Equation sheet

Chapter 3

$P(\text{vacuum}) = P_a - P$

$\Rightarrow P$: اذا نزلنا لتحت موجب
اذا طلعنا لفوق سالب .

$P = \rho g \Delta z$

مركز الجاذبية مش مركز الضغط
from Top to G

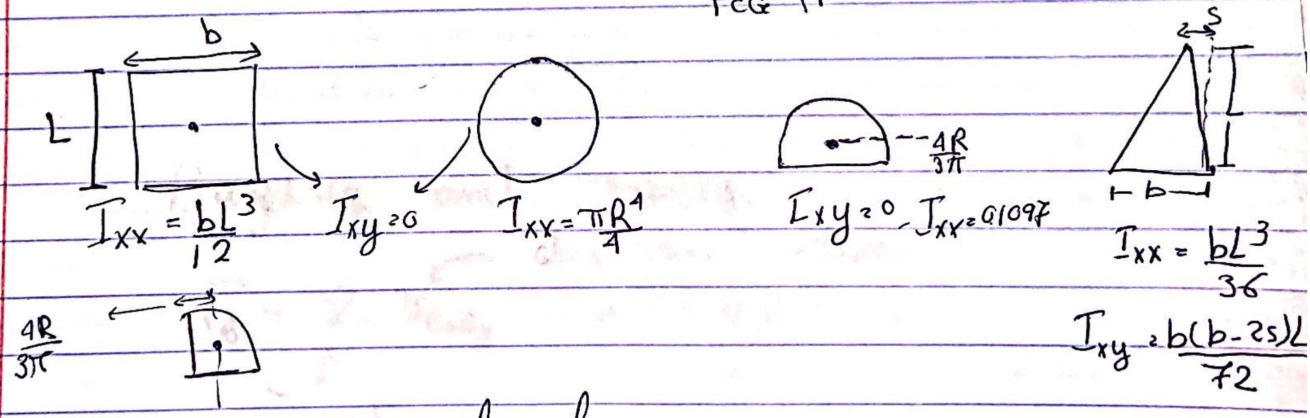
In Gates: $F = \Sigma P \;\; \rho g\, h$

مش دايماً الـ CG بالضبط مركز على الشكل

Between surfaces and Body

$$y_{cp} = \frac{-\gamma \sin\theta \; I_{xx}}{P_{CG} \, A}$$

$$x_{cp} = \frac{-\gamma \sin\theta \; I_{xy}}{P_{CG} \, A}$$



$I_{xx} = \frac{bL^3}{12}$ $I_{xy} = 0$ $I_{xx} = \frac{\pi R^4}{4}$ $I_{xy} = 0$, $I_{xx} = 0.1097$ $I_{xx} = \frac{bL^3}{36}$ $I_{xy} = \frac{b(b-2s)L}{72}$

Use moment for equilibrium

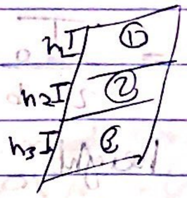
Layered fluid

γ the unit $kN/m^3 = \rho g$

$P_{CG_1} = (h_1)(\gamma)$

$P_{CG_2} = (2h_1)(\gamma_1) + (h_2)(\gamma_2)$

$P_{CG_3} = (2h_1)(\gamma_1) + (2h_2)(\gamma_2) + (h_3)(\gamma_3)$



$F_1 = (P_{CG_1})A_1$

ycp for each Area using → $y_{cp_1} = \frac{\rho \sin\theta I_{xx}}{F_1}$

zcp " " " → $h_{CG} + y_{cp_1}$

→ moment $F_1 z_{cp_1} + F_2 z_{cp_2} = (F_1 + F_2) z_{cp_R}$

↑ with sign

Bayancy and Stability

$F_B = \gamma \, v_{Body} = W_{fluid}$ ← displaced volume

average weight ~~density~~ for fluid

Stability related to waterline Area :-

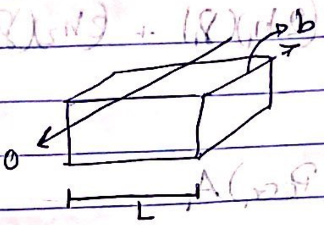
$$\overline{MG} = \frac{I_o}{V_{sub}} - \overline{GB}$$

$\overline{MG}$ → metacentric height

$\overline{GB}$ → مسافة بين B و G

B → الcenter للحجم اللي تحت المي

$$I_o = \frac{bL^3}{12}$$



$MG > 0$ stable

$MG < 0$ unstable

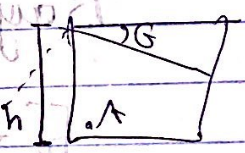
Uniform linear acceleration

$$\theta = \tan^{-1} \frac{a_x}{g + a_z}$$

a_z → مش شرط موجود

معطاه السؤال $G = \sqrt{a_x^2 + (g + a_z)^2}$

at a point A ← $P = \rho G \Delta s$ → $h \cos \theta$



Chapter 6:

$HGL = \frac{P}{\rho g} + \frac{V^2}{2g} + z$

$Re < 2300$ lam

$Re > 4000$ Tur

HGL 1 < HGL 2

from $2 \rightarrow 1$

for lam $\frac{L_e}{d} \approx 0.06 Re$

$L_e \approx 138d$ at critical Re

for Turb $\frac{L_e}{d} \approx 1.6 Re^{\frac{1}{4}}$

$h_f = f \frac{L}{d} \frac{V^2}{2g}$

$= \frac{4 \tau_w L}{\rho g d}$

for lam $h_f = \frac{32 \mu L V}{\rho g d^2} = \frac{128 \mu L Q}{\pi \rho g d^4}$

$f = \frac{64}{Re}$

for Turb: $\frac{1}{\sqrt{f}} = -1.8 \log\left(\left(\frac{\varepsilon/d}{3.7}\right) + \frac{6.9}{Re}\right)$

Problems Types

① find h_f

$$Re \rightarrow \frac{\epsilon}{d} \rightarrow f \rightarrow h_f = f \frac{L}{d} \frac{V^2}{2g}$$

② V, Q

$$f = h_f \frac{d}{L} \frac{2g}{V^2}$$

Start with → fully rough → $\frac{1}{\sqrt{f}} = -2 \log \left(\frac{\epsilon/d}{3.7}\right)$

$f \rightsquigarrow V \rightsquigarrow Re \rightsquigarrow \epsilon/d$ → constant

new $f \rightsquigarrow V \rightsquigarrow$ - - -

③ d

$$f = \frac{\pi^2}{8} \frac{g h_f d^5}{L Q^2}$$ Guess f

$$Re = \frac{4Q}{\pi d \nu}$$ kinematic visc

$\frac{\epsilon}{d}$

Then iterate

④ L

$\boxed{h_p} = \frac{P}{\rho g Q} = h_f = f \frac{L V^2}{d\, 2g}$ if hori & minor losses neg

Re → ε/d → f (using eq)

Hydraulic diameter:

$D_H = \frac{4 \times Area}{b \times 4}$

$D_H = 4h$ → distance apart /2

lam

$\tau_w = \frac{3 \mu V}{h}$

Turb

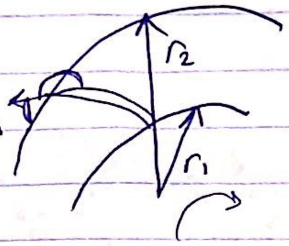
$D_{eff} = \frac{64}{96} D_h$

Equation sheet

1 mm Hg = 0.133322 KPa
1 L = 0.001 m3

Chapter 11:

$$Q = 2\pi r_1 b_1 V_{1n} = 2\pi r_2 b_2 V_{2n}$$



حسب β
الدوران
اذا مع تكون
الصغيرة اذا
عكس تكون الكبيرة

$$V_{t2} = u_2 - \frac{V_{2n}}{\tan\beta_2}$$

$u_1 = r_1\omega \qquad u_2 = r_2 w$

$$T = \rho Q\,(r_2 V_{t2} - r_1 V_{t1})$$
$$P_w = \rho Q\,\omega\,(r_2 V_{t2} - r_1 V_{t1})$$

first assumbtion
$V_{n1} = V_1$
$\alpha_1 = 90$

$$Bhp = \frac{P_w}{n_p}$$

$$H = \frac{u_2 V_{t2} - u_1 V_{t1}}{g}$$

To avoid cavitation:

right-hand side

$$NPSH \leq \frac{P_a - P_v}{\rho g} - z_i - h_f$$

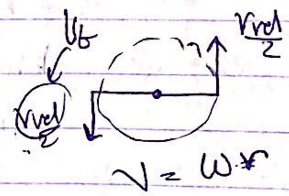
from graph

left-hand side $\frac{P_i}{\rho g} + \frac{V_i^2}{2g} - \frac{P_v}{\rho g}$

PQ

$P = u^2$

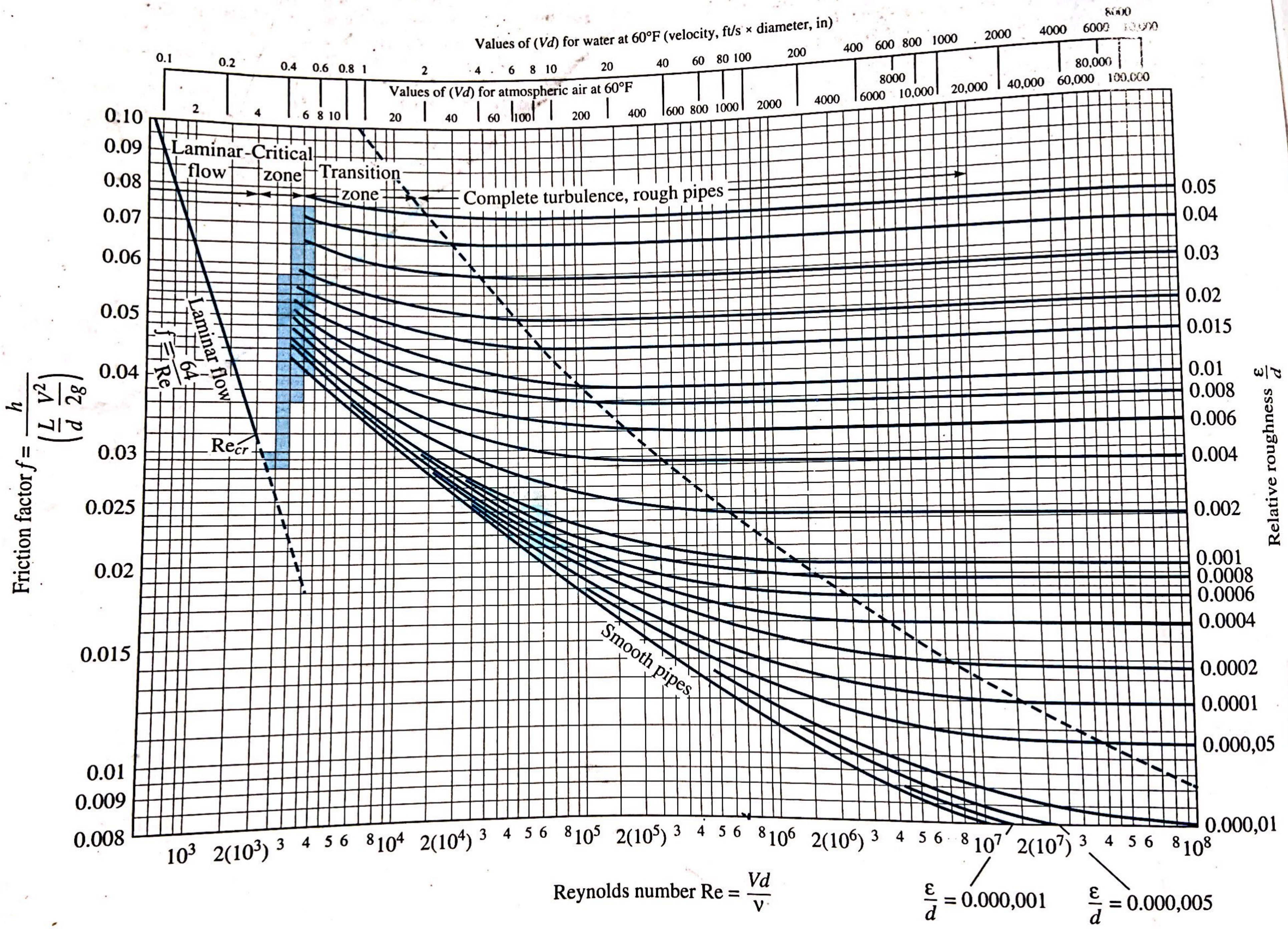
if z is neg → below

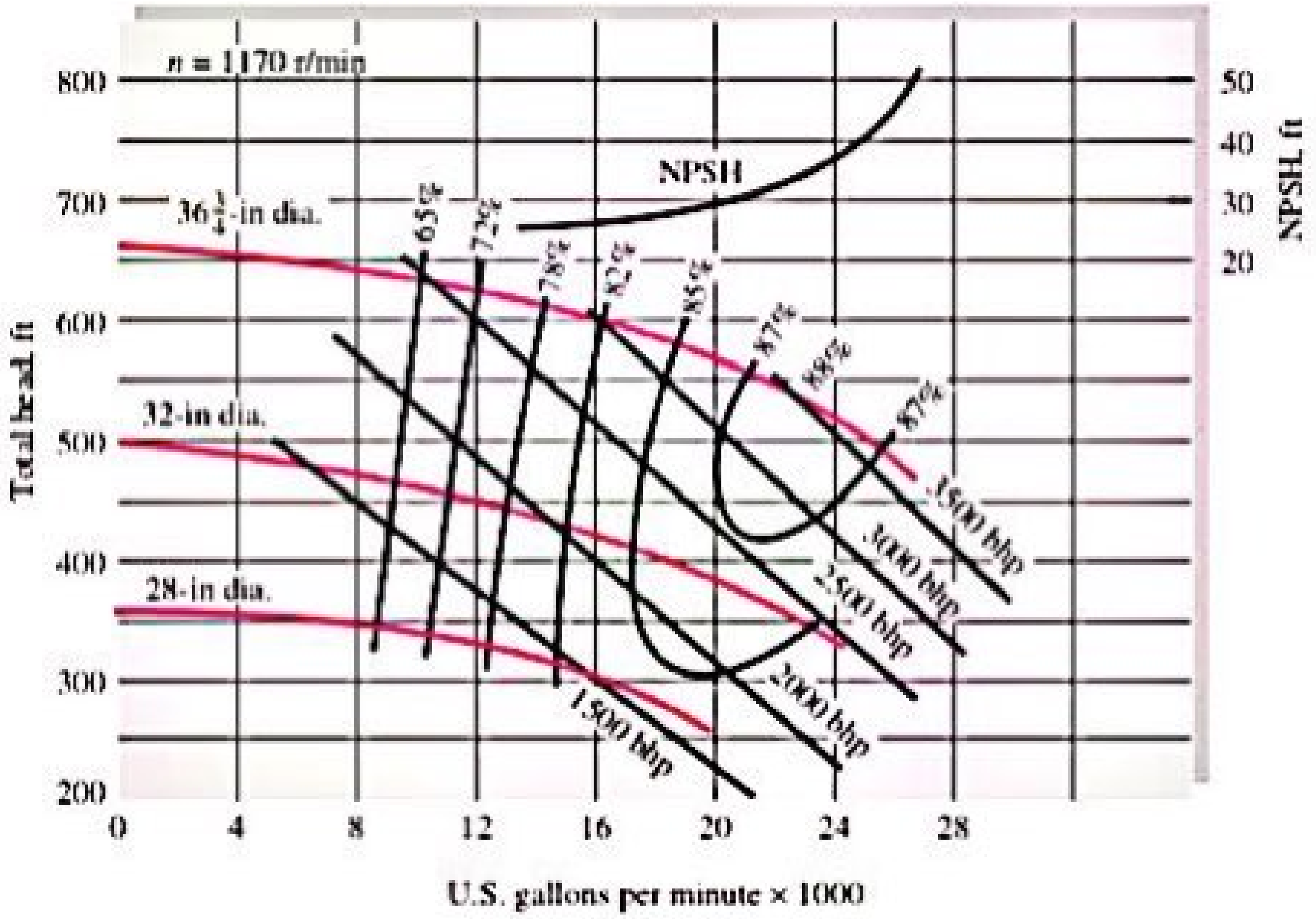


Centrifugal pump:

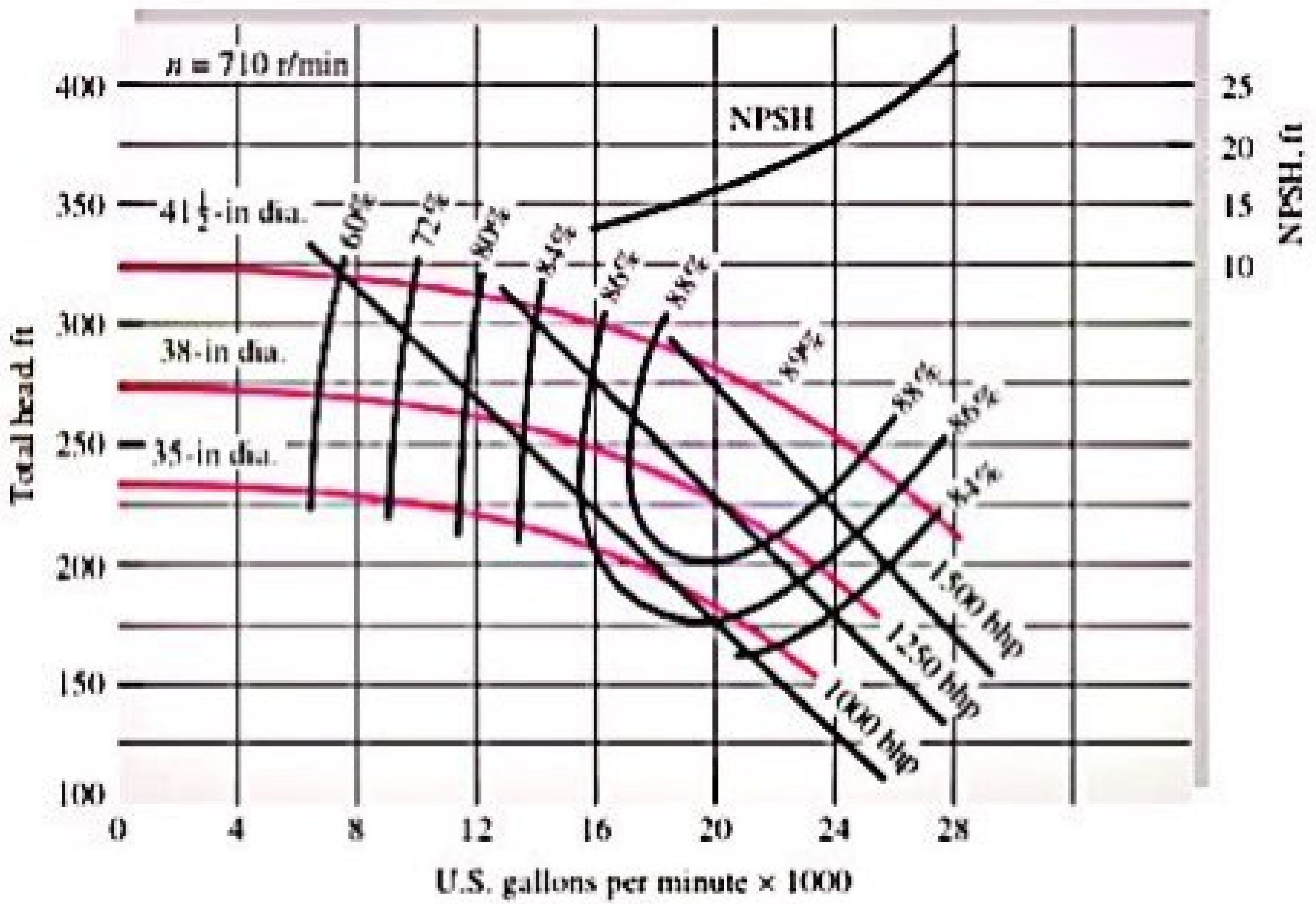
$$H = h_p - h_f = \frac{P_2 - P_1}{\rho g} + \frac{V_2^2 - V_1^2}{2g} + z_2 - z_1$$

$$Power = \frac{\rho g Q H}{n}$$


Values of (Vd) for water at 60°F (velocity, ft/s × diameter, in)
Values of (Vd) for atmospheric air at 60°F
Laminar flow
Critical zone
Transition zone
Complete turbulence, rough pipes
Laminar flow
f = 64/Re
Re_cr
Smooth pipes
Friction factor f = h / ((L/d)(V²/2g))
Relative roughness ε/d
Reynolds number Re = Vd/ν
ε/d = 0.000,001
ε/d = 0.000,005
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.025
0.02
0.015
0.01
0.009
0.008
0.05
0.04
0.03
0.02
0.015
0.01
0.008
0.006
0.004
0.002
0.001
0.0008
0.0006
0.0004
0.0002
0.0001
0.000,05
0.000,01
10³ 2(10³) 3 4 5 6 8 10⁴ 2(10⁴) 3 4 5 6 8 10⁵ 2(10⁵) 3 4 5 6 8 10⁶ 2(10⁶) 3 4 5 6 8 10⁷ 2(10⁷) 3 4 5 6 8 10⁸


n = 1170 r/min
NPSH
36 3/4-in dia.
32-in dia.
28-in dia.
65%
72%
78%
82%
85%
87%
88%
87%
3500 bhp
3000 bhp
2500 bhp
2000 bhp
1500 bhp
Total head, ft
NPSH, ft
U.S. gallons per minute × 1000

(a)


n = 710 r/min
NPSH
41 1/2-in dia.
38-in dia.
35-in dia.
60%
72%
80%
84%
86%
88%
89%
88%
86%
84%
1500 bhp
1250 bhp
1000 bhp
Total head, ft
NPSH, ft
U.S. gallons per minute × 1000

(b)

	Nominal diameter, in								
	Screwed				Flanged				
	$\frac{1}{2}$	1	2	4	1	2	4	8	20
Valves (fully open):									
Globe	14	8.2	6.9	5.7	13	8.5	6.0	5.8	5.5
Gate	0.30	0.24	0.16	0.11	0.80	0.35	0.16	0.07	0.03
Swing check	5.1	2.9	2.1	2.0	2.0	2.0	2.0	2.0	2.0
Angle	9.0	4.7	2.0	1.0	4.5	2.4	2.0	2.0	2.0
Elbows:									
45° regular	0.39	0.32	0.30	0.29					
45° long radius					0.21	0.20	0.19	0.16	0.14
90° regular	2.0	1.5	0.95	0.64	0.50	0.39	0.30	0.26	0.21
90° long radius	1.0	0.72	0.41	0.23	0.40	0.30	0.19	0.15	0.10
180° regular	2.0	1.5	0.95	0.64	0.41	0.35	0.30	0.25	0.20
180° long radius					0.40	0.30	0.21	0.15	0.10
Tees:									
Line flow	0.90	0.90	0.90	0.90	0.24	0.19	0.14	0.10	0.07
Branch flow	2.4	1.8	1.4	1.1	1.0	0.80	0.64	0.58	0.41