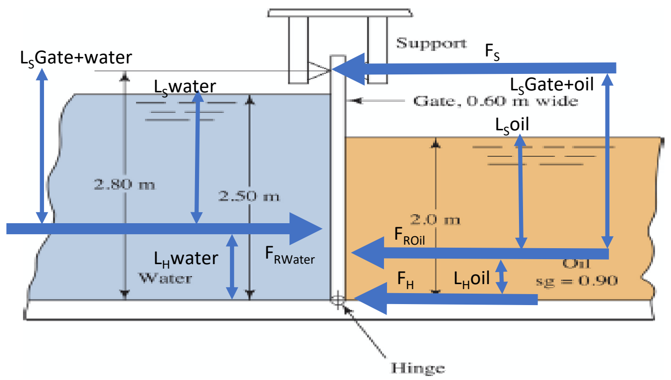
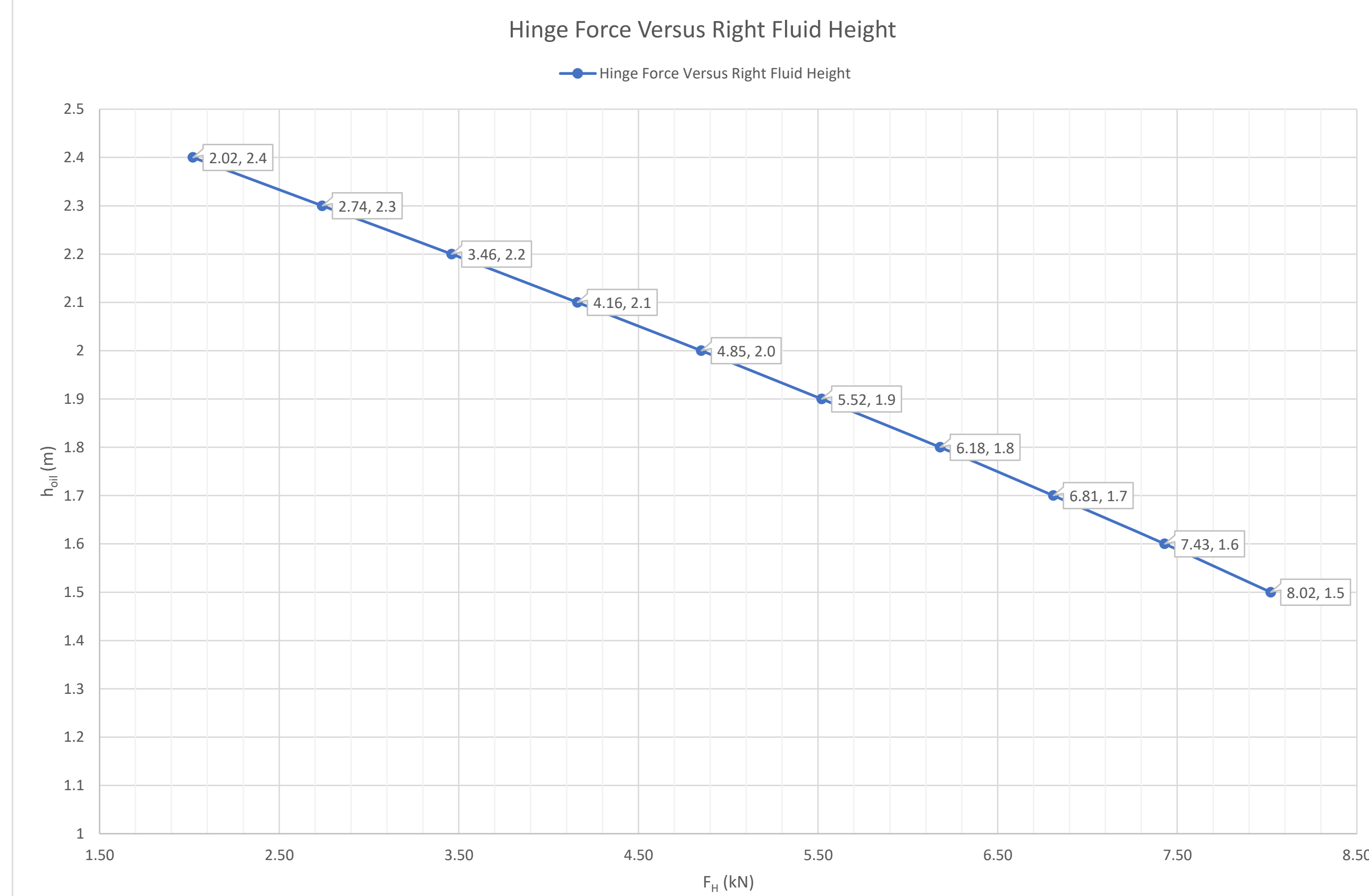
Test 1 Problem 2



2. The figure shows a gate hinged at its bottom and held by a simple support at its top. The gate separates two fluids. Create an Excel spreadsheet to compute the net force on the gate, the force on the hinge, and the force on the support due to the fluid on each side. Make the spreadsheet in such a way that you can input any combination of the depth on either side of the gate and any specific gravity of the fluids. Produce a graph of force at the hinge versus the elevation of the liquid on the right. You will do this plot for different elevation of the liquid on the right.
Make sure you explain in detail the procedure and set of equations you use.

Equations Used	Variable	Value	Unit		Variable	Known Values	Unit	
$F_R = p_{avg} \times A$	h_{water}	2.5	m		γ_{water}	9.81	kN/m^3	
	Area (water and gate)	1.50	m^2		$\gamma_{left\ fluid}$	9.81	kN/m^3	
$p_{avg} = \gamma\left(\frac{h}{2}\right)$	$F_R water$	18.39	kN		$\gamma_{right\ fluid}$	8.83	kN/m^3	
	$L_S water$	1.667	m		h_w	2.5	m	*input value*
	$L_S gate$+water	1.97	m		h_o	2.0	m	*input value*
Resultant force on rectangular wall	$L_H water$	0.833	m		gate$_w$	0.60	m	*input value*
$F_R = \gamma\left(\frac{h}{2}\right) \times A$	h_{oil}	2.0	m		gate$_h$	2.80	m	*input value*
	Area (oil and gate)	1.20	m^2		sg$_{right\ fluid}$	0.90		*input value*
$\gamma_{water}@4°C = 9.81\ \frac{kN}{m^3}$	$F_R oil$	10.59	kN		sg$_{left\ fluid}$	1		*input value*
	$L_S oil$	1.333	m					
	$L_S gate + oil$	2.13	m					
$sg = \frac{\gamma}{9.81\frac{kN}{m^3}}$	$L_H oil$	0.67	m					
	F_H	4.847	kN					
	F_S	2.952	kN					
$L_{fluid} = L - \frac{L}{3}$	$L_H oil = h_{oil} - L_S oil$		$A = BH$					
	$L_H water = h_{water} - L_S water$							
$\Sigma M_{SUPPORT} = 0$								
	$L_S gate + water = L_S water + (gate_h - h_{water})$							
$\Sigma M_{HINGE} = 0$								
	$L_S gate + oil = L_S water + (gate_h - h_{oil})$							
$F_H = ((F_R water * L_S gate + water) + (F_R oil * L_S gate + oil))/gate_h$								
$F_S = ((F_R water * L_H water) + (F_R oil * L_H oil))/gate_h$								

Data Entry Point	F_H	F_H Unit	h_{oil}	h_{oil} Unit
1	8.02	kN	1.5	m
2	7.43	kN	1.6	m
3	6.81	kN	1.7	m
4	6.18	kN	1.8	m
5	5.52	kN	1.9	m
6	4.85	kN	2.0	m
7	4.16	kN	2.1	m
8	3.46	kN	2.2	m
9	2.74	kN	2.3	m
10	2.02	kN	2.4	m



Test Problem 3

3. **Create an Excel spreadsheet to evaluate the stability of a circular cylinder placed in a fluid with its axis vertical. Make the spreadsheet in such a way that you can input any combination diameter, length, and weight (or specific weight) of the cylinder, and specific weight of the fluid. The spreadsheet should provide the position of the cylinder when it is floating, the location of the center of buoyancy, and the metacenter location. Compare the location of the metacenter with the center of gravity to evaluate. Produce a graph of the metacenter location and center of buoyancy location versus the cylinder length. You will do this plot for different cylinder diameter for fixed specific weights of cylinder and fluid. Make sure you explain in detail the procedure and set of equations you use.**

Equations Used

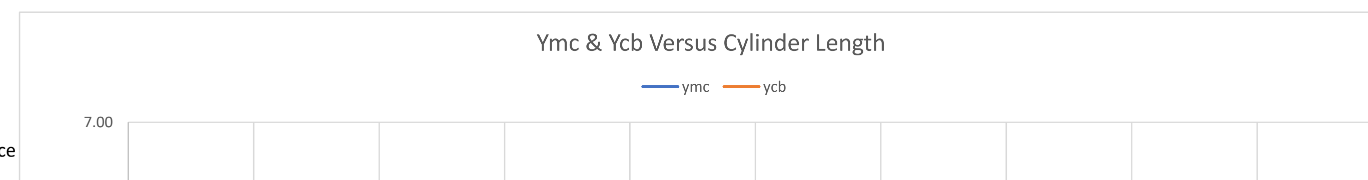
$$V_d = \text{submerged volume} = AX = \frac{\pi D^2}{4}(X)$$

$$\sum F_v = 0$$

$$W = F_b = \gamma_o V_d = \gamma_o \frac{\pi D^2}{4}(X)$$

Where V_d equals volume displaced
Where W equals weight
Where D equals diameter
γ_{fluid} equals specific weight of fluid
Where y_{cb} equals location of center of buoyancy
Where X equals position of cylinder when floating
Where MB equals the distance to the metacenter from the center of buoyancy
Where I equals the least moment of inertia of a horizontal section of the body taken at the surface of the fluid

Data Entry Point	y_{mc}	y_{mc} Unit	y_{cb}	y_{cb} Unit	D	D Unit	Stable/Unstable	L	L Unit
1	1.55	ft	1.10	ft	4	ft	Unstable	6	ft
2	1.60	ft	1.25	ft	3.75	ft	Unstable	6	ft
3	1.70	ft	1.43	ft	3.5	ft	Unstable	6	ft
4	1.86	ft	1.66	ft	3.25	ft	Unstable	6	ft
5	2.10	ft	1.95	ft	3	ft	Unstable	6	ft
6	2.43	ft	2.32	ft	2.75	ft	Unstable	6	ft
7	2.88	ft	2.81	ft	2.5	ft	Unstable	6	ft
8	3.52	ft	3.47	ft	2.25	ft	Stable	6	ft
9	4.42	ft	4.39	ft	2	ft	Stable	6	ft
10	5.75	ft	5.74	ft	1.75	ft	Stable	6	ft



$$X = \frac{4W}{\pi D^2 \gamma_o}$$

$$y_{cb} = X/2$$

$$MB = I/V_d$$

$$I = \frac{\pi D^4}{64}$$

$$V_d = AX = \frac{\pi D^2}{4}(X)$$

$$MB = I/V_d$$

$$y_{mc} = y_{cb} + MB$$

Where A equals area of cylinder
Where y_{mc} equals the metacenter location
Where sg equals specific gravity of fluid
Where L equals length of cylinder
Where y_{cg} equals center of gravity of cylinder
If the distance MB places the metacenter above the center of gravity, the body is stable.
If ymc > ycg , the body is stable.
If ymc < ycg , the body is unstable.

Variable	Value	Unit	
V_d	27.60	ft^3	
W	1550	lb	*input value*
L	6	ft	*input value*
y_{cg}	3	ft	
D	3	ft	*input value*
γ_{fluid}	56.16	lb/ft^3	
y_{cb}	1.95	ft	
X	3.90	ft	
MB	0.14	ft	
I	3.98	ft^4	
A	7.07	ft^2	
y_{mc}	2.10	ft	
sg	0.90		*input value*
Stable/Unstable	UNSTABLE