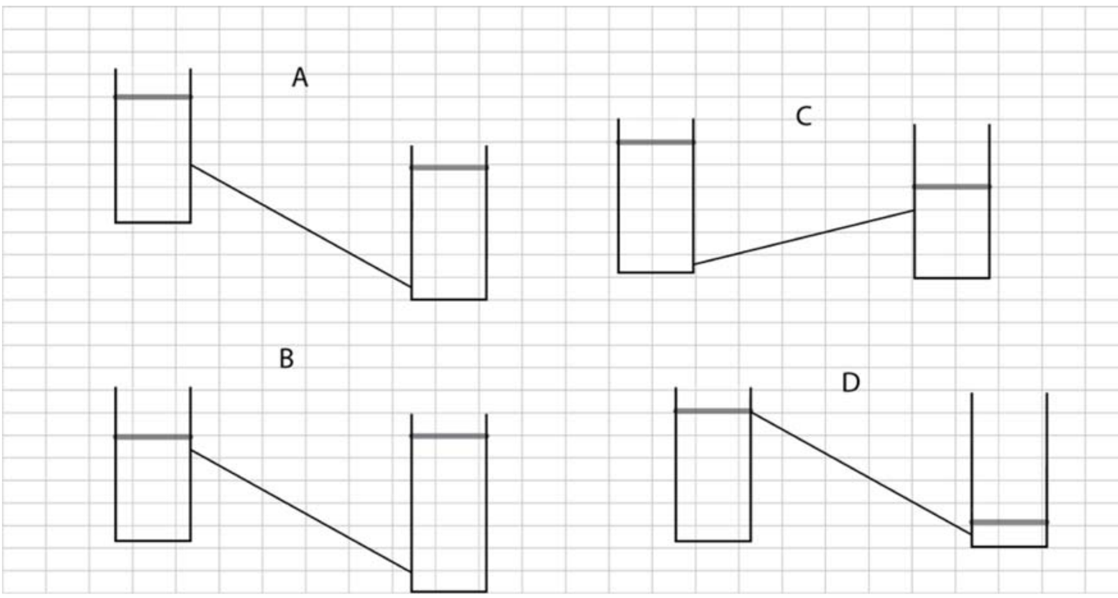
# First Test 2013 Calculations

Equations for friction factor:

```
fexplicit := (1. / (-1.8 Log[10, 6.9 / Reynolds + (relativerough / 3.7)^1.11]))^2

fimplicit := zzz /. FindRoot[1. / Sqrt[zzz] ==
    -2.0 Log[10, relativerough / 3.7 + 2.51 / Reynolds / Sqrt[zzz]], {zzz, 0.01}]
```

---

## Series of tanks




D is fastest, B is slowest, $V = \text{sqrt}\left(2 g \Delta z / \left(fL / D + \sum K\right)\right)$

Starting energy equation:
V1^2/2g + P1/rho g + z1 = V2^2/2g + P2/rho g + z2 + V^2/2g (f L/D + ∑K)
points 1 and 2 are at the top of each tank, V1 and V2 are zero, as are P1 and P2
z1-z2 = V^2/2g (f L/D + ∑K)
$V = \text{sqrt}\left(2 g \Delta z / \left(fL / D + \sum K\right)\right)$

---

## 2. Find the friction factor in Walt’s new tubing if the water flow rate is 10 liters a minute.

```
relativerough = 0.0015 / 15 (* copper tube *)
```

0.0001

```
nu = 10^-6;
dia = 0.015 (* m diameter of tubing *)
area = Pi (0.015 / 2) ^2
vel = 10. / 1000 / 60 / area (* m/s *)
Reynolds = vel dia / nu
Reynolds // ScientificForm
```

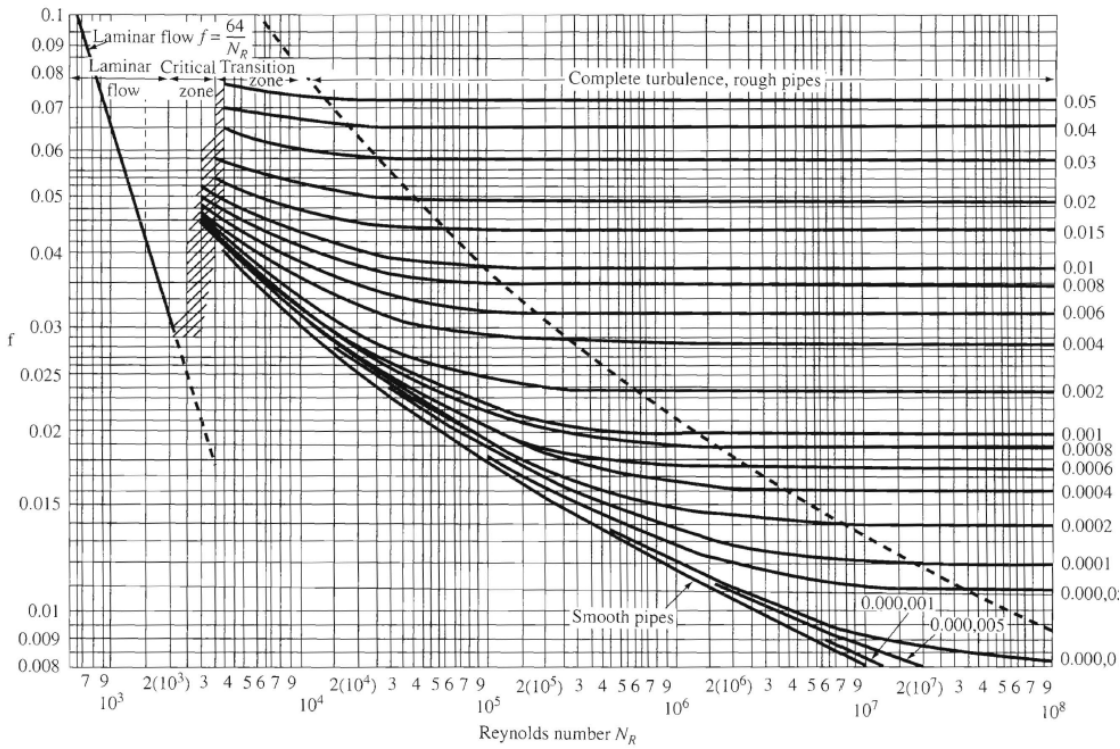
```
0.015

0.000176715

0.94314

14 147.1
```

$1.41471 \times 10^4$

```
fimplicit
```

```
0.0284052
```

Allow 0.25 to 0.3 for the friction factor, this flow is NOT fully turbulent



# 3. wetting on left, non wetting on right

# 4. viscosity and velocity gradient

# 5. Concrete section of Rio Grande

```
In[4]:= slope = 0.005; n = 0.013; b = 21.; m = 4; y = 1.1;
        area = y (b + m y)
        perimeter = b + 2 y (Sqrt[1 + m^2]); hydrad = area / perimeter

Out[5]= 27.94

Out[6]= 0.92914

In[7]:= vel = 1.49 / n hydrad^(2 / 3) Sqrt[slope]

Out[7]= 7.717

In[8]:= discharge = vel * area

Out[8]= 215.613

In[13]:= topwidth = b + 2 m y
         Froude = vel / (Sqrt[32.2 * area / topwidth])

Out[13]= 29.8

Out[14]= 1.40448
```

It is an M section because the normal flow is subcritical (yc < y)
Note: give credit here based upon Froude number, if they (incorrectly) got a Froude number that is supercritical then give them credit if they say it is a steep slope

TABLE 6.1 Cross-Sectional Relationships for Open-Channel Flow

| Section Type | Area ($A$) | Wetted perimeter ($P$) | Hydraulic Radius ($R_h$) | Top Width ($T$) | Hydraulic Depth ($D$) |
|---|---|---|---|---|---|
| Rectangular | $by$ | $b + 2y$ | $\frac{by}{b + 2y}$ | $b$ | $y$ |
| Trapezoidal | $(b + my)y$ | $b + 2y\sqrt{1 + m^2}$ | $\frac{(b + my)y}{b + 2y\sqrt{1 + m^2}}$ | $b + 2my$ | $\frac{(b + my)y}{b + 2my}$ |
| Triangular | $my^2$ | $2y\sqrt{1 + m^2}$ | $\frac{my}{2\sqrt{1 + m^2}}$ | $2my$ | $\frac{y}{2}$ |
| Circular ($\theta$ is in radians) | $\frac{1}{8}(2\theta - \sin 2\theta)d_0^2$ | $\theta d_0$ | $\frac{1}{4}\left(1 - \frac{\sin 2\theta}{2\theta}\right)d_0$ | $(\sin\theta)d_0$ or $2\sqrt{y(d_0 - y)}$ | $\frac{1}{8}\left(\frac{2\theta - \sin 2\theta}{\sin\theta}\right)d_0$ |

*Source:* V. T. Chow, *Open Channel Hydraulics* (New York: McGraw-Hill, 1959).

## 6. This is a Parshall flume

## 7. Pipe, piezometer, and pitot tube

```
vel = 2. ; pres = 4000. ; rho = 1000.; g = 9.81;
piezometer = pres / rho / g
```

```
0.407747
```

```
pitot = vel^2 / (2 g) + piezometer
```

```
0.611621
```

```
vel^2 / (2 g)
```

```
0.203874
```

Notes: give half credit for the pitot tube if they only include the velocity head

## 8. critical depth increases with flow as shown in the graph

## 9. since the normal depth (y2) is subcritical, since it is after the

**jump, this must be a mild (M) section, a mild section with supercritical flow (before the jump) is an M3**

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## 10. Based on the density given in the story, they float

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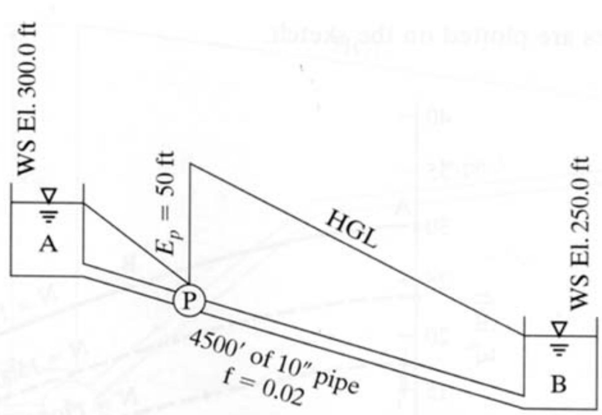
## 11.




Write the energy equation from $A$ to $B$ in terms of water surface elevation ($WSEL$).

$$E_p + WSEL_A = H_L + WSEL_B$$

$$H_L = E_p + WSEL_A - WSEL_B$$

$$\frac{fL}{D}\frac{V^2}{2g} = 50.0 + 300.0 - 250.0$$

$$\frac{0.02 \times 4500}{0.833}\frac{V^2}{2g} = 100.0 \text{ ft}$$

$$\frac{V^2}{2g} = \frac{100.0}{108.0} = 0.926 \text{ ft}$$

$$V = 7.72 \text{ fps}$$

$$Q = AV = 0.545 \times 7.72 = 4.2 \text{ cfs}$$

---

## Rational Equation IDF Curve

```
<< Units`
```

```
Convert[5 Inch / Hour * 12. Acre * 0.85, Foot^3 / Second]
Convert[1. Acre Inch / Hour, Foot^3 / Second] (* 1 Acre*Inch/Hour = 1 cfs *)
```

$$\frac{51.425\ \text{Foot}^3}{\text{Second}}$$

$$\frac{1.00833\ \text{Foot}^3}{\text{Second}}$$

```
Convert[5 Inch / Hour * 12. Acre * 0.85, Inch^3 / Second]
Convert[5 Inch / Hour * 12. Acre * 0.85, Foot^3 / Hour]
Convert[5 Inch / Hour * 12. Acre * 0.85, Meter^3 / Second]
Convert[5 Inch / Hour * 12. Acre * 0.85, Meter^3 / Hour]
```

$$\frac{88\,862.4\ \text{Inch}^3}{\text{Second}}$$

$$\frac{185\,130.\ \text{Foot}^3}{\text{Hour}}$$

$$\frac{1.45619\ \text{Meter}^3}{\text{Second}}$$

$$\frac{5242.3\ \text{Meter}^3}{\text{Hour}}$$

# Binomial

```
Prob := n! / (x! (n - x)!) p^x (1 - p)^(n - x)
x = 2;(* number success *)
n = 2; (* number trials *)
p = 1 / 50.
```

0.02

```
x = 0; Prob
```

0.9604

```
1 - Prob
```

0.0396

# Fetter Flow Tube

```
-10^-4 (130 - 150) / 100. // ScientificForm
```

$2. \times 10^{-5}$

# Flow Tube

### Solution

(a) Superficial velocity

$$v = -K\frac{dh}{dl} = -(7.5\times10^{-4}\ \text{m/s})\frac{-35\ \text{m}}{1500\ \text{m}} = 1.75\times10^{-5}\ \text{m/s}$$

# Winter Single Lake

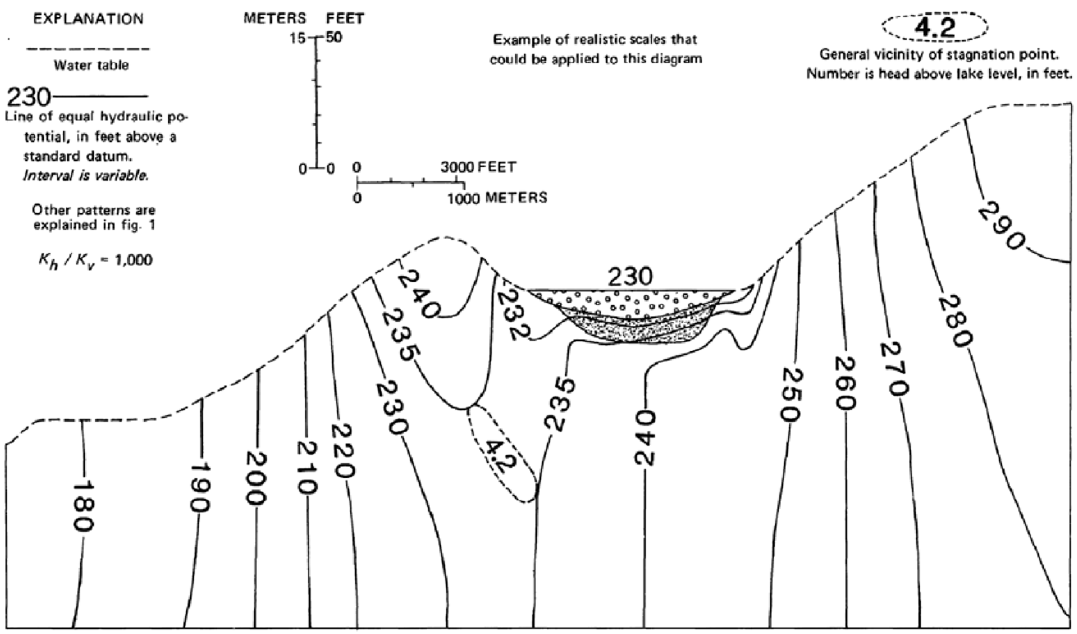
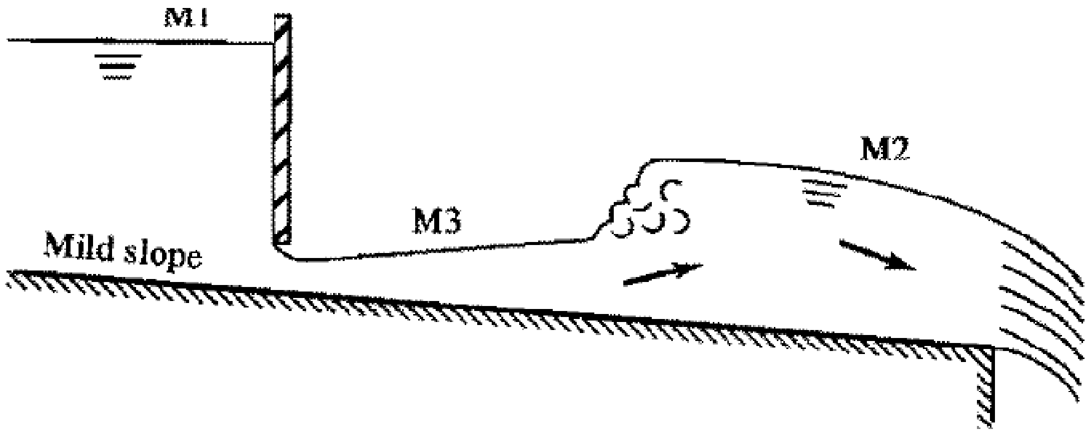



FIGURE 9.—Hydrologic section showing distribution of hydraulic head in the ground-water reservoir of a one-lake system that contains lake sediments but does not contain aquifers.

# Flow Profiles


M1
M2
M3
Mild slope