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Experiment 3a

Name - Manav Doshi
Roll Number - 200100094

Using rr no 2:
Given $r = 55 \times 10^{-3}$ m

$$\omega = \frac{2\pi n}{60}$$

$$h = \frac{\omega^2 r^2}{2g}$$

$$h = \left(\frac{2\pi \times 103}{60}\right)^2 \times \frac{(55 \times 10^{-3} m)^2}{2 \times 9.81}$$

$= 0.5929$ mm

* Sources of errors
i) we neglect the viscosity of water which might cause resistance at the walls
ii) Human errors while taking readings
iii) ~~Test~~ steady state velocity might not have been achieved when taking readings.

* Conclusion
We can observe that the nature of the graph of experimental height vs radius is almost parabolic. The deviation from theoretical values might be due to sources of errors.

Q) From pressure gradient equations

$$\frac{\partial P}{\partial \theta} = 0, \quad \frac{\partial P}{\partial r} = \rho r \omega^2, \quad \frac{\partial P}{\partial z} = -\rho g$$

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We know for isobars $dP=0$

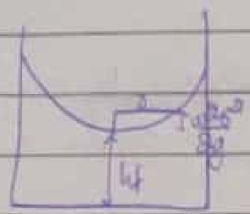
$$0 = \frac{\partial p}{\partial \theta} d\theta + \frac{\partial p}{\partial r} dr + \frac{\partial p}{\partial z} dz$$

$$\int \rho g\, dz = \int \rho \omega^2 r\, dr$$

$$\boxed{z = \frac{\omega^2 r^2}{2g} + h_f}$$

2a) Initial volume $= \frac{\pi D^2}{4} H$

Finally let $\Rightarrow$



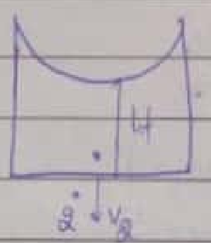
$V_i = V_f$

$$\frac{\pi D^2}{4} H = \int_0^{D/2} 2\pi r \left(h_f + \frac{\omega^2 r^2}{2g}\right) dr$$

$$\frac{\pi D^2 H}{4} = \frac{\pi \omega^2 D^4}{64 g} + \frac{\pi h_f D^2}{4}$$

$$\boxed{h_f = H - \frac{\omega^2 D^2}{16 g}}$$

b) using Bernoulli's between 1 and 2

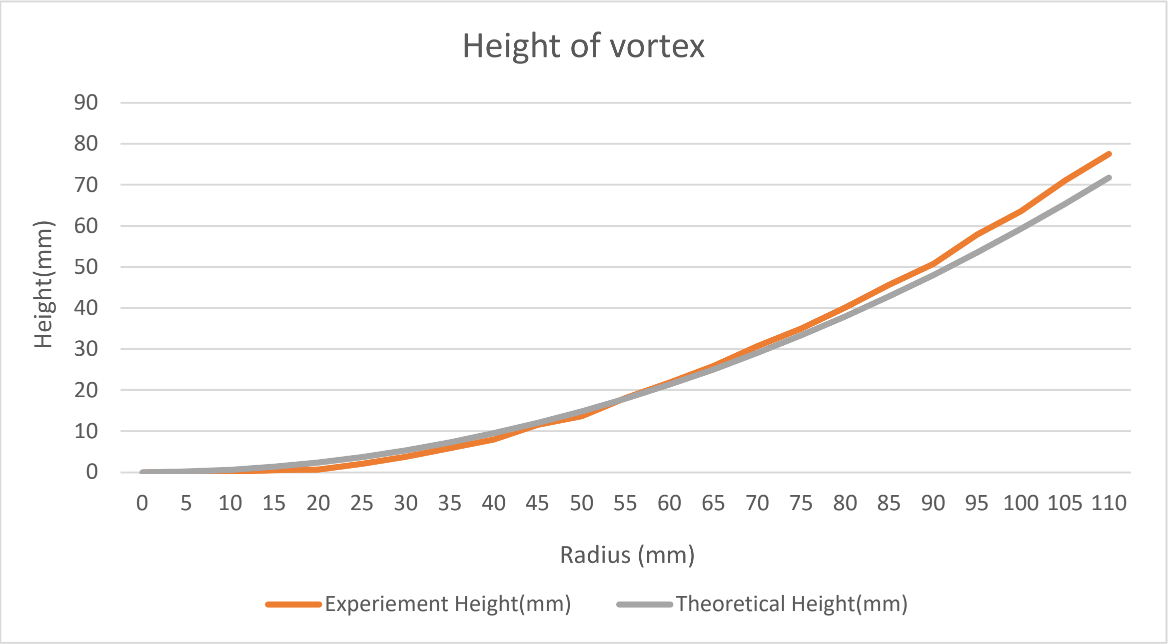


$$P_1 + \frac{\rho v_1^2}{2} = P_2 + \frac{\rho v_2^2}{2}$$

$$P_{atm} + \rho g h_f = P_{atm} + \frac{\rho v_2^2}{2}$$

$$\boxed{v_2 = \sqrt{2 g h_f} = \sqrt{2g\left(H - \frac{\omega^2 D^2}{16 g}\right)}}$$

Sr. No.	Radius (mm)	Experimental Height (mm)	Theoretical Height (mm)	RPM of the tank
0	0	0	0	103
1	5	0.07	0.148242487	103
2	10	0.1	0.592969946	103
3	15	0.46	1.334182379	103
4	20	0.62	2.371879785	103
5	25	2.02	3.706062163	103
6	30	3.76	5.336729515	103
7	35	5.83	7.26388184	103
8	40	7.97	9.487519138	103
9	45	11.55	12.00764141	103
10	50	13.67	14.82424865	103
11	55	18.08	17.93734087	103
12	60	21.81	21.34691806	103
13	65	25.91	25.05298022	103
14	70	30.68	29.05552736	103
15	75	34.97	33.35455947	103
16	80	40.13	37.95007655	103
17	85	45.64	42.84207861	103
18	90	50.7	48.03056564	103
19	95	57.86	53.51553764	103
20	100	63.58	59.29699461	103
21	105	71.03	65.37493656	103
22	110	77.56	71.74936348	103



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Experiment 3b

Name - Manav Doshi
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* Working and Calculations (Sr no 4)

$\rho = 1860\ kg\,m^{-3}$

$d = 11.41 \times 10^{-3}\ m$

$$F_B = \frac{\rho g \pi d^3}{6} = \frac{1260 \times 9.81 \times \cancel{3.}\pi \times (11.41 \times 10^{-3})^3}{6} = 0.0096138\ N$$

$$v = \frac{0.5}{t} = \frac{0.5}{4.7} = 0.10638298\ s$$

$$\text{Dynamic viscosity} = \frac{D}{3\pi v d} = \frac{mg - F_B}{3\pi v d} = \frac{0.00162 \times 9.81 - 0.0096138}{3\pi \times 0.10638298 \times 11.41} = 0.54880748$$

$$\text{Kinematic viscosity} = \frac{\text{Dynamic viscosity}}{\rho} = \boxed{0.00049556}$$

* Sources of error

i) Human error while measuring the time using stop watch

ii) A thin glass tube might not give as ~~much~~ effective results as a large liquid tank

iii) Steady state might not have been achieved when we assume velocity to have reached terminal velocity

Q) $ma = mg - (F_B + 6\pi\eta r v)$

$$mv\frac{dv}{dx} = mg - (\rho V g + 6\pi\eta r v)$$

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$$\int \frac{mv\,dv}{mg - \rho V g - 6\pi\eta r v} = dx$$

~~Integ~~ Integrating we get

$$\boxed{\frac{m}{6\pi\eta r}\left[-v - \left(\frac{mg - \rho V g}{6\pi\eta r}\right) \ln\left[1 - \frac{6\pi\eta r v}{mg - \rho V g}\right]\right] = x}$$

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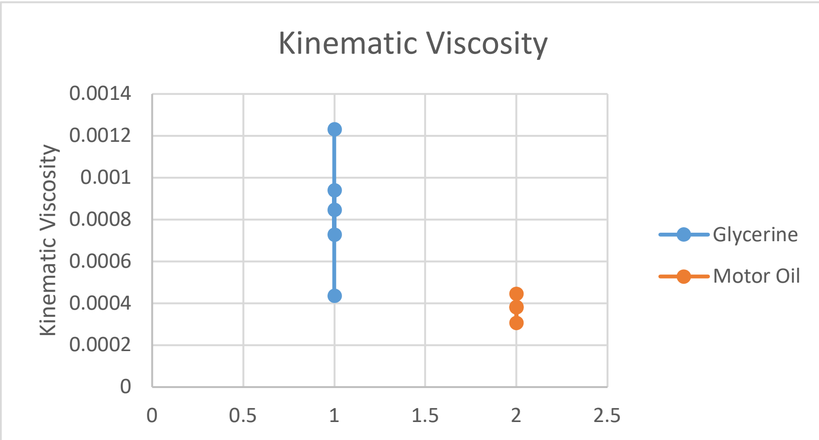

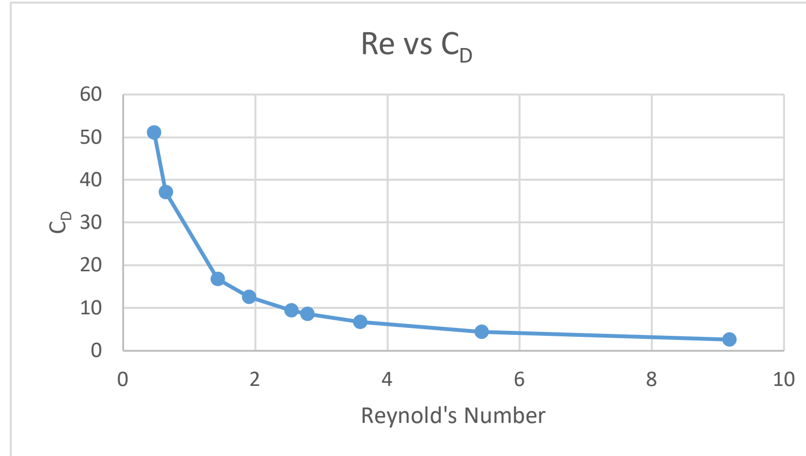

	Kinematic viscosity
1	0.001230723
1	0.000846526
1	0.000728112
1	0.00094009
1	0.000435561
2	0.000379865
2	0.000445708
2	0.000307095
2	0.000383986

Re	C_D
0.469657551	51.10106
0.646582768	37.11822
1.432637849	16.75231
1.906225902	12.59032
2.544853446	9.430798
2.786816101	8.611978
3.585616474	6.69341
5.422811443	4.425749
9.171189712	2.616891