Equations for the exam

- Bernoulli equation:

$$\frac{p_1}{\rho g} + z_1 + \frac{V_1^2}{2g} = \frac{p_2}{\rho g} + z_2 + \frac{V_2^2}{2g} + h_{f1\to 2}$$

For channels:

$$y_1 + z_1 + \frac{V_1^2}{2g} = y_2 + z_2 + \frac{V_2^2}{2g} + h_{f1-2}$$

- Local (Minor) losses:

$$h_m = K\frac{V^2}{2g}$$; K from tables

- Manning's equation:

$$V = \frac{K_m}{m} R^{2/3} S_o^{1/2}$$; $K_m = 1$ in SI; $K_m = 1.486$ in English units.

- Chèzy equation:

$$V = C R^{1/2} S_o^{1/2}$$

- Shear stress at bottom of channel:

$$\tau_w = \rho g R S_o$$

- $$Re = \frac{VD}{\nu}$$

- Direct method by Rouse

$$B = h_f g D^3 / (L \nu^2)$$

(dimensionless)

$$Re = -(8B)^{1/2} \log_{10}\left[\frac{\varepsilon/D}{3.7} + \frac{1.775}{\sqrt{B}}\right]$$

- Darcy-Weisbach equation:

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

- Froude [redacted] number

$$Fr = \frac{V}{\sqrt{g y}}$$ ← or L in general

- Critical depth for rectangular cross section

$$y_c = \sqrt[3]{\frac{q^2}{g}}$$

- $R = \dfrac{\text{Area}}{\text{Wetted perimeter}}$

- Gradually varied flow

$$\frac{dy}{dx} = \frac{S_o - S_f}{1 - Fr^2}$$

- Hydraulic jump

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8\mathrm{Fr}_1^2} - 1\right)$$

$$\Delta E = \frac{(y_2 - y_1)^3}{4\, y_2\, y_1}$$

- Colebrook – White equation

$$\frac{1}{\sqrt{f}} = -2 \log_{10}\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right)$$

- Iterative method to compute Q given

$D, L, \varepsilon, \rho, \mu, h_f$

dimensional

$$f V^2 = \frac{h_f\, D\, 2g}{L} = B = \text{known}$$

- POWER:

$$\text{Power} = \rho\, g\, h_{pump}\, Q$$

- Power required = $\dfrac{\text{Power delivered to water}}{\eta}$

- Explicit formula:

$$\frac{1}{f^{1/2}} \approx -1.8 \log\left[\frac{6.9}{\mathrm{Re}} + \left(\frac{\varepsilon/D}{3.7}\right)^{1.11}\right]$$

- Discharge of broad-crested weir

$$C_{wb} = \frac{0.65}{(1 + H/p)^{1/2}}$$

$$Q = C_{wb}\, b\, \sqrt{g}\, \left(\frac{2}{3}\right)^{3/2} H^{3/2}$$

- Discharge of V-shaped weir:

$$Q = 0.7542 \times g^{1/2} \times \tan\alpha \times H^{5/2}$$

- Conversions:

$$1 \text{ gallon} = 3.785\, \ell$$

$$1 \text{ hp} = 745.7 \ \frac{\text{N m}}{\text{s}}$$

$$1 \text{ hp} = 550 \ \frac{\text{lb ft}}{\text{s}}$$

- Drag (skin formulas):

$$F_{drag} = \frac{1}{2} C_D\, \rho\, U_\infty^2 A$$

$$C_D = \frac{0.031}{(Re_L)^{1/7}} \ ;$$

if turbulent ($Re_L > 3 \times 10^6$)

$$C_D = \frac{1.328}{(Re_L)^{1/2}}$$

- Reynolds scaling:

$$\frac{V_M}{V_P} = \frac{L_P}{L_M} = \lambda^{-1}$$

- Froude scaling:

$$\frac{V_M}{V_P} = \lambda^{1/2}$$

- Specific speed of pumps

$$N_S = \frac{\omega \sqrt{Q}}{(gH)^{3/4}}$$

- Net positive suction head:

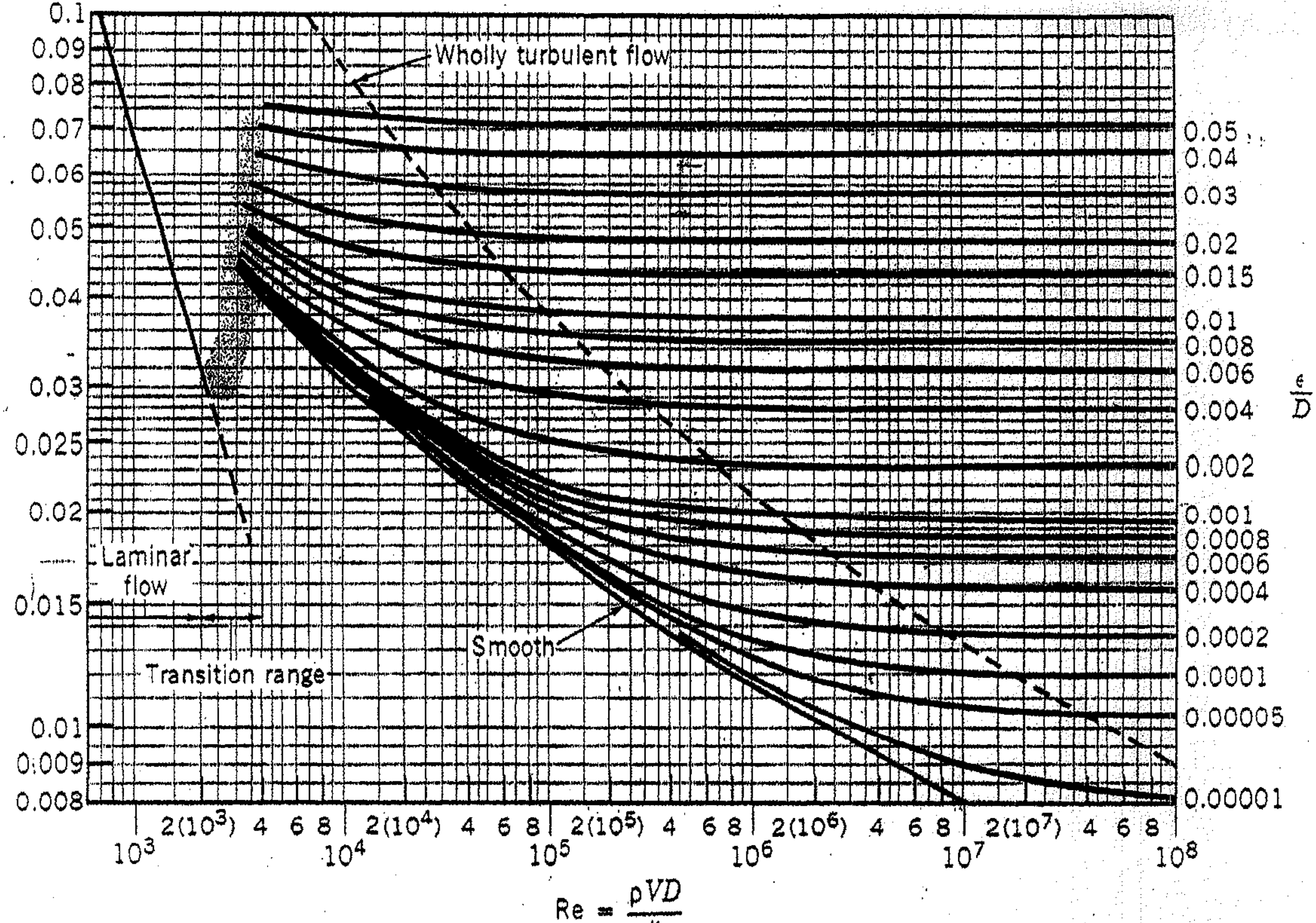
$$NPSH = \frac{P_{inlet}}{\gamma} - \frac{P_{vapor}}{\gamma} =$$

$$\frac{P_{atm}}{\gamma} - \left[H_s + h_{f_{1\to3}} + \sum h_{m_{1\to3}} + \frac{V_{inlet}^2}{2g} + \frac{P_{vapor}}{\gamma} \right]$$

- $P_{vapor\ 20°C} = 2.337$ KPa

  $P_{vapor\ 30°C} = 4.242$ KPa

  $P_{atmospheric} = 101{,}350$ Pa $\approx 10^5$ Pa



■ FIGURE 8.23 Friction factor as a function of Reynolds number and relative roughness for round pipes—the Moody chart (Data from Ref. 7 with permission).

ort dashed or dotted lines.

known backwater curve; it is n the practical point of view. end of a long mild channel is than the normal depth of the in zone 1. The upstream end pth line, since $dy/dx = 0$ as to the horizontal pool surface, nples of the $M1$ profile are the ig. 9-4a) and the profile in a

of the channel at the down- a depth less than the normal ofile is tangent to the normal- f the amount of submergence ical depth, the flow profile will a vertical line at a depth equal for $y = y_c$. This means the h of submergence at the down- th, then as much of the profile n the reservoir. Examples are n enlargement of a canal cross al leading to a reservoir, where l below the critical-depth line

upstream channel bottom, e angle, depending on the type nd terminates with a hydraulic of profile usually occurs when a The beginning of the profile, by the theory, depends on the e higher the velocity, the farther theoretical upstream end of the . At this end $y = 0$; thus the re, the theoretical upstream end ly. Examples of the $M3$ profile (Fig. 9-4e) and the profile after o mild (Fig. 9-4f).

e upstream and becomes tangent stream end. Examples are the

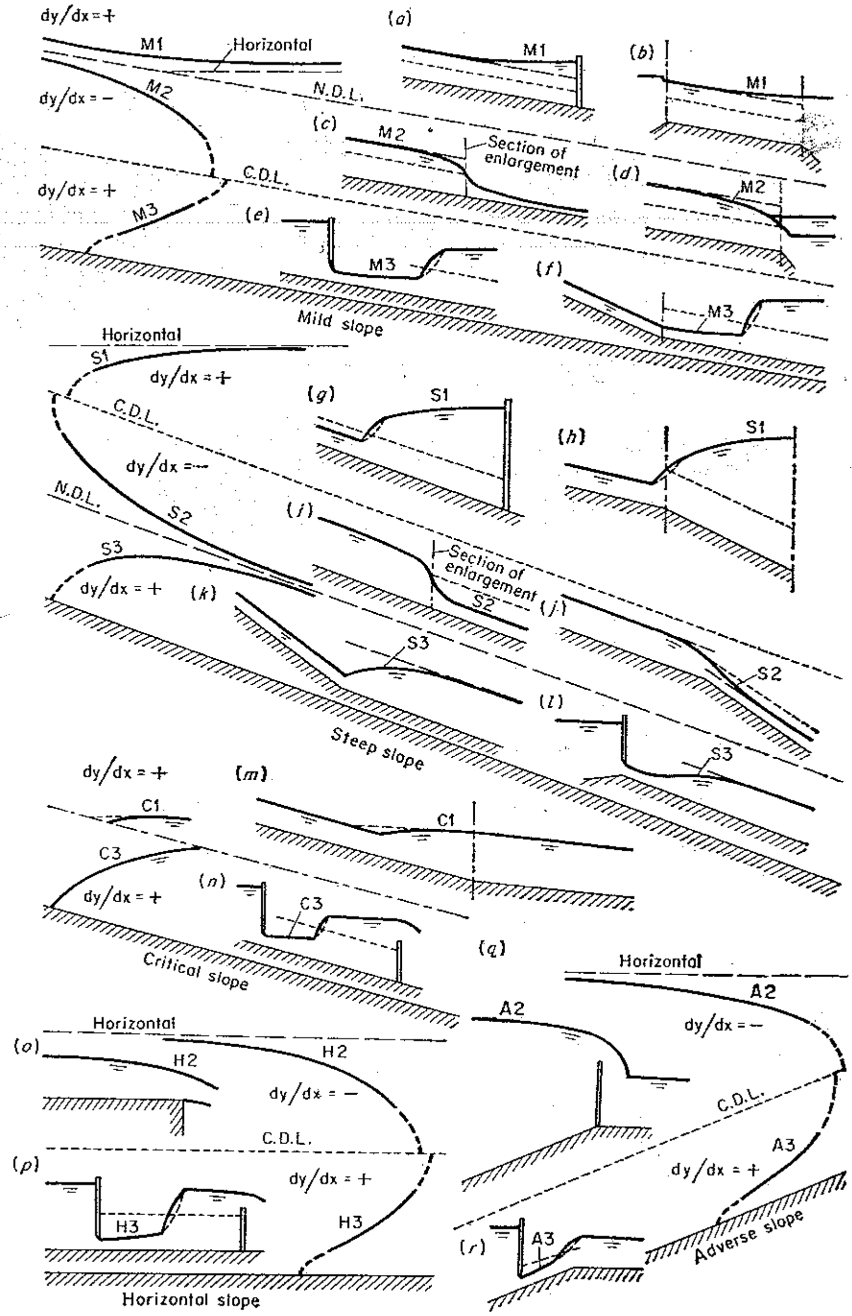


FIG. 9-4. Examples of flow profiles.