Experiment 2: Metacentric Height

Specifications: Weight of the ship model (W) = 18.64 N. Movable Weight (m) = 0.98 N.

Observation & Result Table (Ref. Pg 12)

Sr. No.	**Movable Weight (m) in N**	**Distance moved (X) in m**	**Angle of Tilt θ (°)**	**Tan θ**	**Metacentric Height GM (m)**
1	0.98	0.015	1.41	0.0246	0.0320
2	0.98	0.025	2.35	0.0411	0.0320
3	0.98	0.035	3.29	0.0575	0.0320
4	0.98	0.045	4.23	0.0739	0.0320

Calculation formula: GM = (m * X) / (W * tanθ)

Make sample calculation by yourself for above 4 observations

Average Metacentric Height (GM) = 0.0320 m

Experiment 3: Verification of Bernoulli's Theorem

Observation Table (Ref. Pg 18)

Piezometer No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Width (mm)	40	40	40	40	40	40	40	40
Height (mm)	17	13	10	7	9	12	15	18
Area (m^2)	0.000680	0.000520	0.000400	0.000280	0.000360	0.000480	0.000600	0.000720

Result Table - Run No. 1

Parameter	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Discharge Q	0.000286							
v = Q/A (m/s)	0.4202	0.5495	0.7143	1.0204	0.7937	0.5952	0.4762	0.3968
$v^2/2g$ (m)	0.0090	0.0154	0.0260	0.0531	0.0321	0.0181	0.0116	0.0080
p/w + z (m)	0.2410	0.2296	0.2140	0.1819	0.1979	0.2069	0.2084	0.2070
Total Energy E (m)	0.2500	0.2450	0.2400	0.2350	0.2300	0.2250	0.2200	0.2150

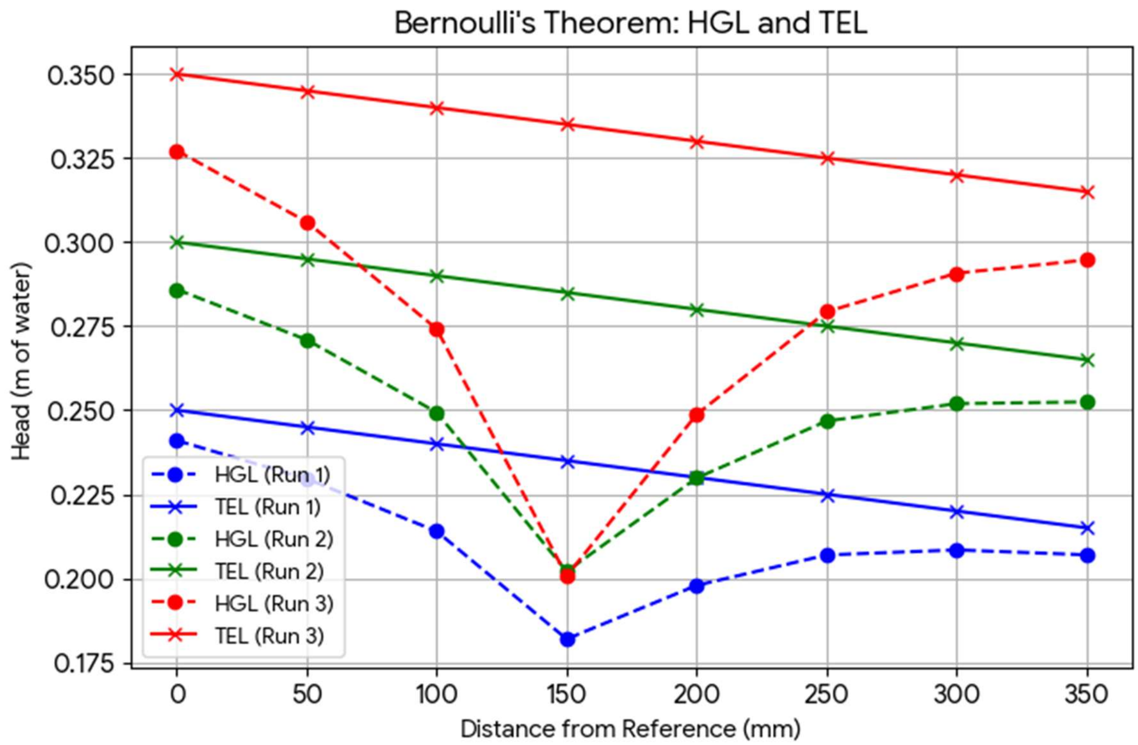
Result Table - Run No. 2

Parameter	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Discharge Q	0.000357							
v = Q/A (m/s)	0.5252	0.6868	0.8929	1.2755	0.9921	0.7440	0.5952	0.4960
$v^2/2g$ (m)	0.0141	0.0240	0.0406	0.0829	0.0502	0.0282	0.0181	0.0125
p/w + z (m)	0.2859	0.2710	0.2494	0.2021	0.2298	0.2468	0.2519	0.2525
Total Energy E (m)	0.3000	0.2950	0.2900	0.2850	0.2800	0.2750	0.2700	0.2650

Result Table - Run No. 3

Parameter	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Discharge Q	0.000455							
v = Q/A (m/s)	0.6684	0.8741	1.1364	1.6234	1.2626	0.9470	0.7576	0.6313
$v^2/2g$ (m)	0.0228	0.0389	0.0658	0.1343	0.0813	0.0457	0.0293	0.0203
p/w + z (m)	0.3272	0.3061	0.2742	0.2007	0.2487	0.2793	0.2907	0.2947
Total Energy E (m)	0.3500	0.3450	0.3400	0.3350	0.3300	0.3250	0.3200	0.3150

Graph: Hydraulic Gradient Line & Total Energy Line (Ref. Pg 19)



Experiment 4: Venturimeter

Specifications:

Diameter at Inlet D1 = 26 mm = 0.026 m

Diameter at Throat D2 = 16 mm = 0.016 m

Area A1 = 0.000531 m^2

Area A2 = 0.000201 m^2

Delivery Tank Volume = 0.3 x 0.3 x 0.1 = 0.009 m^3

Observation & Calculation Table (Ref. Pg 23 & 24)

Sr. No.	**Manometer Diff (mm of Hg)**	**Time for 0.1m height t (sec)**	**Discharge Q (m^3/s)**	**Cd**
1	9.6	28.00	0.000321	0.9600
2	14.2	23.00	0.000391	0.9600
3	20.9	19.00	0.000474	0.9600

Calculations:

Discharge Q = L*B*H / t

h_w = 12.6 * h_Hg

Cd = Q / (A2 * sqrt(2g h_w / (1 - $(A2/A1)^2$)))

Make sample calculation by yourself for above 3 observations

Average Co-efficient of discharge for Venturi meter is = 0.9600

Experiment 5: Orifice meter

Specifications:

Diameter at Inlet D1 = 26 mm = 0.026 m

Diameter at Orifice D2 = 16 mm = 0.016 m

Area A1 = 0.000531 m^2

Area A2 = 0.000201 m^2

Delivery Tank Volume = 0.3 x 0.3 x 0.1 = 0.009 m^3

Observation & Calculation Table (Ref. Pg 27 & 28)

Sr. No.	**Manometer Diff (mm of Hg)**	**Time for 0.1m height t (sec)**	**Discharge Q (m^3/s)**	**Cd**
1	17.6	32.00	0.000281	0.6200
2	26.7	26.00	0.000346	0.6200
3	41.0	21.00	0.000429	0.6200

Make sample calculation by yourself for above 3 observations

Average Co-efficient of discharge for Orifice meter is = 0.6200

Experiment 6: Flow over a Notch

Specifications: Tank capacity for time measurement = 10 Liters (0.01 m^3). V-Notch Angle = 60°. Trapezoidal Notch Crest L = 0.03 m, θ/2 = 30°.

Observation & Calculation Table (Ref. Pg 32)

Sr. No.	Type of Notch	Sill Level (s) m	Water Height (h) m	Time for 10L (t) sec	Discharge Q (m^3/s)	Cd
1	V-Notch (60°)	0.05	0.09	38.19	0.000262	0.6000
2	V-Notch (60°)	0.05	0.1	21.86	0.000457	0.6000
3	Trapezoidal	0.05	0.08	23.97	0.000417	0.6200
4	Trapezoidal	0.05	0.09	14.08	0.000710	0.6200

Calculations (Pg 32-33):

For Triangular Notch:

Q_th = (8/15) * sqrt(2g) * tan(θ/2) * H^(5/2)

For Trapezoidal Notch:

Q_th = sqrt(2g) * H^(3/2) * [(2/3)L + (8/15)H*tan(θ/2)]

Make sample calculation by yourself for above 4 observations

1. Average Co-efficient of discharge of triangular notch is = 0.6000

2. Average Co-efficient of discharge of trapezoidal notch is = 0.6200

Experiment 7: Coefficient of discharge of an orifice

Specifications: Orifice diameter (d) = 10 mm (0.01 m). Measuring tank Area L x B = 0.3 x 0.3 = 0.09 m^2.

Observation & Calculation Table (Ref. Pg 37)

Sr	Head h(m)	d_c (m)	a_c (m^2)	Cc	x (m)	y (m)	Cv	Δh tank	t (s)	Vol(m^3)	Q_act	Cd
1	0.4	0.0079	0.000049	0.6300	0.388	0.100	0.9700	0.05	33.5	0.0045	0.000134	0.6111
2	0.5	0.0079	0.000049	0.6300	0.434	0.100	0.9700	0.05	29.9	0.0045	0.000150	0.6111
3	0.6	0.0079	0.000049	0.6300	0.475	0.100	0.9700	0.05	27.3	0.0045	0.000165	0.6111

Calculations Formulae:

Cv = sqrt(x^2 / 4yh)

Cc = (d_c / d)^2

Cd = Q_act / (a * sqrt(2gh))

Make sample calculation by yourself for above 3 observations

Experiment 8: Reynolds Experiment

Specifications: Pipe inner diameter D = 15 mm (0.015 m). Kinematic viscosity $\nu = 1.004 \times 10^{-6}$ m^2/s. Measuring tank L x B = 0.3 x 0.3 m.

Observation & Calculation Table (Ref. Pg 41)

Sr. No.	Rise of water h (m)	Time t (sec)	Discharge Q (m^3/s)	Velocity V (m/s)	Reynolds No. Re	Flow Regime
1	0.02	126.8	0.000014	0.0803	1200	Laminar
2	0.02	54.4	0.000033	0.1874	2800	Transition
3	0.02	27.7	0.000065	0.3681	5500	Turbulent

Make sample calculation by yourself for above 3 observations

Experiment 9: Pipe Friction Factor

Specifications: Length L = 1 m. GI Pipe D = 27 mm. Copper Pipe D = 22 mm. SS Pipe D = 17 mm. Volume for t = 10 Liters (0.01 m^3).

Observation & Calculation Table (Ref. Pg 45-46)

Sr. No.	**Pipe Type**	**H (mm Hg)**	**Time t (sec)**	**Q (m^3/s)**	**V (m/s)**	**Friction factor (f)**
1	G.I. Pipe	2.9	20.0	0.000500	0.8733	0.0250
2	G.I. Pipe	2.4	22.0	0.000455	0.7939	0.0250
3	Copper Pipe	3.3	24.0	0.000417	1.0961	0.0150
4	Copper Pipe	2.8	26.0	0.000385	1.0118	0.0150
5	SS Pipe	7.1	28.0	0.000357	1.5735	0.0120
6	SS Pipe	6.2	30.0	0.000333	1.4686	0.0120

Calculations Formulae:

hf = 12.6 * H (where H is in meters of Hg)

hf = f * L * V^2 / (2*g*D)

Make sample calculation by yourself for above 6 observations

Average value of 'f' for G.I pipe = 0.0250

Average value of 'f' for Copper pipe = 0.0150

Average value of 'f' for SS pipe = 0.0120

Experiment 10: Loss Coefficients for Pipe Fittings

Specifications: Basic piping 15mm. Sudden expansion 15mm to 26mm. Sudden contraction 26mm to 15mm. Volume for t = 10 Liters (0.01 m^3).

Observation & Calculation Table (Ref. Pg 49-50)

Sr	Fitting	H (m Hg)	t (sec)	Q (m^3/s)	V (m/s)	Head Loss h_L (m)	K_L
1	Small bend (Elbow)	0.0360	18.0	0.000556	3.1438	0.4534	0.9000
2	Large bend	0.0160	18.0	0.000556	3.1438	0.2015	0.4000
3	Sudden expansion	0.0200	18.0	0.000556	3.1438	0.2519	0.5000
4	Sudden contraction	0.0160	18.0	0.000556	3.1438	0.2015	0.4000

For Elbow (Small Bend)

1. Mean cross sectional area $A = (\pi/4)D^2 = (\pi/4)(0.015\ m)^2 = 0.0001767\ m^2$

Where D = mean diameter = 0.015 m

2. Discharge, $Q = (0.01 / t) = 0.01 / 20.0 = 0.000500\ m^3/s$

Velocity of flow, $V = (Q / A) = 0.000500 / 0.0001767 = 2.8294$ m/s

(Velocity head $V^2/2g = 2.8294^2 / 19.62 = 0.4080$ m)

3. $h\_L = (13.6 - 1) H = 12.6 H$

Observed Manometer difference (H) = 0.029 m of Hg

$h\_L = 12.6 \times 0.029 = 0.3654$ m of water

4. Theoretical head loss $h\_L = k\_L (V^2 / 2g)$

$0.3654 = k\_L \times 0.4080$

5. From above equation find loss coefficient k_L:

$k\_L = 0.3654 / 0.4080 = 0.8955$

For Large Bend

1. Mean cross sectional area $A = (\pi/4)D^2 = (\pi/4)(0.015\ m)^2 = 0.0001767\ m^2$

Where D = mean diameter = 0.015 m

2. Discharge, $Q = (0.01 / t) = 0.01 / 20.0 = 0.000500\ m^3/s$

Velocity of flow, $V = (Q / A) = 0.000500 / 0.0001767 = 2.8294$ m/s

(Velocity head $V^2/2g = 2.8294^2 / 19.62 = 0.4080$ m)

3. $h\_L = (13.6 - 1) H = 12.6 H$

Observed Manometer difference (H) = 0.013 m of Hg

$h\_L = 12.6 \times 0.013 = 0.1638$ m of water

4. Theoretical head loss $h\_L = k\_L (V^2 / 2g)$

$0.1638 = k\_L \times 0.4080$

5. From above equation find loss coefficient k_L:

$k\_L = 0.1638 / 0.4080 = 0.4014$

For Sudden Enlargement (from Ø=15mm to Ø=26mm)

1. Mean cross sectional area $A = (\pi/4)D^2 = (\pi/4)(0.015\ m)^2 = 0.0001767\ m^2$

Where D = mean diameter = 0.015 m

2. Discharge, $Q = (0.01 / t) = 0.01 / 20.0 = 0.000500\ m^3/s$

Velocity of flow, $V = (Q / A) = 0.000500 / 0.0001767 = 2.8294\ m/s$

(Velocity head $V^2/2g = 2.8294^2 / 19.62 = 0.4080\ m$)

3. $h\_L = (13.6 - 1)\ H = 12.6\ H$

Observed Manometer difference (H) = 0.014 m of Hg

$h\_L = 12.6 \times 0.014 = 0.1764$ m of water

4. Theoretical head loss $h\_L = k\_L\ (V^2 / 2g)$

$0.1764 = k\_L \times 0.4080$

5. From above equation find loss coefficient k_L:

$k\_L = 0.1764 / 0.4080 = 0.4323$

For Sudden Contraction (from Ø=26mm to Ø=15mm)

1. Mean cross sectional area $A = (\pi/4)D^2 = (\pi/4)(0.015\ m)^2 = 0.0001767\ m^2$

Where D = mean diameter = 0.015 m

2. Discharge, $Q = (0.01 / t) = 0.01 / 20.0 = 0.000500\ m^3/s$

Velocity of flow, $V = (Q / A) = 0.000500 / 0.0001767 = 2.8294\ m/s$

(Velocity head $V^2/2g = 2.8294^2 / 19.62 = 0.4080\ m$)

3. $h\_L = (13.6 - 1)\ H = 12.6\ H$

Observed Manometer difference (H) = 0.011 m of Hg

$h\_L = 12.6 \times 0.011 = 0.1386$ m of water

4. Theoretical head loss $h\_L = k\_L\ (V^2 / 2g)$

$0.1386 = k\_L \times 0.4080$

5. From above equation find loss coefficient k_L:

$k\_L = 0.1386 / 0.4080 = 0.3397$

Experiment 11: Velocity using Pitot Tube

Specifications: A = 0.1 m^2 (Tank area), a = 0.0006157 m^2 (Pipe area). Tank liquid rise R = 5 cm (0.05m).

Observation Table (Ref. Pg 56)

Sr	H (+8mm)	H (+6mm)	H (+4mm)	H (0mm)	H (-4mm)	H (-6mm)	H (-8mm)	R (cm)	t (sec)
1	0.4	0.4	0.4	0.4	0.4	0.4	0.4	5.0	30.0
2	0.6	0.6	0.6	0.6	0.6	0.6	0.6	5.0	25.0
3	0.9	0.9	1.0	1.0	1.0	0.9	0.9	5.0	20.0

Calculation Table (Ref. Pg 56)

Sr	Cv	Va (m/s)	V (+8)	V (+6)	V (+4)	V (0)	V (-4)	V (-6)	V (-8)
1	0.98	0.2707	0.3070	0.3156	0.3209	0.3248	0.3209	0.3156	0.3070
2	0.98	0.3248	0.3684	0.3787	0.3851	0.3898	0.3851	0.3787	0.3684
3	0.98	0.4060	0.4605	0.4733	0.4814	0.4873	0.4814	0.4733	0.4605