened plots obtained in question-4.

5. Derive an expression relating $h$,$r$ and $\omega$. Also Obtain the relationship for errors in $h$ as a function of errors in all the quantities in the above expression. (Hint:Refer to "function of errors/propagation of errors" in your textbooks.)

6. For each $\omega$ make a plot of $r$ vs $h$. Obtain a best fit curve. What is the mathematical form of this curve? Compare it with the theoretically derived curve in question-6.

7. What are the disadvantages of the current experimental setup? Suggest some improvements.

In addition to answers to the above questions each report should also include introduction about the experiment , schematics of the experimental setup, a results and discussion section and a conclusion section.