BIRZEIT UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MECHATRONICS ENGINEERING

First Semester 2024

Fluid Mechanics Lab ENME312

Exp (1): Center of pressure

Submitted to: Dr. Adel Dweik, Dr. Mahdi Abu Homos

T.A: Eng. Ahmad Abu Baker

Group (3):

Name: Nada Abu al teen ID Number: 1200663

Name: Lara abu Zir ID Number: 1190345

Section Num: 2

Date of the experiment was performed & submitted: 19-11-2024.

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ABSTRACT

The main objective for this experiment is to determine the hydrostatic pressure, the center where it acts normally, the moment caused by it and the average specific weight to compare it with the actual one all these results were founded for partially and fully submerged planes depending on hydrostatic principle in addition to summation of moment at the point equals zero by using the center of pressure apparatus which is quadrant shaped tank and different values of weight.

The main results from this experiment are specific weight for the fully submerged which equals 9694.2 N/m^3 and for the partially submerged plane which equals 11370.4 N/m^3, so the average value for both of them is 10532.3 N/m^3 and need to be compared with the actual one 9810 N/m^3. The moment against depth curve for partially and fully submerged planes shows approximately linear relation.

From the results it is obvious that there is a difference between the actual and calculated value of the specific weight and this difference is equal to 7.4% which is acceptable.

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OBJECTIVES & MEASUREMENT METHOD'S

This experiment aims to find the hydrostatic pressure caused by water with its point of action, force acting by the water pressure, the moment caused by the force the average specific weight and the relation between the moment and the height for fully and partially submerged planes depending on the hydrostatic principle. All these need to be found by measuring the depth of water in mm for different weight values starting by 50 grams and then increase it for each run, these measurements need to be done twice, first at tilting angle equals to zero and second for tilting angle equals to 20 degrees using the center of pressure apparatus (quadrant shaped tank holds water).

SAMPLE CALCULATIONS

$$\mathrm{M} = \mathrm{W} \times R_3 \quad \text{………. Eq (1)}$$

Where:

M: The moment.

W: The weight of the weights added to the arm [kg].

R3: The arm radius [mm].

For fully submerged:

$$M = \frac{\gamma\, B\, \cos\theta}{3}(R_2^3 - R_1^3) - \frac{\gamma\, B\, (R_2^2 - R_1^2)h}{2} \quad \text{………. Eq (2)}$$

θ: Tilting angle [Degrees].

γ: Specific weight, which equals ρg [N/m3] and will be determined experimentally.

h: Water depth [mm].

R1, R2 and B values are given in table (1) below.

$$Slope = -\frac{\gamma_1\, \mathrm{B}({R_2}^2 - R_1^2)}{2}$$

$$-10.906 = -\frac{\gamma\, 0.075\,(0.2^2 - 0.1^2)}{2}$$

$$\gamma_1 = 9694.2\ \text{N/m3}$$

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For partially submerged:

$$M = \frac{\gamma \ B \ R_2^3 \ \cos\theta}{3} - \frac{\gamma \ B \ R_2^2 h}{2} + \frac{\gamma \ B \ h^3 sec^2\theta}{6} \qquad \text{…..… Eq (3)}$$

Sample for θ = 0

$$Slope = \frac{M'}{h^3} = \frac{\gamma_2 B sec^2\theta}{6}$$

$$142.13 = \frac{\gamma_2 * 0.075 * sec^2 0}{6}$$

$$\gamma_2 = 11370.4 \text{N}/m^3$$

$$\text{Yavg} = (\text{y1}+\text{y2})/2 = 10532.3 \ \text{N}/m^3$$

Same goes for θ = 20 but using cosine of 20

PRESENTATION & RESULTS

Table 1: data given (R1, R2, B, R3) in (mm))

Parameter	Value (mm)
R1	100
R2	200
B	75
Arm radius R3	250

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Table 2: data and calculations for tilting angle equals to 0 (weight (g), depth of water (mm), depth of water (m), weight (Kg), moment (N.m).

		ϴ=0				
weight(g)	h(mm)	h(m)	weight(kg)	M(N.m)	Mprime	h^3
50	155	0.155	0.05	0.122625	2.37648	0.003724
70	144	0.144	0.07	0.171675	2.265579	0.002986
90	138	0.138	0.09	0.220725	2.227383	0.002628
110	128	0.128	0.11	0.269775	2.131023	0.002097
130	122	0.122	0.13	0.318825	2.092827	0.001816
150	118	0.118	0.15	0.367875	2.083713	0.001643
180	108	0.108	0.18	0.44145	2.011878	0.00126
200	106	0.106	0.2	0.4905	2.031846	0.001191
250	92	0.092	0.25	0.613125	1.950897	0.000779
270	88	0.088	0.27	0.662175	1.941783	0.000681
290	84	0.084	0.29	0.711225	1.932669	0.000593
310	78	0.078	0.31	0.760275	1.894473	0.000475
330	74	0.074	0.33	0.809325	1.885359	0.000405
350	70	0.07	0.35	0.858375	1.876245	0.000343
380	64	0.064	0.38	0.93195	1.862574	0.000262
400	58	0.058	0.4	0.981	1.824378	0.000195

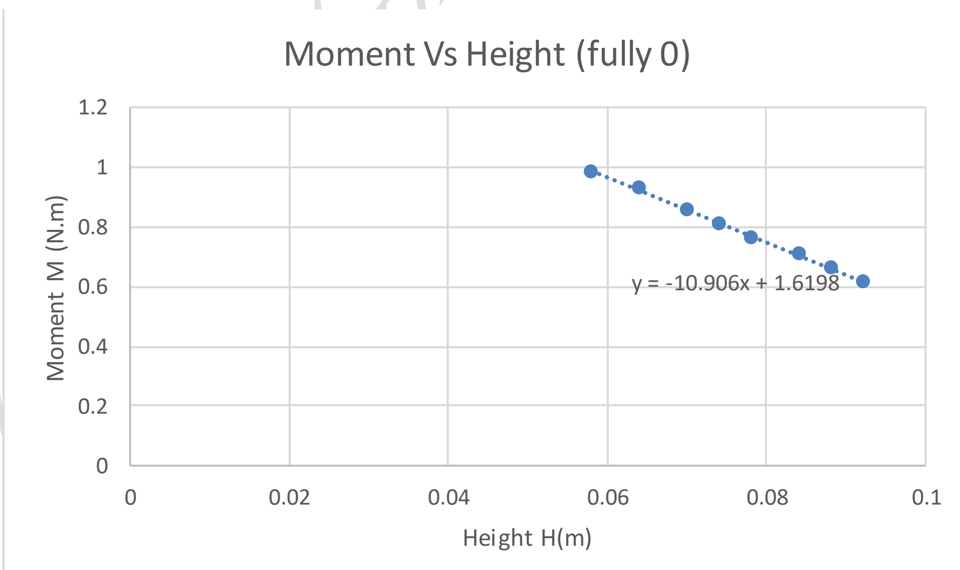

Figure 1: moment (N.m) Vs. water depth (m) for tilting angle 0 for fully submerged plane.

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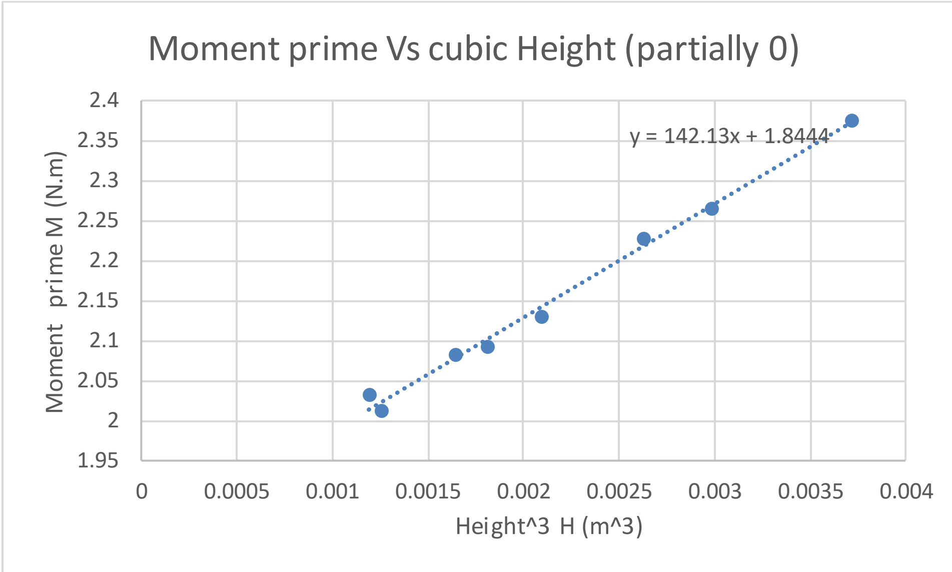

Figure 2: M prime Vs. cubic height (m) for tilting angle 0 for partially submerged plane.

Table 3: data and calculations for tilting angle equals to 20 (weight (g), depth of water (mm), depth of water (m), weight (Kg), moment (N.m).

		Ө=20				
weight(g)	h(mm)	h(m)	weight(kg)	M(N.m)	M PRIME	h^3
20	150	0.15	0.02	0.04905	2.2302	0.003375
40	140	0.14	0.04	0.0981	2.13384	0.002744
60	134	0.134	0.06	0.14715	2.095644	0.002406
90	120	0.12	0.09	0.220725	1.965645	0.001728
110	116	0.116	0.11	0.269775	1.956531	0.001561
160	104	0.104	0.16	0.3924	1.904664	0.001125
180	98	0.098	0.18	0.44145	1.866468	0.000941
200	92	0.092	0.2	0.4905	1.828272	0.000779
220	90	0.09	0.22	0.53955	1.84824	0.000729
240	86	0.086	0.24	0.5886	1.839126	0.000636
260	80	0.08	0.26	0.63765	1.80093	0.000512
290	72	0.072	0.29	0.711225	1.758177	0.000373
310	70	0.07	0.31	0.760275	1.778145	0.000343
360	58	0.058	0.36	0.8829	1.726278	0.000195
380	54	0.054	0.38	0.93195	1.717164	0.000157
400	50	0.05	0.4	0.981	1.70805	0.000125

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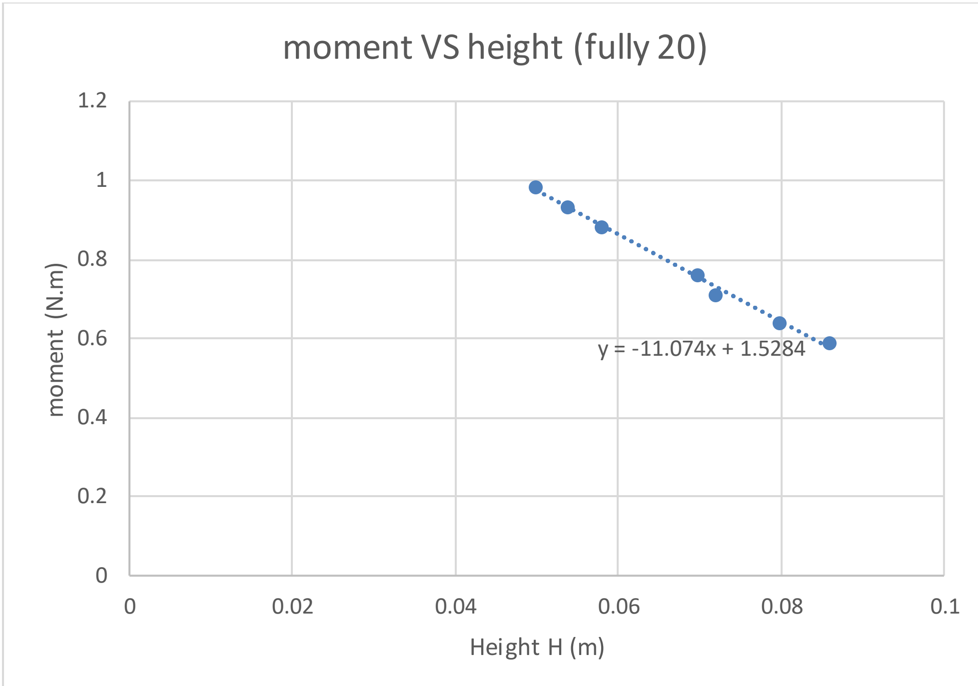

Figure 3: moment (N.m) Vs. water depth (m) for tilting angle 20 for fully submerged plane.

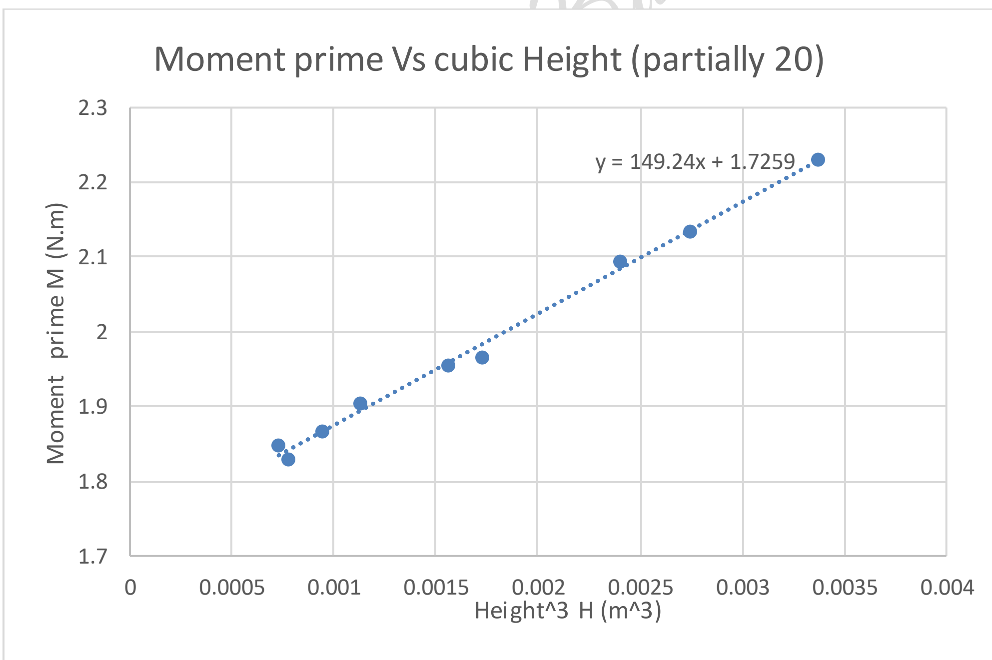

Figure 4: M prime (N.m) Vs. cubic height (m) for tilting angle 20 for partially submerged plane.

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DISCUSSION OF RESULTS

Two pressure levels are used in this experiment: totally submerged and half submerged. All heights from 100 and up were partially submerged—all heights from 100 and below were entirely submerged—when the angle in the first section was zero.

In this instance, the quarter form rises, suggesting that the shape below is the one that is fully affected, setting it apart from partially submerged situations. This is because the area of the center of pressure is fully submerged in water. The distinction in this case of being partially submerged in water is that not all of them are in the water.

Weights and height have an inverse connection; as weights rise, height falls and the body submerges entirely in water.

The height of the moment around the pin decreased as the weights increased from the tables. If an object's height is less than 100, it is considered fully submerged at angle 0, and if it is larger than 100, it is considered partially submerged. This is because I need more water to regain my equilibrium when lifting greater weights, particularly those at lower heights.

The sources of inaccuracy in this experiment are represented by the low accuracy because it was difficult to construct precisely. In addition to the possibility that the height of the water may have been approximated, the balance through the quadrant is also approximate, and the state of pouring water to reach equilibrium is through the eye, which includes inaccuracy.

CONCLUSIONS

It is obvious that any resting liquid on walls produce a hydrostatic force and pressure acted at the center of pressure and depend on the density of the fluid and the depth of it below the surface also the moment on the plane surface is opposite to the moment caused by fluid.

The main results from the experiment are the calculated average specific weight 10532.3N/m^3, for fully submerged is equal to 9694.2 N/m^3 and for partially submerged is equal to 11370.4N/m^3 while the theoretical value is equal to 9810 N/m^3 and the difference between it and the average one is equal to 7.4% which is an acceptable value and it is nearer to the fully submerged than the partially one, and also the moment value which is different for each run.

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To improve the experiment results we need to be more accurate while taking the reading of depth from the scale and repeat the reading more than one time by different persons also if we took more runs the results and graphs will be more accurate.

The center of pressure from fluid has many applications from the real life like vertical dams and curved reservoirs, sluice gates, floating objects like boats and submerged cylinders in water tank.

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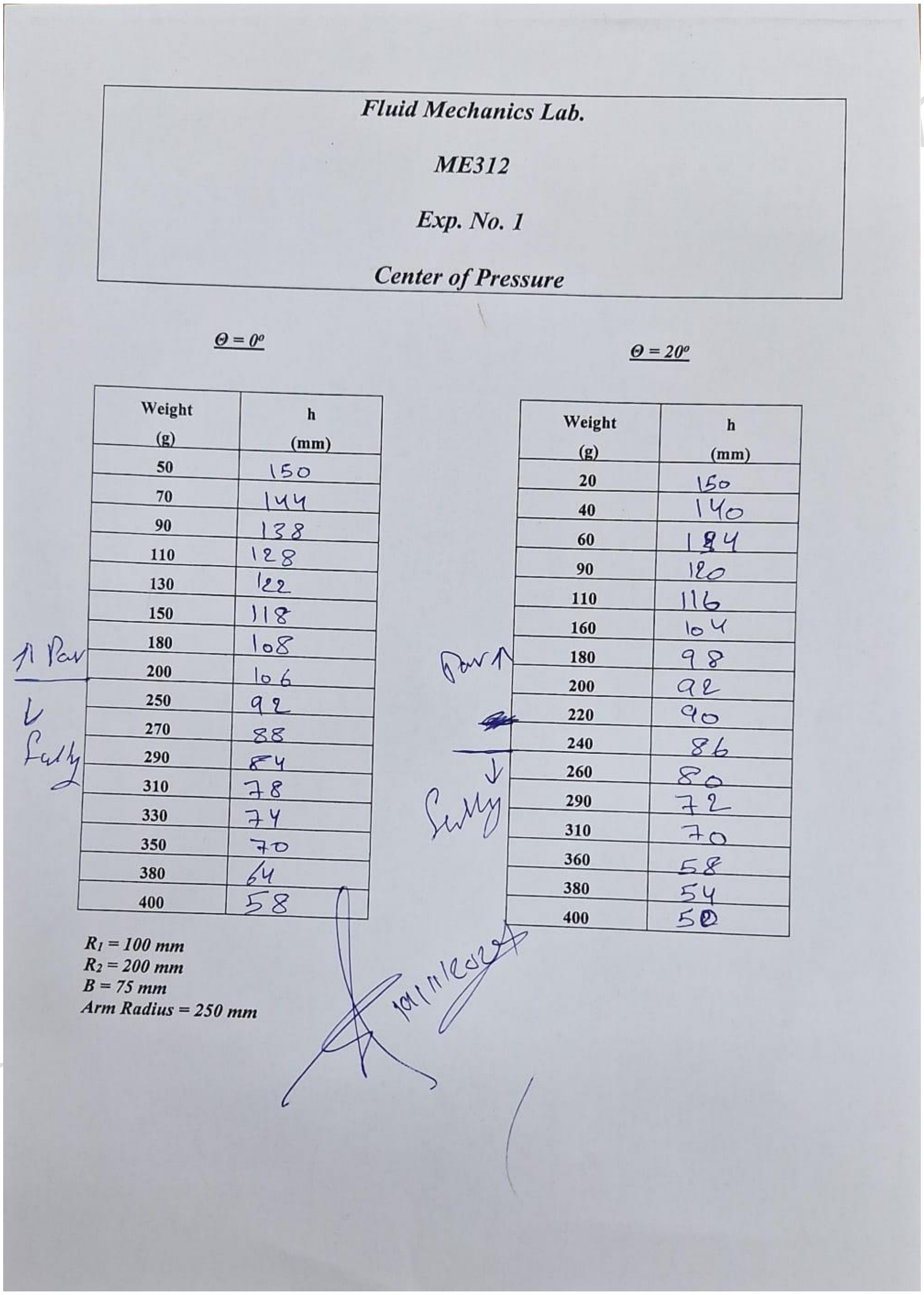
APPENDICES

- Fluid laboratory manual



Fluid Mechanics Lab.

ME312

Exp. No. 1

Center of Pressure

Θ = 0°

Weight (g)	h (mm)
50	150
70	144
90	138
110	128
130	122
150	118
180	108
200	106
250	92
270	88
290	84
310	78
330	74
350	70
380	64
400	58

Θ = 20°

Weight (g)	h (mm)
20	150
40	140
60	134
90	120
110	116
160	104
180	98
200	92
220	90
240	86
260	80
290	72
310	70
360	58
380	54
400	50

R_1 = 100 mm
R_2 = 200 mm
B = 75 mm
Arm Radius = 250 mm

Figure 4: original data sheet

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