ENGINEERING 4020

MARINE FLUID DYNAMICS

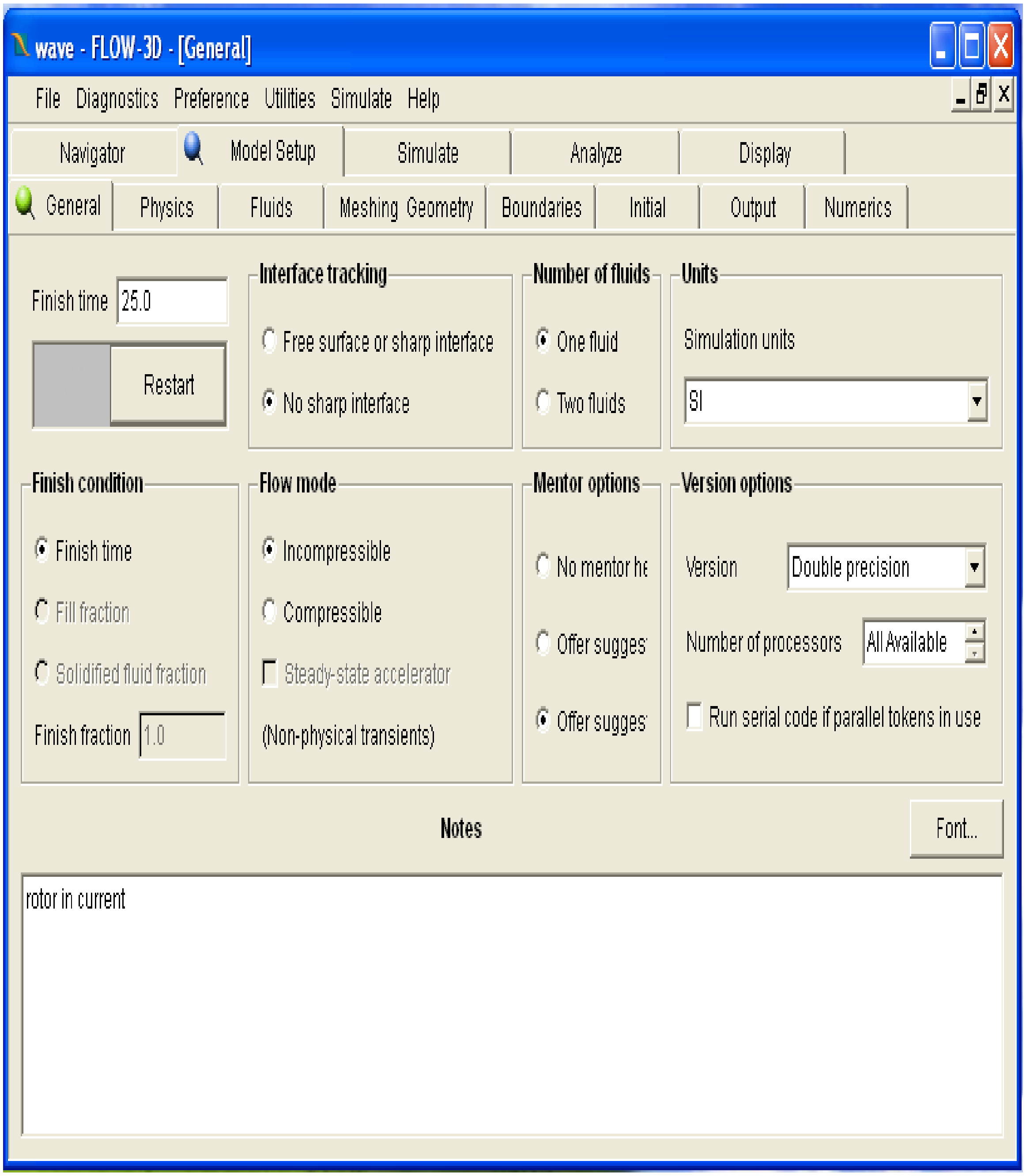
QUIZ #2

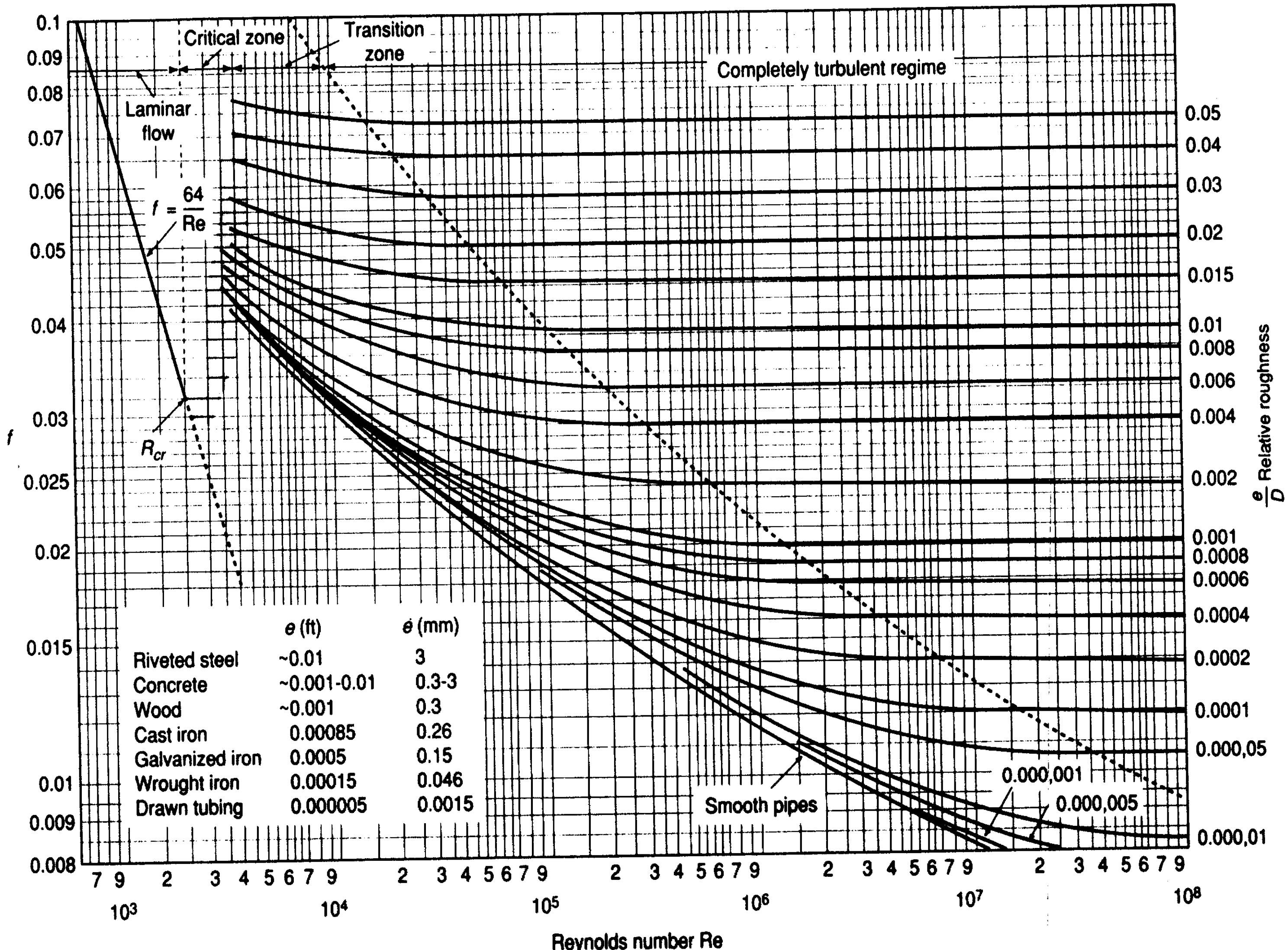
Give a TRUE or FALSE answer to each of the following statements and briefly explain each answer: (1) lubrication flows are turbulent (2) boundary layers have a sharp outer edge (3) the circulation around a foil is caused by a doublet (4) a potential vortex is very viscous (5) head losses are governed by the Bernoulli Equation. [20] [BONUS: Identify formulas for each case on the formula sheets.]

State the conservation laws for fluid flows. Identify the integral forms of the laws on the formula sheets. Identify the stream tube forms of the laws on the formula sheets. Outline the derivation of each stream tube law. [20]

The general menu for the CFD software FLOW-3D is attached. Outline the function of each of the submenus at the top of this menu. Where appropriate use sketches to illustrate your answer. Explain briefly how FLOW-3D works. [20]

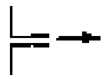
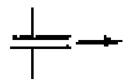
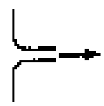
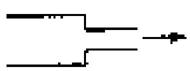
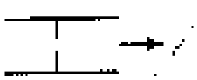
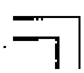
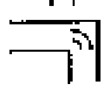
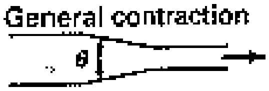
A certain pump moves cooling water through a closed pipe on a ship at 60 GPM. The overall length of the pipe is 25m. Its diameter is 5cm. It has sixty 180° bends and one globe valve. How would you get the demand curve for the system? How you would get the pump power? How would you determine the type of pump? What would NPSH tell you? [40]


wave - FLOW-3D - [General]
File Diagnostics Preference Utilities Simulate Help
Navigator
Model Setup
Simulate
Analyze
Display
General
Physics
Fluids
Meshing Geometry
Boundaries
Initial
Output
Numerics
Finish time
25.0
Restart
Interface tracking
Free surface or sharp interface
No sharp interface
Number of fluids
One fluid
Two fluids
Units
Simulation units
SI
Finish condition
Finish time
Fill fraction
Solidified fluid fraction
Finish fraction
1.0
Flow mode
Incompressible
Compressible
Steady-state accelerator
(Non-physical transients)
Mentor options
Version options
Version
Double precision
Number of processors
All Available
Run serial code if parallel tokens in use
Notes
Font...
rotor in current



Moody diagram. (From L. F. Moody, *Trans. ASME*, Vol. 66, 1944.)

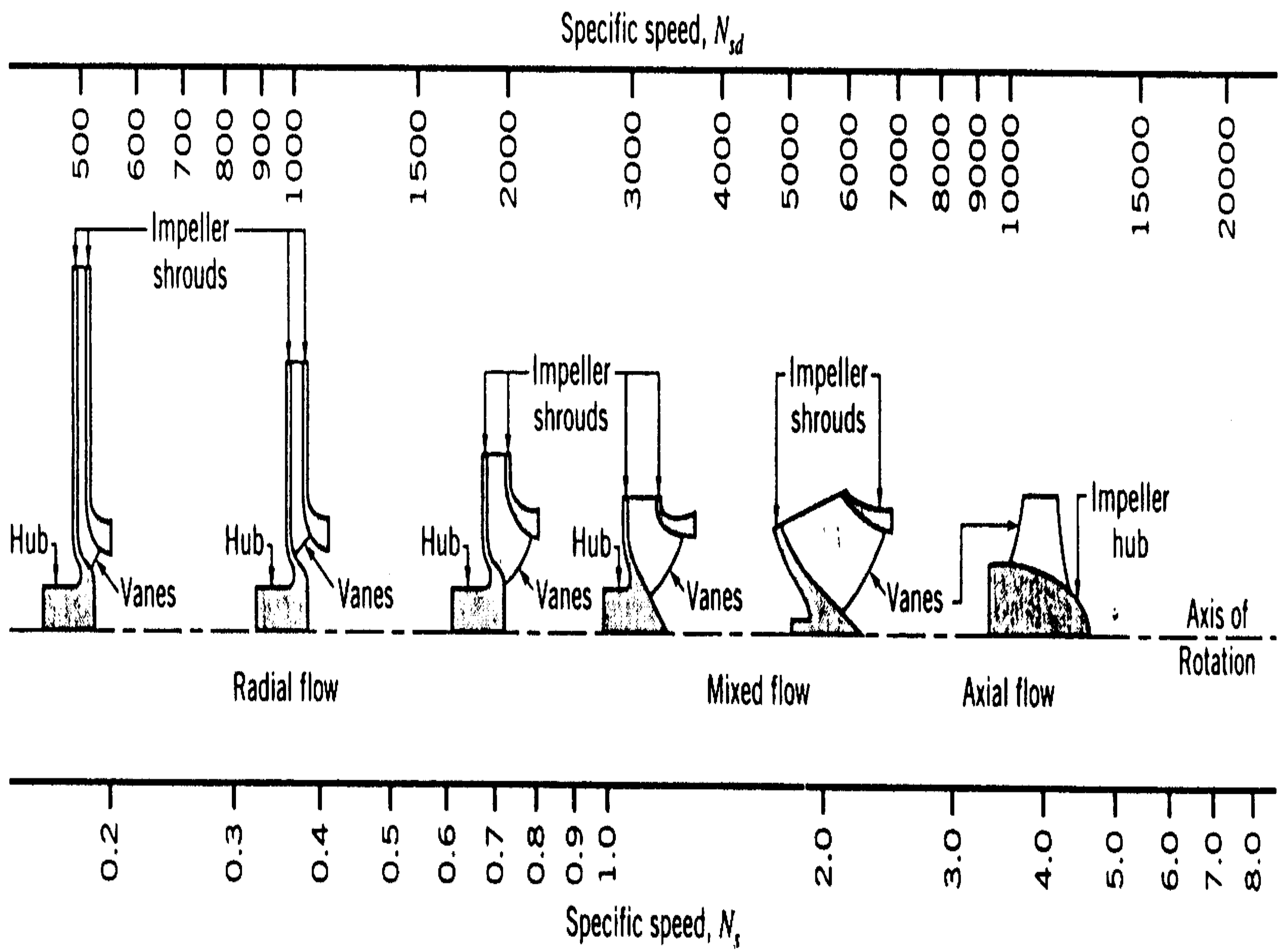
Nominal Loss Coefficients K (Turbulent Flow)[a]

Type of fitting	Screwed			Flanged		
Diameter	1 in.	2 in.	4 in.	2 in.	4 in.	8 in.
Globe valve (fully open)	8.2	6.9	5.7	8.5	6.0	5.8
(half open)	20	17	14	21	15	14
(one-quarter open)	57	48	40	60	42	41
Angle valve (fully open)	4.7	2.0	1.0	2.4	2.0	2.0
Swing check valve (fully open)	2.9	2.1	2.0	2.0	2.0	2.0
Gate valve (fully open)	0.24	0.16	0.11	0.35	0.16	0.07
Return bend	1.5	.95	.64	0.35	0.30	0.25
Tee (branch)	1.8	1.4	1.1	0.80	0.64	0.58
Tee (line)	0.9	0.9	0.9	0.19	0.14	0.10
Standard elbow	1.5	0.95	0.64	0.39	0.30	0.26
Long sweep elbow	0.72	0.41	0.23	0.30	0.19	0.15
45° elbow	0.32	0.30	0.29			
Square-edged entrance 			0.5			
Reentrant entrance 			0.8			
Well-rounded entrance 			0.03			
Pipe exit			1.0			
Sudden contraction[b]  — Area ratio 2:1			0.25			
Area ratio 5:1			0.41			
Area ratio 10:1			0.46			
Orifice plate  — Area ratio A/A_0 1.5:1			0.85			
Area ratio A/A_0 2:1			3.4			
Area ratio A/A_0 4:1			29			
Area ratio A/A_0 ≥ 6:1			$2.78\left(\frac{A}{A_0} - 0.6\right)^2$			
Sudden enlargement[c] 			$\left(1 - \frac{A_1}{A_2}\right)^2$			
90° miter bend (without vanes) 			1.1			
(with vanes) 			0.2			
General contraction  (30° included angle)			0.02			
(70° included angle)			0.07			

[a] Values for other geometries can be found in *Technical Paper 410*, The Crane Company, 1957.

[b] Based on exit velocity V_2.

[c] Based on entrance velocity V_1.



Specific speed, N_{sd}
500
600
700
800
900
1000
1500
2000
3000
4000
5000
6000
7000
8000
9000
10000
15000
20000
Impeller shrouds
Hub
Vanes
Impeller hub
Axis of Rotation
Radial flow
Mixed flow
Axial flow
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Specific speed, N_s

$$\frac{D}{Dt}\int_V \rho \, dV = \int_V \partial\rho/\partial t \, dV + \int_S \rho \, \mathbf{v.n} \, dS = 0$$

$$\frac{D}{Dt}\int_V \rho\mathbf{v} \, dV = \int_V \partial\rho\mathbf{v}/\partial t \, dV + \int_S \rho\mathbf{v} \; \mathbf{v.n} \, dS$$

$$= \int_S \boldsymbol{\sigma} \, dS + \int_V \rho\mathbf{b} \, dV$$

$$\frac{D}{Dt}\int_V \rho e \, dV = \int_V \partial\rho e/\partial t \, dV + \int_S \rho e \; \mathbf{v.n} \, dS$$

$$= - \int_S \mathbf{q.n} \, dS + \int_S \mathbf{v.\boldsymbol{\sigma}} \, dS$$

$$\sum[\rho CA]_{OUT} - \sum[\rho CA]_{IN} = 0$$

$$\sum \dot{M}_{OUT} - \sum \dot{M}_{IN} = 0 \qquad \sum \dot{M}_{OUT} = \sum \dot{M}_{IN}$$

$$\sum[\rho \mathbf{v} CA]_{OUT} - \sum[\rho \mathbf{v} CA]_{IN}$$

$$= - \sum[PA\mathbf{n}]_{OUT} - \sum[PA\mathbf{n}]_{IN} + \mathbf{R}$$

$$\sum [\dot{M} U]_{OUT} - \sum [\dot{M} U]_{IN} = - \sum PA\mathbf{n_x} \mathbf{+} R_x$$

$$\sum [\dot{M} V]_{OUT} - \sum [\dot{M} V]_{IN} = - \sum PAn_y + R_y$$

$$\sum [\dot{M} W]_{OUT} - \sum [\dot{M} W]_{IN} = - \sum PAn_z + R_z$$

$$\sum [\dot{M} (C^2/2 + gz)]_{OUT} - \sum [\dot{M} (C^2/2 + gz)]_{IN} =$$

$$- \sum[PA\mathbf{C}]_{OUT} + \sum[PA\mathbf{C}]_{IN} + \sum\dot{T} - \sum\dot{L}$$

$$\sum [\dot{M} gh]_{OUT} - \sum [\dot{M} gh]_{IN} = + \sum\dot{T} - \sum\dot{L}$$

$$h = C^2/2g + P/\rho g + z$$

$$\dot{T} = \dot{M} gh_T \qquad \dot{L} = \dot{M} gh_L$$

$$h_{OUT} - h_{IN} = h_T - h_L$$

$$h_L = (fL/D + \Sigma K) C^2/2g$$

$$C^2/2g + P/\rho g + z = K$$

$$C^2/2 + P/\rho + gz = \kappa$$

$$H = X + Y Q^2 \qquad Q = C A$$

$$X = \Delta [P/\rho g + z]$$

$$Y = [fL/D + \Sigma K]/[2gA^2]$$

$$\mathbf{N} = [N \sqrt{Q}]/[H^{3/4}]$$

$$NPSH = P_s/\rho g + C_s C_s/2g - P_v/\rho g$$

$$d = (P_o - P_v)/\rho g - h_L - NPSH$$

$$\mathbf{P} = \Delta [T \omega] = \Delta [\rho Q V_t R \omega]$$

$$\mathbf{P} = \rho g H Q$$

$$\partial U/\partial x + \partial V/\partial y + \partial W/\partial z = 0$$

$$\partial P/\partial x = \mu \, \partial^2 U/\partial z^2$$

$$\partial P/\partial y = \mu \, \partial^2 V/\partial z^2$$

$$0 = \mu \, \partial^2 W/\partial z^2$$

$\rho \Gamma S$ $\qquad$ $\Gamma = 4\pi SR \, \mathrm{Sin}\kappa$

$\kappa = \Theta + \varepsilon$ $\qquad$ $\varepsilon = \tan^{-1}[m/(n+a)]$

$$a = \sqrt{[R^2 - m^2]} - n$$

$$\alpha = x + [xa^2/(x^2+y^2)]$$

$$\beta = y - [ya^2/(x^2+y^2)]$$

$\delta^* \, \mathbf{U}$ $\qquad$ $\delta^* = \int (1-U/\mathbf{U})\,dy$ $\qquad$ $\delta^* = I\delta$

$\rho \, \mathbf{U}^2 \, \Theta$ $\qquad$ $\Theta = \int U/\mathbf{U}(1-U/\mathbf{U})\,dy$ $\qquad$ $\Theta = J\delta$

$U/\mathbf{U} = (y/\delta)^{1/n}$ $\qquad$ $\tau = C \, \rho\mathbf{U}^2/(\mathbf{U}\delta/\nu)^{1/k}$

$\mathbf{D}/b = \rho \, \mathbf{U}^2\Theta$ $\qquad$ $\tau = d[\mathbf{D}/b]/dx = \rho\mathbf{U}^2 \, d\Theta/dx$

$\mathbf{D} = M \, bL \, R_{EL}^{-1/m} \, \rho\mathbf{U}^2$ $\qquad$ $\mathbf{W} = C \, B \, \rho\mathbf{U}^2/2$

$$\mathbf{P} = [\, \mathbf{D} + \mathbf{W} \,] \, \mathbf{U}$$