Cover Sheet

ME 3414 Experiment #2 – Spring 2026

Printed name: Zachary Rohloff

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6:30PM 3/23/26

Impact of a jet: Application of the linear momentum equation

1. At a flow rate of 0.35 liter/s determine how far above the nozzle exit the target would need to be located such that the water jet just touches the target, but exerts no force on the target? Show your analysis and calculations.

$Q = 0.35 = 0.00035 m^3/s$

$D = 10mm$

$A = \frac{\pi}{4} 0.01^2$

$V = \frac{Q}{A} = 4.456 m/s$

$a = g = -9.81$

$V_f^2 = V_0^2 + 2a\Delta h$

$0 = 4.456^2 + 2 \cdot 9.81 \cdot y$

$y = h = \frac{4.456^2}{2 \cdot 9.81} = 1.012 m$

At the given flow rate a vane would need to be placed 1.012 meters from the nozzle exit to be just touched by the water jet.

CamScanner

Data Sheet for Experiment #2, Spring 2026 (Must be included in your formal report, with signatures).

CRN and Group: 22639 - B3 Date and time: 3123126 6:30 PM

Honor Pledge: I have neither given nor received unauthorized assistance on this assignment.

Printed names of bench members: Zachary Rohloff Lollin Lyons

Signatures of bench members: Zachary Rohloff Lollin Lyons

Table 1

Flat Plate Vane			
Q	*y* *Trial 1*	*y* *Trial 2*	*y* *Trial 3*
(liters/s)	(mm)	(mm)	(mm)
0.60	110	110	111
0.55	93	94	93
0.50	75	75	76
0.45	61	60	60
0.40	50	51	50
0.35	35	35	35
0.30	22	22	22
0.25	~~15~~ 15	~~14~~ 14	~~14~~ 14
0.20	9	10	10
0.15	4	4	4

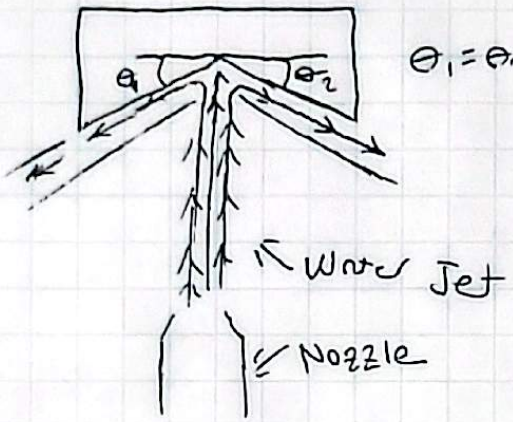
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Table 1 (continued)

Conical Vane			
Q	*y* *Trial 1*	*y* *Trial 2*	*y* *Trial 3*
(liters/s)	(mm)	(mm)	(mm)
0.60	166	166	165
0.55	139	139	140
0.50	116	115	115
0.45	97	97	97
0.40	78	77	78
0.35	57	57	57
0.30	44	43	45
0.25	28	23	27
0.20	17	16	17
0.15	10	10	9

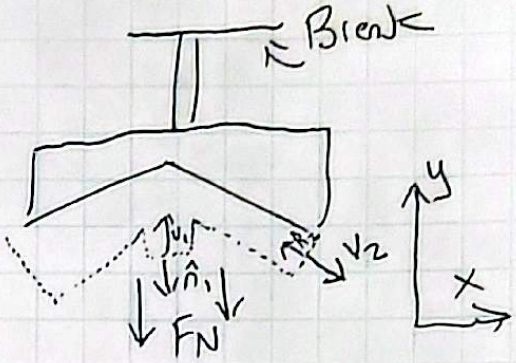
Hemispherical Vane			
Q	*y* *Trial 1*	*y* *Trial 2*	*y* *Trial 3*
(liters/s)	(mm)	(mm)	(mm)
0.60	203	204	203
0.55	172	173	173
0.50	139	138	140
0.45	115	116	115
0.40	91	90	90
0.35	61	69	69
0.30	51	50	50
0.25	34	34	34
0.20	22	22	22
0.15	12	12	13

Part 3 (C) Pie Lab



$\theta_1 = \theta_2 = 30°$

CV used ie just before "impact" & just after leaving surface



Assumptions

$W = 0$

$\frac{\partial}{\partial t} = 0$

Uniform flow

incompressible & invicid flow

$P_{gague} = 0$

$$\sum F = \frac{\partial}{\partial t}\int_{CV} v\rho dV + \oint_{CS} v\rho(v\cdot\hat{n})dA$$

$\frac{\partial}{\partial t} \to 0$

$$F_N = \int_{CS\,in} v_y \rho(v\cdot\hat{n})dA + \int_{CS\,out} (\text{same thing})$$

$$v_1\cdot\hat{n}_1 = u(-1)$$

$$int_{in} = \rho u A_1 \cdot -u = -\rho u^2 A_1 = -\dot{m}u$$

$$int_{out} = u\cos\theta\,\rho(u)A_2 = \dot{m}u\cos\theta$$

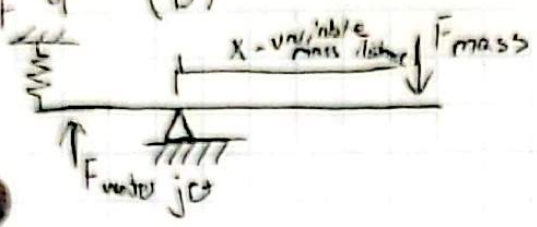
$F_N = -F_y$

$$-F_y = -\dot{m}u + \dot{m}u\cos\theta$$

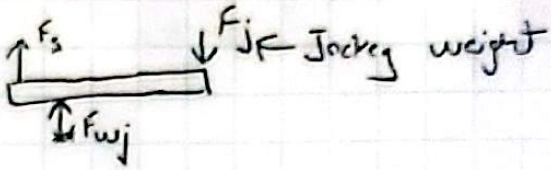
$$F_y = (1-\cos\theta)\dot{m}u$$

u = velocity

Part 4 (D)



→



W_j = weight jockey

m_j = mass jockey

F_s = F spring

F_{wj} = force of water Jet on vane

x_0 = initial distance of jockey

x = distance jockey is moved

L = distance from pivot to vane attachment point

x_{os} = distance from spring to pivot

b

$$\sum M_{pivot} = 0$$

$$= M_0 - (W_j \cdot x_0)$$

$$M_0 = F_s \cdot x_{os} - (x_{com\,beam\ relative\ to\ pivot} \cdot M_{beam})$$

$W_j \cdot x_0 = M_0$

$m_j \cdot g \cdot x_0 = M_0$

c

$$\sum M_{pivot} = 0$$

$$= M_0 + F_{wj} \cdot L - W_j(x_0 + x)$$

d

$$M_0 = W_j \cdot x_0$$

$$0 = W_j x_0 - W_j x_0 - W_j x + F_{wj} L$$

$$W_j x = F_{wj} L \qquad F_{wj} = \frac{W_j \cdot x}{L} = \frac{m_j \cdot g \cdot x}{L}$$

e

given $m_j = 0.6$ kg

$g = 9.81$ m/s²

$L = .150$ m

$x = 0.069$ m

$$F_{wj} = \frac{0.6 \cdot 9.81 \cdot 0.069}{.150} = 2.708 \text{ N}$$

CamScanner

Flat Plate Vane

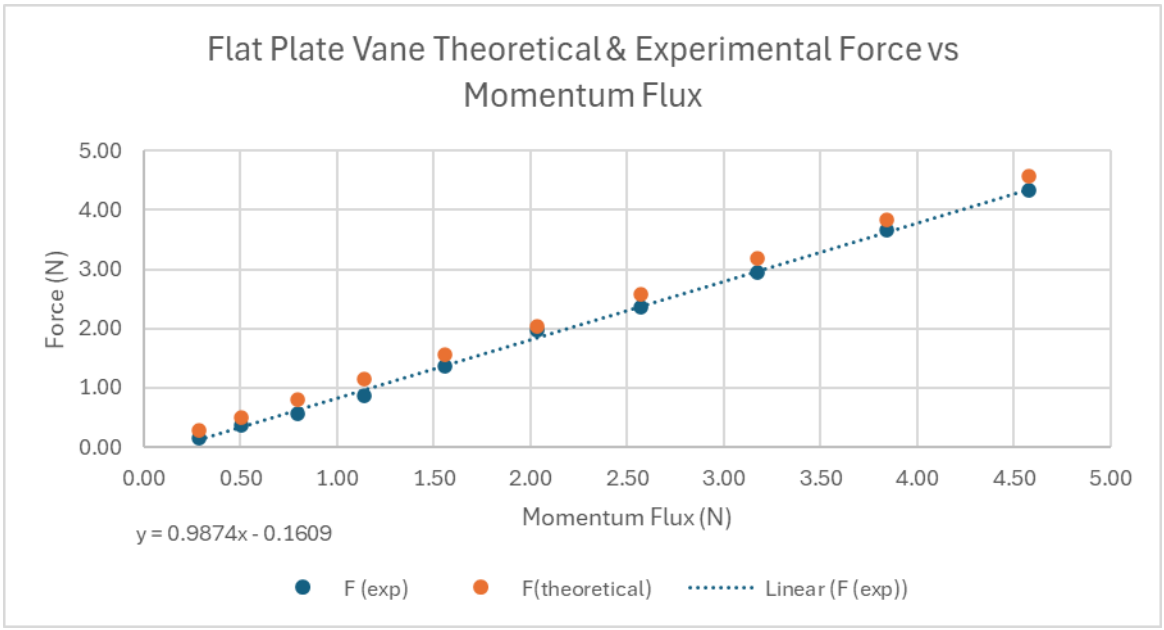
Q	ṁ	y Trial 1	y Trial 2	y Trial 3	ȳ	u	ṁu	F (exp)	F (theroetical)
(liters/s)	*(kg/s)*	*(mm)*	*(mm)*	*(mm)*	*(mm)*	*(m/s)*	*(N)*	*(N)*	*(N)*
0.60	0.60	110	110	111	110.33	7.64	4.58	4.33	4.58
0.55	0.55	93	94	93	93.33	7.00	3.84	3.66	3.84
0.50	0.50	75	75	76	75.33	6.37	3.18	2.96	3.18
0.45	0.45	61	60	60	60.33	5.73	2.57	2.37	2.57
0.40	0.40	50	51	50	50.33	5.09	2.03	1.98	2.03
0.35	0.35	35	35	35	35.00	4.46	1.56	1.37	1.56
0.30	0.30	22	22	22	22.00	3.82	1.14	0.86	1.14
0.25	0.25	15	14	14	14.33	3.18	0.79	0.56	0.79
0.20	0.20	9	10	10	9.67	2.55	0.51	0.38	0.51
0.15	0.15	4	4	4	4.00	1.91	0.29	0.16	0.29

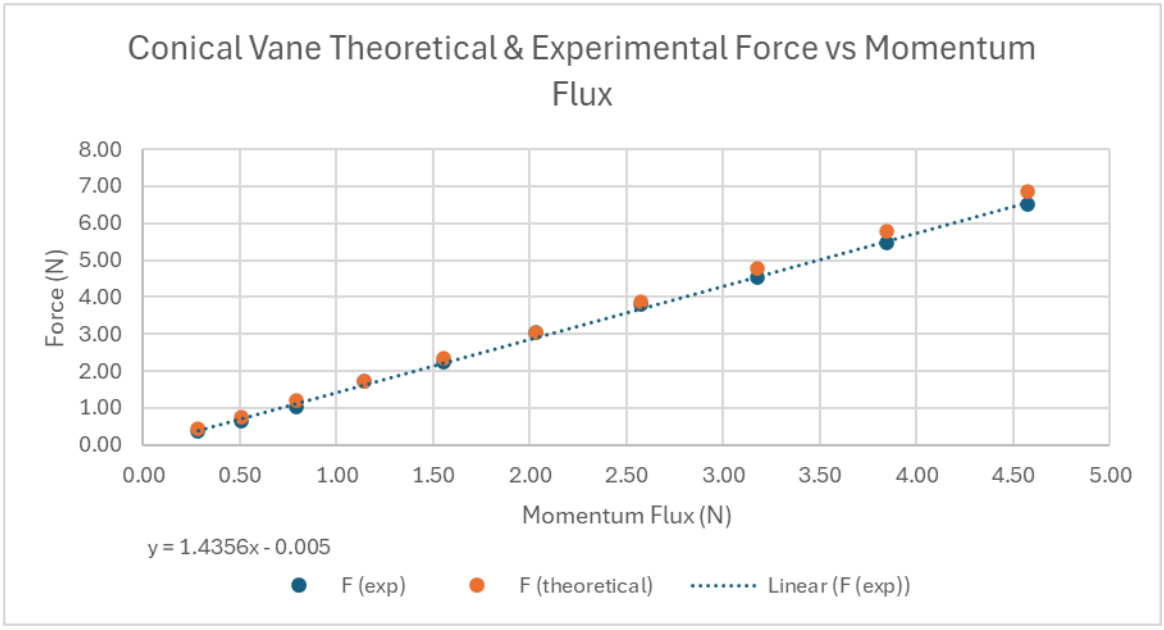
Conical Vane

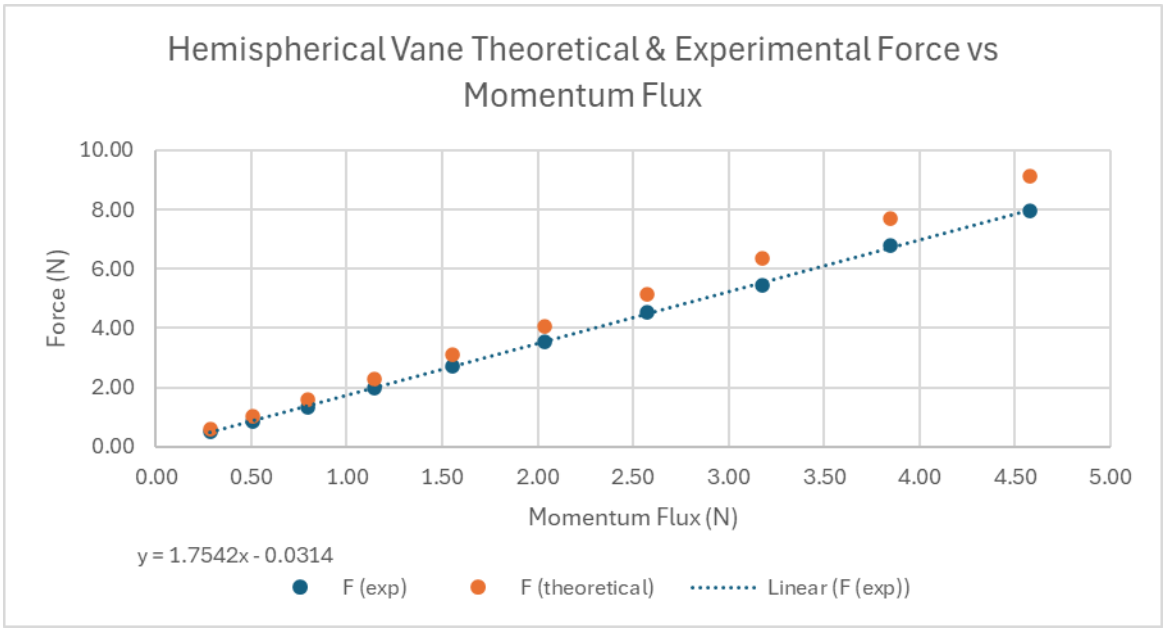
Q	ṁ	y Trial 1	y Trial 2	y Trial 3	ȳ	u	ṁu	F (exp)	F (theroetical)
(liters/s)	*(kg/s)*	*(mm)*	*(mm)*	*(mm)*	*(mm)*	*(m/s)*	*(N)*	*(N)*	*(N)*
0.60	0.60	166	166	165	165.67	7.64	4.58	6.50	6.86
0.55	0.55	139	139	140	139.33	7.00	3.84	5.47	5.77
0.50	0.50	116	115	115	115.33	6.37	3.18	4.53	4.77
0.45	0.45	97	97	97	97.00	5.73	2.57	3.81	3.86
0.40	0.40	78	77	78	77.67	5.09	2.03	3.05	3.05
0.35	0.35	57	57	57	57.00	4.46	1.56	2.24	2.34
0.30	0.30	44	43	45	44.00	3.82	1.14	1.73	1.72
0.25	0.25	28	23	27	26.00	3.18	0.79	1.02	1.19
0.20	0.20	17	16	17	16.67	2.55	0.51	0.65	0.76
0.15	0.15	10	10	9	9.67	1.91	0.29	0.38	0.43

Hemispherical Vane

Q	ṁ	y Trial 1	y Trial 2	y Trial 3	ȳ	u	ṁu	F (exp)	F (theroetical)
(liters/s)	*(kg/s)*	*(mm)*	*(mm)*	*(mm)*	*(mm)*	*(m/s)*	*(N)*	*(N)*	*(N)*
0.60	0.60	203	204	203	203.33	7.64	4.58	7.98	9.15
0.55	0.55	172	173	173	172.67	7.00	3.84	6.78	7.69
0.50	0.50	139	138	140	139.00	6.37	3.18	5.45	6.35
0.45	0.45	115	116	115	115.33	5.73	2.57	4.53	5.15
0.40	0.40	90	90	90	90.00	5.09	2.03	3.53	4.07
0.35	0.35	69	69	69	69.00	4.46	1.56	2.71	3.11
0.30	0.30	51	50	50	50.33	3.82	1.14	1.98	2.29
0.25	0.25	34	34	34	34.00	3.18	0.79	1.33	1.59
0.20	0.20	22	22	22	22.00	2.55	0.51	0.86	1.02
0.15	0.15	12	12	13	12.33	1.91	0.29	0.48	0.57


Flat Plate Vane Theoretical & Experimental Force vs Momentum Flux
Force (N)
5.00
4.00
3.00
2.00
1.00
0.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Momentum Flux (N)
y = 0.9874x - 0.1609
F (exp)
F(theoretical)
Linear (F (exp))


Conical Vane Theoretical & Experimental Force vs Momentum Flux
Force (N)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Momentum Flux (N)
y = 1.4356x - 0.005
F (exp)
F (theoretical)
Linear (F (exp))


Hemispherical Vane Theoretical & Experimental Force vs Momentum Flux
Force (N)
10.00
8.00
6.00
4.00
2.00
0.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Momentum Flux (N)
y = 1.7542x - 0.0314
F (exp)
F (theoretical)
Linear (F (exp))