PipeCalc4

Pipe calculator for partial flow

8/16/2025 by E Shiomoto

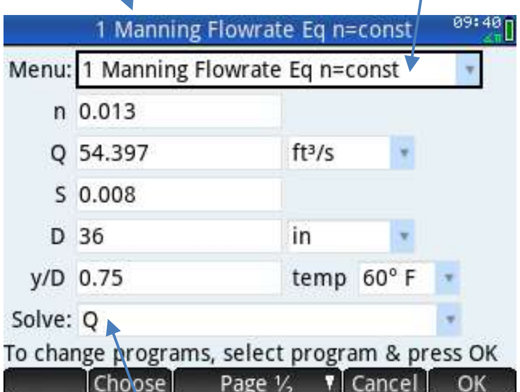
This program calculates the unknown variable for Manning n=constant, Manning n=f(D), Colebrook-White, Q=VA, and other equations for a circular pipe flowing partially full. The results are displayed on the calculator's print terminal. To switch programs, select the new program from the Menu on the INPUT screen and press the OK tab. To rerun the same program, press the Esc key to exit the terminal, and press the Enter key to rerun the program.

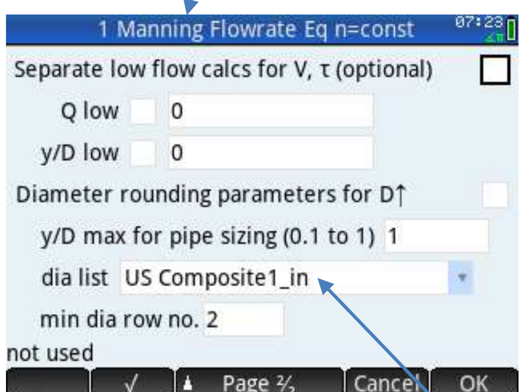
The Menu box is used to change programs. To change the program, select a new program from the list and press the OK tab.

1 Manning Flowrate Eq n=const
2 Manning Velocity Eq n=const
3 Manning Flowrate Eq n=f(D)
4 Manning Velocity Eq n=f(D)
5 Colebrook-White Flowrate Eq
6 Colebrook-White Velocity Eq
7 S min program
8 Q=VA Eq
9 Critical Flow Eq
10 Shear Stress Eq
11 Raths-McCauley sand particle
12 Q/Qf ⇆ y/D Conversions
13 Q Conversions
14 Set no. of digits

Low flow inputs and diameter rounding settings are shown on the second page of the input screen. These options are only available for the Manning and Colebrook flowrate programs.

Current program in use





n
Q
S
D
y/D
D↑, y/D given n Q S
clear inputs
clear terminal
view terminal
view pipe diameter list

To solve for the unknown variable, input the known values and units. Select the variable to be solved from the Solve menu. Then, press the OK tab.

If the solve variable has units, select the units to be use.

The results will be displayed on the print terminal.

To run the program again, press the Esc key to exit the print terminal. Then, press the Enter key to run the program again.

US Composite1_in
US Composite1_mm
US Composite2_in
US Composite2_mm
US RCP_in
US VC_ in
UK Composite_mm
Aus Composite_mm
Ger Composite_mm

A. Instructions

Calculator System Settings and Operations

At the start of the program, the calculator will change the app angle mode to radians and the Home number format to floating with 4 digits (default). At the end of the program, the calculator will restore the previous angle mode and number format. The number of digits can be changed using program "14 Set no. of digits".

When the program solves for the unknown variable, the results are displayed on the calculator's print terminal. When the program is run a second time, the results are added to the bottom of the previous text. The print terminal will hold about 100 lines of text. To clear the print terminal, select "clear print terminal" form the menu and press the OK tab. To view the print terminal, select view menu from the "menu" on the INPUT screen.

This program was used with software version 2.3.1 and build date 2025-01-31.

This program was written with the period used as the decimal point, and will not work when the comma is used as the decimal point.

Changing Programs

The name of the current program is displayed in the title of the input screen. To switch between the various programs, select the new program from the "Menu" choose list and then press the OK tab located in the lower right corner of the screen. The input screen of the new program will display the input values and units from the previous program, where applicable.

Rerun the program

When the program ends, the print terminal is displayed with the calculated results. To rerun the program, press the Esc key to exit the print terminal, then press the Enter key to run the program. Another way to rerun the program is to press the Enter key twice. Alternatively, the program can be launched by pressing the Toolbox key, and then pressing the User tab, and the selecting PipeCalc.

When the program is run a second time, the program will run the last program that was used and will display the previous input entries and unit selections. The previous solve variable results are added to the input screen. This was done to facilitate chain calculations.

To clear the previous inputs, select "clear inputs" from the Solve input box, and press the OK tab. "clear inputs" does not change the previous unit selections.

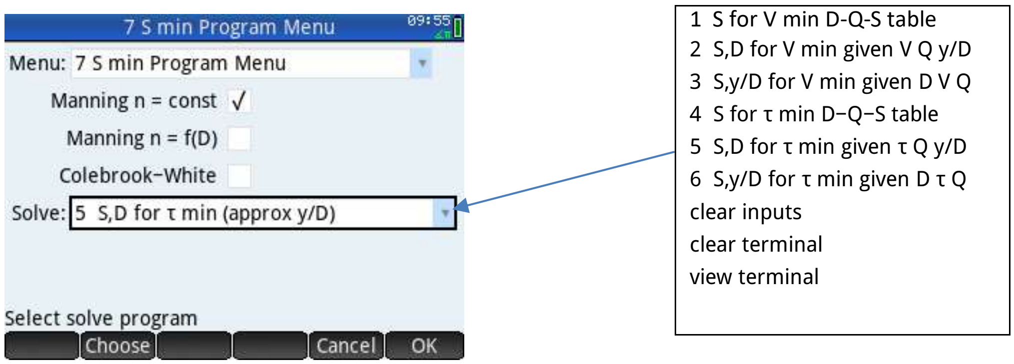
Exit the Program

To exit the program from the input screen, press the Cancel tab on the input screen, or press the Esc key.

To exit the print terminal and return to the Home screen, press the Esc key or press the Home key.

S min program

One of the programs in PipeCalc is the "S min program". The program allows the user to run a set of minimum slope programs for either V_{min} or τ_{min} for the Manning n=const, Manning n=f(D), and Colebrook-White equations.



Set no. of digits program

This program allows the user to set the number of digits displayed on the input screen and printed on the print terminal.

Accuracy of the Manning Equation

This program calculates Manning's equation in SI (MKSA) units, where the Manning k constant is the exact value of 1. The program then converts the values to BG units, as necessary. Because of this, the program's results will be slightly different from other programs that use a rounded Manning's k value of 1.49 or 1.486. The use of the exact Manning's k value not only effects the value of Q and V, but can affect other Manning's parameters.

Program background

PipeCalc was written as a replacement for the Field's Hydraulic Calculator and the HP-41 Pipe Slide-Rule program.

B. Solve for the unknown variable

In general, you can solve for any one variable of an equation on PipeCalc, provided the other variables are known. Simply, run PipeCalc. Switch to the desired equation. Enter the values and units of the known variables. Specify the variable to be solved in the "Solve" box. If the solve variable has units, specify the units of the solve variable. Finally, press the OK tab located in the lower right corner of the screen. The program will solve for the unknown variable and display the results on the print terminal.

Problem

Determine the discharge rate in a 24 in concrete pipe on a slope of 0.008 that has a relative depth of y/D = 0.45. (Use the Manning equation and assume n = 0.014 for a concrete pipe)

To switch to the "Manning Flowrate Eq n=const" program, select "Manning Flowrate Eq n=const" in menu box, and press the OK tab.

On the input screen for the Manning flowrate equation, the variables n, Q, S, D, and y/D are displayed. Note that input variables Q and D have units. Below the input variables is a "Solve" drop box that list all of the variables. There is a water temperature box near the lower right corner of the input screen, that is used to determine the equivalent ks value. The input screen second page has optional inputs for low flows and diameter rounding that are not used in this example.

In this problem, n, S, D, and y/D are the known variables, and Q is the unknown variable.

Enter the value and units of the known variables. When solving for Q, you need to enter the units of Q. In the solve box, select Q. Finally, press the OK tab located in the lower right-hand corner.

Input screen for Manning Flowrate Eq n=const

Menu:	1 Manning Flowrate Eq n=const		
n:	0.014		
Q:	0	ft^3/s	
S:	0.008		
D:	24	in	
y/D:	0.45		temp 60° F
Solve:	Q		

Separate low flow calcs for V, τ (optional)
Q low ❑ 0
y/D low ❑ 0
Diameter rounding parameters for D↑
y/D max for pipe sizing (0.1 to 1): 1
dia list: US Composite1_in
min dia row no.: 2

The calculator indicates the flowrate Q = 7.8257 ft^3/s.

Print Terminal

```
-----------------------------------
01 Manning Flowrate Eq n=const
02 Solve: Q
 ▹ Manning n = 0.014
   flowrate Q = 7.8257_(ft^3/s)✶
 ▹ slope S = 0.008
   slope ratio = 1 : 125
 ▹ diameter D = 24_in
 ▹ relative depth y/D = 0.45
   depth y = 10.8_in
   central angle θ = 2.9413_rad
 ▹ water temp = 60° F
   ---
   velocity V = 5.7075_(ft/s)
   ave shear stress τ = 0.23257_(lbf/ft²)
   froude no. = 1.2122
   (equivalent ks = 2.5359_mm)
```

```
   area A = 1.3711_ft^2
   hydraulic radius Rh = 0.46617_ft
   wetted perimeter P = 2.9413_ft
   top width T = 1.99_ft
Q full = 18.788_(ft^3/s)   y/D = 1 & 0.81963
Q peak = 20.21_(ft^3/s)   y/D = 0.93818
V full = 5.9803_(ft/s)   y/D = 1 & 0.5
V peak = 6.8178_(ft/s)   y/D = 0.8128
critical rel. depth (y/D crit) = 0.49766
critical depth (y crit) = 11.944_in
kinematic viscosity vk = 12.170E-6_(ft^2/s)
density ρ = 1.9383E0_(slug/ft^3)
Notes
● The calculation of τ uses the approximate
equation, where sin(θ)=S.
```

C. Solve for depth of flow using the Colebrook-White flowrate equation

Determine the depth of flow for a 500 mm concrete pipe on a slope of 0.01 m/m with a discharge rate of 0.118 m^3/s. (assume roughness ks = 0.6 mm for a concrete pipe)

In this problem, the Colebrook-White flowrate equation program used to solve for depth y. Depth y is not part of the variables used in the program's flowrate equation. So, we solve for the relative depth y/D, instead of depth y. After the program solves for y/D, the program will calculate depth y.

To solve this problem, switch to the Colebrook-White Flowrate Eq program. Input the known variables values and units. Select the water temperature. Select y/D as the solve variable. Finally, press the OK tab. Note that the inputs on page 2 are not used for this example.

Input screen for Colebrook-White Flowrate Eq n=const

```
Menu: 5 Colebrook−White Flowrate Eq n=const
   ks:   0.6     mm
    Q:   0.118   m^3/s
    S:   0.01
    D:   500     mm
  y/D:   0                    temp 15° C
Solve:   y/D
```

```
Separate low flow calcs for V, τ  (optional)
     Q low ❑  0
   y/D low ❑  0
Diameter rounding parameters for D↑
   y/D max for pipe sizing (0.1 to 1):  1
   dia list:  US Composite1_in
   min dia row no.:  2
```

The print terminal indicates the relative depth y/D = 0.35814 and depth y = 179.07 mm.

Print Terminal

```
-----------------------------------
05 Colebrook−White Flowrate Eq
05 Solve: y/D
 ▹ roughness ks = 0.6_mm
 ▹ flowrate Q = 0.118_(m^3/s)
 ▹ slope S = 0.01
   slope ratio = 1 : 100
 ▹ diameter D = 500_mm
   relative depth y/D = 0.35814✶
   depth y = 179.07_mm
   central angle θ = 2.5662_rad
 ▹ water temp = 15° C
   ---
   velocity V = 1.8674_(m/s)
   ave shear stress τ = 9.6504_Pa
   froude no. = 1.6425
   (equivalent n = 0.01142)
```

```
   area A = 0.06319_m^2
   hydraulic radius Rh = 0.0985_m
   wetted perimeter P = 0.64156_m
   top width T = 0.47945_m
Q full = 0.42614_(m^3/s)   y/D = 1 & 0.82692
Q peak = 0.45576_(m^3/s)   y/D = 0.94081
V full = 2.1703_(m/s)   y/D = 1 & 0.5
V peak = 2.455_(m/s)   y/D = 0.8128
critical rel. depth (y/D crit) = 0.46379
critical depth (y crit) = 231.89_mm
kinematic viscosity vk = 1.1390E-6_Pa
density ρ = 999.10E0_(kg/m^3)
Notes
• The calculation of τ uses the approximate
equation, where sin(θ)=S.
```

D. Solve for depth of flow given Q min and Q max

For a 24 in diameter pipe at a slope of 0.10 feet per hundred with a pipe roughness of n = 0.013, determine the depth of flow and velocity for the following flowrates: Q max = 3.9 MGD and Q min = 0.9 MGD.

If necessary, switch to the Manning Flowrate Eq n=const program.

On the input screen, Q min is entered on the 2nd page under "Separate low flow calcs". The checkbox adjacent to Q min must be checked. When entering the value for Q min, use the same units as with Q, which in this case is in MGD.

Input screen for Manning Flowrate Eq n=const

```
Menu:   1 Manning Flowrate Eq n=const
    n:   0.013
    Q:   3.9     MGD
    S:   0.001
    D:   24      in
  y/D:   0                    temp 70° F
Solve:   y/D
```

```
Separate low flow calcs for V, τ  (optional)
     Q low ☑  0.9
   y/D low ❑  0
Diameter rounding parameters for D↑
   y/D max for pipe sizing (0.1 to 1):  1
   dia list:  US Composite1_in
   min dia row no.:  2
```

The print terminal indicates: For Q max = 3.9 MGD, y/D = 0.70404, y = 16.897 in, and V = 2.5528 ft/s. For Q low = 0.9 MGD, y/D = 0.29907, y = 7.1778 in, and V = 1.7643 ft/s.

Print Terminal

```
-----------------------------------
01 Manning Flowrate Eq n=const
05 Solve: y/D
 ▹ Manning n = 0.013
 ▹ flowrate Q = 3.9_(MgalUS/d)
 ▹ slope S = 0.001
   slope ratio = 1 : 1000
 ▹ diameter D = 24_in
   relative depth y/D = 0.70404✶
   depth y = 16.897_in
   central angle θ = 3.9823_rad
 ▹ water temp = 70° F
   ---
   velocity V = 2.5528_(ft/s)
   ave shear stress τ = 0.03698_(lbf/ft²)
   froude no. = 0.39556
   (equivalent ks = 1.3758_mm)
   area A = 2.3637_ft^2
   hydraulic radius Rh = 0.59355_ft
```

```
   wetted perimeter P = 3.9823_ft
   top width T = 1.8259_ft
Low flow calcs for Q low = 0.9_(MgalUS/d)
   V = 1.7643_(ft/s)
   τ = 0.02125_(lbf/ft²)
   y/D = 0.29907
   y = 7.1778_in
Q full = 4.6234_(MgalUS/d)   y/D = 1 & 0.81963
Q peak = 4.9734_(MgalUS/d)   y/D = 0.93818
V full = 2.277_(ft/s)   y/D = 1 & 0.5
V peak = 2.5959_(ft/s)   y/D = 0.8128
critical rel. depth (y/D crit) = 0.43441
critical depth (y crit) = 10.426_in
kinematic viscosity vk = 10.590E-6_(ft^2/s)
density ρ = 1.9364E0_(slug/ft^3)
Notes
• The calculation of τ uses the approximate
equation, where sin(θ)=S.
```

E. Sizing a pipe using chain calculations

PipeCalc supports successive chain calculations. The program will retain the last values of the known and solved variables. (On the HP-41 Pipe Slide Rule, the previous input values were not saved, and one had to enter all of the inputs every time the program was run.)

Problem

Given a flow rate of 18.6 cfs, n of 0.013 and a slope of .0015, determine the required pipe size and velocity of flow.

answer: D = 33 in, Q full = 13 MGD, V full = 3.4 ft/s, *y/D = 0.77 and V = 3.8 ft/s.*

For this problem, the Manning equation is used twice: 1) to solve for the calculated diameter, where the calculated diameter is manually rounded up, and 2) to solve for the relative depth y/D and velocity.

Run the PipeCalc program. If necessary, switch to the Manning Flow Equation program by selecting the Manning Flow Eq from the menu and then press the OK tab.

1) Solve for the diameter

Enter the following on the Manning flowrate input screen. The diameter is the variable to be solved, so set the diameter units to inch. The program will ignore the current value of the diameter. For the slope, you can enter "0.0015" or key in the sequence "0.15 ÷ 100 Enter". To size the pipe for full flow, set y/D = 1. Finally, set the solve box to "D", and press the OK tab.

Input screen for Manning Flowrate Eq n=const

```
Menu:   1 Manning Flowrate Eq n=const
   n:   0.013
   Q:   18.6     ft^3/s
   S:   0.0015
   D:   0        in
 y/D:   1                    temp 60° F
Solve:  D
```

```
  Separate low flow calcs for V, τ  (optional)
     Q low ❏  0
   y/D low ❏  0
Diameter rounding parameters for D↑
   y/D max for pipe sizing (0.1 to 1):  1
   dia list:  US Composite1_in
   min dia row no.:  2
```

The print terminal indicates the diameter D = 31.829 in.

Print Terminal

```
-----------------------------------
01 Manning Flowrate Eq n=const
04 Solve: D
 ▹ Manning n = 0.013
 ▹ flowrate Q = 18.6_(ft^3/s)
 ▹ slope S = 0.0015
   slope ratio = 1 : 666.67
   diameter D = 31.829_in✶
 ▹ relative depth y/D = 1
   depth y = 31.829_in
   central angle θ = 6.2832_rad
 ▹ water temp = 60° F
   ---
   velocity V = 3.3663_(ft/s)
   ave shear stress τ = 0.06203_(lbf/ft²)
   froude no. = not applic.
   (equivalent ks = 1.3424_mm)
```

```
   area A = 5.5254_ft^2
   hydraulic radius Rh = 0.6631_ft
   wetted perimeter P = 8.3327_ft
   top width T = not applic.
Q full = 18.6_(ft^3/s)    y/D = 1 & 0.81963
Q peak = 20.008_(ft^3/s)    y/D = 0.93818
V full = 3.3663_(ft/s)    y/D = 1 & 0.5
V peak = 3.8376_(ft/s)    y/D = 0.8128
critical rel. depth (y/D crit) = 0.54114
critical depth (y crit) = 17.224_in
kinematic viscosity vk = 12.170E-6_(ft^2/s)
density ρ = 1.9383E0_(slug/ft^3)
Notes
• The calculation of τ uses the approximate
equation, where sin(θ)=S.
```

Round the diameter upwards to 33 in.

2) Solve for the relative depth y/D

Rerun PipeCalc and solve for the depth of flow using the rounded diameter of 33 inch.

PipeCalc can be rerun by pressing the Esc key to exit the print terminal, and pressing the Enter key to rerun the program. The program's input screen will display the last values and units.

On the input screen, change the diameter to be 33 in. Change Solve to y/D. When solving for y/D, the program will ignore the previous value of y/D. Press the OK tab.

Input screen for Manning Flowrate Eq n=const

```
Menu:   1 Manning Flowrate Eq n=const
   n:   0.013
   Q:   12       MGD
   S:   0.0015
   D:   33       in
 y/D:   1                    temp 60° F
Solve:  y/D
```

```
  Separate low flow calcs for V, τ  (optional)
     Q low ❏  0
   y/D low ❏  0
Diameter rounding parameters for D↑
   y/D max for pipe sizing (0.1 to 1):  1
   dia list:  US Composite1_in
   min dia row no.:  2
```

The print terminal indicates that for a 33 in pipe, the relative depth y/D = 0.74735, depth y = 24.663 in, and velocity V = 3.9067 ft/s.

Print Terminal

```
----------------------------------
01 Manning Flowrate Eq n=const
05 Solve: y/D
 ▹ Manning n = 0.013
 ▹ flowrate Q = 18.6_(ft^3/s)
 ▹ slope S = 0.0015
   slope ratio = 1 : 666.67
 ▹ diameter D = 33_in
   relative depth y/D = 0.74735✶
   depth y = 24.663_in
   central angle θ = 4.1766_rad
 ▹ water temp = 60° F
   ---
   velocity V = 3.9067_(ft/s)
   ave shear stress τ = 0.07755_(lbf/ft²)
   froude no. = 0.48798
   (equivalent ks = 1.258_mm)
```

```
   area A = 4.761_ft^2
   hydraulic radius Rh = 0.82904_ft
   wetted perimeter P = 5.7428_ft
   top width T = 2.3899_ft
Q full = 20.482_(ft^3/s)   y/D = 1 & 0.81963
Q peak = 22.032_(ft^3/s)   y/D = 0.93818
V full = 3.4484_(ft/s)   y/D = 1 & 0.5
V peak = 3.9312_(ft/s)   y/D = 0.8128
critical rel. depth (y/D crit) = 0.51613
critical depth (y crit) = 17.032_in
kinematic viscosity vk = 12.170E-6_(ft^2/s)
density ρ = 1.9383E0_(slug/ft^3)
Notes
• The calculation of τ uses the approximate
equation, where sin(θ)=S.
```

F. Sizing a pipe using the D↑ auto sizing option

The D↑ auto sizing option is only available on the Manning and Colebrook-White flowrate equations. D↑ means solve for the diameter and round upwards based on a predefined diameter list, and then solve for the actual depth. To use the D↑ option, the diameter rounding parameters on page 2 of the input screen must be specified.

Predefined diameter lists

A few generic pipe diameter lists were added to the program. The “US Composite1_in” list is the same as the “US Composite2_in”, except the US Composite1_in list does not contain a 33” and 39” diameters.

The program contains soft metric versions of the US Composite1 and US Composite2 diameter lists. These lists are in millimeters rounded to the nearest 5 mm.

The UK, Australia and Germany pipe diameter lists are generic in nature and may not accurately represent the pipe diameters used in those countries. These lists were added for testing purposes.

Viewing the pipe diameter lists

The diameter lists can be viewed by setting solve to “view pipe diameter list” and then pressing the OK tab. Then, on the “view pipe diameter list” input screen, select “US Composite in” and press the OK tab. The diameter list will be printed on the print terminal. Row no. 2 always represents the smallest diameter on the diameter list.

```
Terminal                          10:55
----------------------------------
Diameter List = US Composite in
where row 1 = units
row    Dia
1       1_in
2       4
3       6
4       8
5       10
6       12
7       15
8       18
9       21
```

Problem

Design a storm pipe to handle 10 ft³/s under gravity flow, where the available slope is 0.009 ft/ft. Use n = 0.014. To maintain a self-cleaning velocity in the storm drain, the storm drain is to maintain full-flow pipe velocity of 3 feet per second or greater.

For this problem, y/D max is set to 1 for full flow. The diameter list is set to "US Composite1_in". The minimum diameter row number is set to 2, which represents the smallest diameter in the diameter list.

Input screen for Manning Flowrate Eq n=const

Menu: 1 Manning Flowrate Eq n=const
n: 0.014
Q: 10 ft³/s
S: 0.009
D: 0 in
y/D: 0 temp 60° F
Solve: D↑,y/D given n Q S

Separate low flow calcs for V, τ (optional)
Q low ❑ 0
y/D low ❑ 0
Diameter rounding parameters for D↑
y/D max for pipe sizing (0.1 to 1): 1
dia list: US Composite1_in
min dia row no.: 2

The print terminal indicates the diameter D = 21_in, relative depth y/D = 0.62619, and depth y = 13.15_in. V_{full} = 5.8028 ft/s, which is greater than the minimum velocity for self-cleaning.

Print Terminal

----
01 Manning Flowrate Eq n=const
06 Solve: D↑, y/D given n Q S
▹ Manning n = 0.013
▹ flowrate Q = 10_(ft^3/s)
▹ slope S = 0.009
slope ratio = 1 : 111.11
diameter D = 21_in✶
(calculated diameter = 18.024_in)
▹ y/D max for pipe sizing = 1
▹ dia. list = US Composite1_in
▹ minimum diameter row no. = 2
minimum diameter = 4_in
relative depth y/D = 0.59618✶
depth y = 12.52_in
central angle θ = 3.5287_rad
▹ water temp = 60° F
---
velocity V = 6.6873_(ft/s)
ave shear stress τ = 0.27183_(lbf/ft²)

froude no. = 1.2634
(equivalent ks = 1.4902_mm)
area A = 1.4954_ft^2
hydraulic radius Rh = 0.48431_ft
wetted perimeter P = 3.0876_ft
top width T = 1.7173_ft
Q full = 15.031_(ft^3/s) y/D = 1 & 0.81963
Q peak = 16.169_(ft^3/s) y/D = 0.93818
V full = 6.2492_(ft/s) y/D = 1 & 0.5
V peak = 7.1243_(ft/s) y/D = 0.8128
critical rel. depth (y/D crit) = 0.67299
critical depth (y crit) = 14.133_in
kinematic viscosity vk = 12.170E-6_(ft^2/s)
density ρ = 1.9383E0_(slug/ft^3)
Notes
• The calculation of τ uses the approximate equation, where sin(θ)=S.

G. Size a pipe for y/D max = 0.75 using the D↑ auto sizing option

Size a pipe to handle 83 l/s under gravity flow where y/D max = 0.75, and the available slope is 0.006 and ks = 0.6 mm.

For this problem, use the Colebrook-White flowrate equation with the *D↑,y/D given n Q S* solve option. Enter ks, Q and S. Set "y/D max for pipe sizing" to 0.75. The diameter list is set to "UK Composite mm". No minimum pipe diameter was specified, so set "min dia row no." = 2, which corresponds to a 100 mm pipe. 100 mm is the smallest diameter in the "UK Composite mm" diameter list.

Input screen for Colebrook-White Flowrate Eq

```
Menu:   5  Colebrook−White Flowrate Eq
  ks:   0.6      mm
   Q:   83       l/s
   S:   0.006
   D:   0        mm
 y/D:   0                     temp 15° C
Solve:  D↑,y/D  given  n Q S
```

```
Separate low flow calcs for V, τ  (optional)
     Q low  ❑  0
   y/D low  ❑  0
Diameter rounding parameters for D↑
   y/D max for pipe sizing (0.1 to 1):  0.75
   dia list:  UK Composite_mm
   min dia row no.:  2
```

The print terminal indicates the diameter D↑ = 375 mm, relative depth y/D = 0.52204, and depth y = 195.76 mm.

Print Terminal

```
-----------------------------------
05 Colebrook−White Flowrate Eq
06 Solve: D↑, y/D  given  n Q S
 ▹ roughness ks = 0.6_mm
 ▹ flowrate Q = 83_(l/s)
 ▹ slope S = 0.006
   slope ratio = 1 : 166.67
   diameter D = 375_mm✶
   (calculated diameter = 307.46_mm)
 ▹ y/D max for pipe sizing = 0.75
 ▹ dia. list = UK Composite mm
 ▹ minimum diameter row no. = 2
   minimum diameter = 100_mm
   relative depth y/D = 0.52204✶
   depth y = 195.76_mm
   central angle θ = 3.2298_rad
 ▹ water temp = 15° C
   ---
   velocity V = 1.4231_(m/s)
   ave shear stress τ = 5.6616_Pa
```

```
   froude no. = 1.1518
   (equivalent n = 0.01144)
   area A = 0.05832_m^2
   hydraulic radius Rh = 0.09631_m
   wetted perimeter P = 0.60558_m
   top width T = 0.37464_m
Q full = 154.52_(l/s)    y/D = 1 & 0.82569
Q peak = 165.42_(l/s)    y/D = 0.94039
V full = 1.399_(m/s)    y/D = 1 & 0.5
V peak = 1.5846_(m/s)    y/D = 0.8128
critical rel. depth (y/D crit) = 0.56213
critical depth (y crit) = 210.8_mm
kin viscosity vk = 1.1390E-6_Pa
density ρ = 999.10E0_(kg/m^3)
Notes
• The calculation of τ uses the approximate
equation, where sin(θ)=S.
```

H. Solve S,D for τ min (approx. method)

Given an average flow of 2.25 l/s, and a maximum flow of 6.25 l/s, determine the slope and pipe diameter required for a minimum tractive force of 1 Pa and for a minimum flow relative depth of y/D = 0.2 and a maximum flow relative depth of y/D = 0.7. Manning's roughness = 0.013.

Step 1, solve for the slope

Assume y/D min is 0.2.

Switch to the "S min program". On the S min input screen, checkmark the "Manning n = const" and select the "S,D (τ min) given τ Q y/D" solve option. Then press the OK tab.

Input screen for 7 S min program

```
Menu:  7 S min program
     Manning n = const  ❑
       Manning n = f(D)  ❑
      Colebrook−White  ☑
Solve:   5  S,D  (τ min)  given   τ  Q  y/D
```

On the 2nd input screen for *S,D (τ min) given τ Q y/D* solve option, input the following and press the OK tab.

Input screen for *05 S,D (τ min) given τ Q y/D*

```
          n:   0.013
          τ :   1        Pa
          Q:   2.25     l/s
     D unit:   mm
  y/D min:   0.2
      temp:   15° C
```

The print terminal indicates the approx. slope S = 0.00388.

Print Terminal

```
-----------------------------------
07 S(min) Programs
05 S,D  (τ min) given τ Q y/D
Manning's Eq n=const
  ▹ Manning n = 0.013
  ▹ ave shear stress τ = 1.0_(N/m²)
    velocity V = 0.42373_(m/s)
  ▹ flowrate Q = 2.25_(l/s)
    slope S = 0.00388✶
    slope ratio = 1 : 257.47
    diameter D = 217.91_mm✶(a)
  ▹ relative depth y/D = 0.2
    central angle θ = 1.8546_rad
    depth y = 43.582_mm
  ▹ water temp = 15° C
    ---     froude no. = 0.7753
    (equivalent ks = 1.5529_mm)
    area A = 0.00531_m^2
    hydraulic radius Rh = 0.02628_m
```

```
    wetted perimeter P = 0.20207_m
    top width T = 0.17433_m
Q full = 25.693_(l/s)    y/D = 1 & 0.81963
Q peak = 27.638_(l/s)    y/D = 0.93818
V full = 0.68893_(m/s)    y/D = 1 & 0.5
V peak = 0.7854_(m/s)    y/D = 0.8128
A full = 0.03729_m^2
critical rel. depth Yc/D = 0.17566
critical depth Yc = 38.278_mm
kin viscosity VK = 1.1390E-6_Pa
density ρ = 999.10E0_(kg/m^3)
Notes
● The calculation of τ uses the approximate
equation, where sin(θ)=S.
(a)  D is the calculated diameter, and is
generally not used, as the pipe diameter is
usually sized by Q max.
```

Step 2, solve for the diameter

Switch to the *Manning Flowrate Eq n=const* equation. On the input screen enter n, Q max, Q min, S, y/D min, y/D max and other information shown, and press the OK tab.

Input screen for Manning Flowrate Eq

Menu:	1 Manning Flowrate Eq n=const
n:	0.013
Q:	6.25 l/s
S:	0.00388
D:	0 mm
y/D:	0 temp 15° C
Solve:	D↑,y/D given n Q S

Separate low flow calcs for V, τ (optional)
Q low ☑ 2.25
y/D low ❑ 0
Diameter rounding parameters for D↑
y/D max for pipe sizing (0.1 to 1): 0.7
dia list: Aus Composite_mm
min dia row no.: 2

The print terminal indicates the diameter D = 150 mm and relative depth y/D = 0.59243. For the low flows, V = 0.43973 m/s, τ = 1.0569 N/m^2 and y/D = 0.33147.

Print Terminal

```
-----------------------------------
01 Manning Flowrate Eq n=const
06 Solve: D↑, y/D  given  n Q S
  ▹ Manning n = 0.013
  ▹ flowrate Q = 6.25_(l/s)
  ▹ slope S = 0.00388
    slope ratio = 1 : 257.73
    diameter D = 150_mm✶
    (calculated diameter = 137.11_mm)
  ▹ y/D max for pipe sizing = 0.7
  ▹ dia. list = Aus Composite_mm
  ▹ minimum diameter row no. = 2
    minimum diameter = 100_mm
    relative depth y/D = 0.59243✶
    depth y = 88.864_mm
    central angle θ = 3.5134_rad
  ▹ water temp = 15° C
    ---
    velocity V = 0.57322_(m/s)
    ave shear stress τ = 1.573_Pa
    froude no. = 0.67305
    (equivalent ks = 1.6168_mm)
```

```
    area A = 0.0109_m^2
    hydraulic radius Rh = 0.04138_m
    wetted perimeter P = 0.26351_m
    top width T = 0.14742_m
Low flow calcs for Q low = 2.25_(l/s)
    V = 0.43973_(m/s)
    τ = 1.0569_(N/m²)
    y/D = 0.33147
    y = 49.72_mm
Q full = 9.4863_(l/s)    y/D = 1 & 0.81963
Q peak = 10.205_(l/s)    y/D = 0.93818
V full = 0.53682_(m/s)    y/D = 1 & 0.5
V peak = 0.61199_(m/s)    y/D = 0.8128
critical rel. depth (y/D crit) = 0.48155
critical depth (y crit) = 72.232_mm
kinematic viscosity vk = 1.1390E-6_Pa
density ρ = 999.10E0_(kg/m^3)
Notes
• The calculation of τ uses the approximate
equation, where sin(θ)=S.
```

1. Solve S,y/D for τ min

In the previous problem, $S_{\tau\ min}$ and D were solved using the approximate method. Now that diameter is known, the exact $S_{\tau\ min}$ and y/D can be solved using the *S,y/D for τ min given D τ Q* solve option in the S min program.

Run the *S,y/D for τ min given D τ Q* solve option in the S min program. Enter n = 0.013, D = 150 mm, τ min = 1 Pa, Q min = 2.25 l/s, and temp = 15° C. Finally press the OK tab.

The print terminal indicates the slope for τ min equals 0.00362 at a relative depth of 0.33762.

Print Terminal

```
-----------------------------------
07 S min program
06 S,y/D for τ min given D τ Q
Manning's Eq n=const
 ▹ Manning n = 0.013
 ▹ ave shear stress τ = 1_(N/m²)
   velocity V = 0.42877_(m/s)
 ▹ flowrate Q = 2.25_(l/s)
   slope S = 0.00362✶
   slope ratio = 1 : 276.41
 ▹ diameter D = 150_mm
   relative depth y/D = 0.33762✶
   central angle θ = 2.4801_rad
   depth y = 50.643_mm
 ▹ water temp = 15° C
   ---
   froude no. = 0.71193
   (equivalent ks = 1.56_mm)
```

```
   area A = 0.00525_m^2
   hydraulic radius Rh = 0.02821_m    wetted
perimeter P = 0.18601_m    top width T =
0.14187_mQ full = 9.1602_(l/s)    y/D = 1 &
0.81963Q peak = 9.8537_(l/s)    y/D = 0.93818V
full = 0.51836_(m/s)    y/D = 1 & 0.5V peak =
0.59095_(m/s)    y/D = 0.8128A full =
0.01767_m^2critical rel. depth Yc/D =
0.28329critical depth Yc = 42.493_mmkin
viscosity VK = 1.1390E-6_Padensity ρ =
999.10E0_(kg/m^3)Notes• The calculation of τ
uses the approximate equation, where
sin(θ)=S.
```

J. Revisions

Several bugs were fixed. The program was simplified to be easier to use. Some features were removed.

K. Program comments

Internal unit variables and unit handling

Unit variables are a list that contains the SI value part, SI unit part, user value part, user unit part, number that identifies if the variable is an input variable or solve variable, and input and output flags. The SI unit part is predefined in the variable declarations.

After data is inputted on the input screen, the program stores the user value part and user unit part into the unit variable. The program then calculates the SI value part. From this point on, all calculations in the program are done using the SI value part. After solving for the unknown variable, the SI values are converted back to the user's units. The results are printed on the print terminal using the user value part multiplied by the unit part.

Diameter rounding adjustment

PipeCalc uses a diameter rounding adjustment of 0.6 mm. In the D↑ rounding procedure, 0.6 mm is subtracted from the calculated diameter, when rounding the diameter upwards. The HP-41 Pipe Slide Rule program used a diameter rounding adjustment of 0.003 in.