iemisc: Open Channel Flow Examples involving Geometric Shapes with the Gauckler-Manning-Strickler Equation

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Contents

About the examples

The following examples only cover open channel flow problems using the Gauckler-Manning-Strickler equation (commonly called Manning's equation) [Wikimedia] to calculate the missing parameters and the critical depth.

Other examples using the Gauckler-Manning-Strickler equation can be found at Open Channel Flow Examples using the Gauckler-Manning-Strickler equation written by the author.

Examples

rectangular cross-section

```
install.load::load_package("iemisc", "iemiscdata", "rivr")
# load needed packages using the load_package function from the install.load
# package (it is assumed that you have already installed these packages)


# 1) Practice Problem 14.10 from Mott (pages 391-392)
```

```
# What is the Q (discharge) for this cross-section?

# See nchannel in iemiscdata for the Manning's n table that the following
# example uses Use the normal Manning's n value for Natural streams - minor
# streams (top width at floodstage < 100 ft), Lined or Constructed Channels,
# Concrete, and unfinished.

# The 1st heading is 'Manning's n for Channels' The 2nd heading is 'Natural
# streams - minor streams (top width at floodstage < 100 ft)' The 3rd heading
# is 'Lined or Constructed Channels,' The 4th heading is 'Concrete' The 5th
# heading is 'unfinished'


data(nchannel)
# load the data set nchannel from iemiscdata

nlocation <- grep("unfinished", nchannel$"Type of Channel and Description")
# search for the term 'unfinished' in the 'Type of Channel and Description'
# column in the nchannel data set

nlocation

## [1] 72

n <- nchannel[nlocation, 3]  # 3 for column 3 - Normal n
# the value of n will be found in column 3 at the location specified by
# nlocation

n

## [1] 0.017

Q <- Manningrect(b = 3.5, y = 2, Sf = 0.1/100, n = n, units = "SI")

##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is subcritical flow.

# b = 3.5 m, y = 2 m, Sf = 0.1 percent m/m, n = 0.017, units = SI units This
# will solve for Q since it is missing and Q will be in m^3/s

# Note: Q (discharge), velocity (V), area (A), wetted perimeter (P), R
# (hydraulic radius), Re (Reynolds number), and Fr (Froude number) are returned
# as a R list

Q

## $Q
## [1] 12.4358
##
## $V
## [1] 1.776542
##
```

```
## $A
## [1] 7
##
## $P
## [1] 7.5
##
## $R
## [1] 0.9333333
##
## $B
## [1] 3.5
##
## $D
## [1] 2
##
## $Re
## [1] 1651619
##
## $Fr
## [1] 0.401144
# What is the critical depth for this given discharge?

critical_depth(Q$Q, 2, 9.80665, 3.5, 0)

## [1] 1.087836
# 2) Problem 1 from Hauser (page 88)

# What is the Sf (slope) for this cross-section?

Sf <- Manningrect(Q = 6.25 * 8 * 14.9, b = 8, y = 6.25, n = 0.01, units = "Eng")

##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is supercritical flow.
# Q = 6.25 ft * 8 ft * 14.9 ft/sec, b = 8 ft, y = 6.25 ft, n = 0.01, units =
# Eng units This will solve for Sf since it is missing and Sf will be in ft/ft

# Note: Sf (slope), velocity (V), area (A), wetted perimeter (P), R (hydraulic
# radius), Re (Reynolds number), and Fr (Froude number) are returned as a R
# list

Sf

## $Sf
## [1] 0.003062629
##
## $V
## [1] 14.9
##
## $A
```

```
## [1] 50
##
## $P
## [1] 20.5
##
## $R
## [1] 2.439024
##
## $B
## [1] 8
##
## $D
## [1] 6.25
##
## $Re
## [1] 3363024
##
## $Fr
## [1] 1.050737
```

```
# What is the critical depth for this given discharge?

critical_depth(6.25 * 8 * 14.9, 6.25, 9.80665 * (3937/1200), 8, 0)
```

```
## [1] 6.459654
```

trapezoidal cross-section

```
install.load::load_package("iemisc", "iemiscdata", "rivr")
# load needed packages using the load_package function from the install.load
# package (it is assumed that you have already installed these packages)


# 3) Practice Problem 14.17 from Mott (page 392)

# What is the y (flow depth) for this cross-section?

# See nchannel in iemiscdata for the Manning's n table that the following
# example uses Use the normal Manning's n value for Natural streams - minor
# streams (top width at floodstage < 100 ft), Lined or Constructed Channels,
# Concrete, and unfinished.

# The 1st heading is 'Manning's n for Channels' The 2nd heading is 'Natural
# streams - minor streams (top width at floodstage < 100 ft)' The 3rd heading
# is 'Lined or Constructed Channels,' The 4th heading is 'Concrete' The 5th
# heading is 'unfinished'

data(nchannel)
# load the data set nchannel from iemiscdata

nlocation <- grep("unfinished", nchannel$"Type of Channel and Description")
```

```r
# search for the term 'unfinished' in the 'Type of Channel and Description'
# column in the nchannel data set

nlocation
```

```
## [1] 72
```

```r
n <- nchannel[nlocation, 3]  # 3 for column 3 - Normal n
# the value of n will be found in column 3 at the location specified by
# nlocation

n
```

```
## [1] 0.017
```

```r
m <- 1/0.8390996

y <- Manningtrap(Q = 15, b = 3, m = m, Sf = 0.1/100, n = n, units = "SI", type = "symmetrical",
    output = "data.table")
```

```
##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is subcritical flow.
```

```r
# Q = 15, b = 3 m, m = 1 / tand(40), Sf = 0.1 percent m/m, n = 0.017, units =
# SI units This will solve for y since it is missing and y will be in m

# Note: Flow depth (y), Flow area (A), Wetted Perimeters (P), Top Width (B),
# Bottom width (b), Hydraulic Radius (R), Hydraulic Depth (D), Flow Mean
# Velocity (V), Flow Discharge (Q), Manning's roughness coefficient (n), Slope
# (Sf), Temperature, Absolute Temperature, Saturated Liquid Density, Absolute
# or Dynamic Viscosity, Kinematic Viscosity, Froude number (Fr), Reynolds
# number (Re), symmetric side slope (m), non-symmetric side slope (m1),
# non-symmetric side slope (m2), Wetted Length (w), Wetted Length for a
# non-symmetric trapezoid (w1), Wetted Length for a non-symmetric trapezoid
# (w2), Section Factor (Z), conveyance (K), Specific Energy (E), Velocity Head
# (Vel_Head), Maximum Shear Stress (taud), Average Shear Stress (tau0) along
# with the associated units are returned in a data.table.

y
```

```
##                                      Parameters Normal Value
##  1:                               Flow depth (y) 1.631874e+00
##  2:                                Flow area (A) 8.069276e+00
##  3:                        Wetted Perimeters (P) 8.077490e+00
##  4:                                Top Width (B) 6.889583e+00
##  5:                             Bottom width (b) 3.000000e+00
##  6:                         Hydraulic Radius (R) 9.989831e-01
##  7:                          Hydraulic Depth (D) 1.171228e+00
##  8:                     Flow Mean Velocity (V) 1.858903e+00
##  9:                         Flow Discharge (Q) 1.500000e+01
## 10:         Manning's roughness coefficient (n) 1.700000e-02
## 11:                                   Slope (Sf) 1.000000e-03
```

```
## 12:                                          Temperature 2.000000e+01
## 13:                                 Absolute Temperature 2.931500e+02
## 14:                             Saturated Liquid Density 9.981581e+02
## 15:                        Absolute or Dynamic Viscosity 1.002078e-03
## 16:                                  Kinematic Viscosity 1.003928e-06
## 17:                                   Froude number (Fr) 5.484986e-01
## 18:                                 Reynolds number (Re) 1.849747e+06
## 19:                             symmetric side slope (m) 1.191754e+00
## 20:                        non-symmetric side slope (m1)           NA
## 21:                        non-symmetric side slope (m2)           NA
## 22:                                   Wetted Length (w) 2.538745e+00
## 23: Wetted Length for a non-symmetric trapezoid (w1)           NA
## 24: Wetted Length for a non-symmetric trapezoid (w2)           NA
## 25:                                   Section Factor (Z) 8.063804e+00
## 26:                                       conveyance (K) 4.743414e+02
## 27:                                  Specific Energy (E) 1.808056e+00
## 28:                             Velocity Head (Vel_Head) 1.761825e-01
## 29:                          Maximum Shear Stress (taud) 1.597374e-02
## 30:                          Average Shear Stress (tau0) 9.778632e-03
##                                           Parameters Normal Value
##                Units
##  1:                m
##  2:              m^2
##  3:                m
##  4:                m
##  5:                m
##  6:                m
##  7:                m
##  8:              m/s
##  9:            m^3/s
## 10:    dimensionless
## 11:              m/m
## 12:  degrees Celsius
## 13:           Kelvin
## 14:          kg/m^3
## 15: Pa * s or kg/m*s
## 16:           m^2/s
## 17:    dimensionless
## 18:    dimensionless
## 19:              m/m
## 20:              m/m
## 21:              m/m
## 22:                m
## 23:                m
## 24:                m
## 25:                m
## 26:            m^3/s
## 27:                m
## 28:                m
## 29:   pascal (N/m^2)
## 30:   pascal (N/m^2)
##                Units
```

```r
# list for y_list$y access
y_list <- Manningtrap(Q = 15, b = 3, m = m, Sf = 0.1/100, n = n, units = "SI", type = "symmetrical",
    output = "list")

##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is subcritical flow.
# What is the critical depth for this given discharge?

y_c <- Manningtrap_critical(Q = 15, b = 3, m = m, Sf = 0.1/100, n = n, units = "SI",
    type = "symmetrical", critical = "accurate", output = "data.table")

##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is subcritical flow.
# Q = 15, b = 3 m, m = 1 / tand(40), Sf = 0.1 percent m/m, n = 0.017, units =
# SI units This will solve for y since it is missing and y will be in m

# Note: Flow depth (y), Flow area (A), Wetted Perimeters (P), Top Width (B),
# Bottom width (b), Hydraulic Radius (R), Hydraulic Depth (D), Flow Mean
# Velocity (V), Flow Discharge (Q), Manning's roughness coefficient (n), Slope
# (Sf), Temperature, Absolute Temperature, Saturated Liquid Density, Absolute
# or Dynamic Viscosity, Kinematic Viscosity, Froude number (Fr), Reynolds
# number (Re), symmetric side slope (m), non-symmetric side slope (m1),
# non-symmetric side slope (m2), Wetted Length (w), Wetted Length for a
# non-symmetric trapezoid (w1), Wetted Length for a non-symmetric trapezoid
# (w2), Section Factor (Z), conveyance (K), Specific Energy (E), Velocity Head
# (Vel_Head), Maximum Shear Stress (taud), Average Shear Stress (tau0) along
# with the associated units are returned in a data.table.

y_c

##                                     Parameters Normal Value
##  1:                              Flow depth (y)        1.632
##  2:                               Flow area (A)        8.069
##  3:                        Wetted Perimeters (P)        8.077
##  4:                               Top Width (B)         6.89
##  5:                            Bottom width (b)            3
##  6:                        Hydraulic Radius (R)        0.999
##  7:                         Hydraulic Depth (D)        1.171
##  8:                     Flow Mean Velocity (V)        1.859
##  9:                         Flow Discharge (Q)           15
## 10:         Manning's roughness coefficient (n)        0.017
## 11:                                  Slope (Sf)        0.001
## 12:                                 Temperature           20
## 13:                        Absolute Temperature       293.15
## 14:                    Saturated Liquid Density      998.158
```

```
## 15:                  Absolute or Dynamic Viscosity  0.001002078
## 16:                            Kinematic Viscosity 1.003928e-06
## 17:                             Froude number (Fr)        0.548
## 18:                           Reynolds number (Re)      1849747
## 19:                       symmetric side slope (m)        1.192
## 20:                  non-symmetric side slope (m1)           NA
## 21:                  non-symmetric side slope (m2)           NA
## 22:                             Wetted Length (w)        2.539
## 23: Wetted Length for a non-symmetric trapezoid (w1)           NA
## 24: Wetted Length for a non-symmetric trapezoid (w2)           NA
## 25:                             Section Factor (Z)        8.064
## 26:                                 conveyance (K)      474.341
## 27:                            Specific Energy (E)        1.808
## 28:                       Velocity Head (Vel_Head)        0.176
## 29:                    Maximum Shear Stress (taud)        0.016
## 30:                    Average Shear Stress (tau0)         0.01
##                                         Parameters Normal Value
##     Critical Value            Units
##  1:          1.366                m
##  2:          6.321              m^2
##  3:           7.25                m
##  4:          6.256                m
##  5:             NA                m
##  6:          0.872                m
##  7:           1.01                m
##  8:           3.66              m/s
##  9:         27.347            m^3/s
## 10:             NA    dimensionless
## 11:          0.002              m/m
## 12:             NA  degrees Celsius
## 13:             NA           Kelvin
## 14:             NA           kg/m^3
## 15:             NA Pa * s or kg/m*s
## 16:             NA            m^2/s
## 17:              1    dimensionless
## 18:             NA    dimensionless
## 19:             NA              m/m
## 20:             NA              m/m
## 21:             NA              m/m
## 22:             NA                m
## 23:             NA                m
## 24:             NA                m
## 25:          8.733                m
## 26:             NA            m^3/s
## 27:          1.653                m
## 28:             NA                m
## 29:             NA   pascal (N/m^2)
## 30:             NA   pascal (N/m^2)
##     Critical Value            Units
```

```r
# This can also be done with the critical_depth function from the rivr package
# (below)

critical_depth(Q = 15, yopt = y_list$y, g = 9.80665, B = 3, SS = m)
```

```
## [1] 1.16226
# 4) Example 2 from FHWA

# What is the y (flow depth) for this cross-section?

y <- Manningtrap(Q = 150, b = 4, m = 2, Sf = 2/100, n = 0.03, units = "Eng", type = "symmetrical",
    output = "data.table")

##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is supercritical flow.
# Q = 150 cfs, b = 4 ft, m = 2, Sf = 2/100 ft/ft, n = 0.030, units = Eng units
# This will solve for y since it is missing and y will be in ft

# Note: Flow depth (y), Flow area (A), Wetted Perimeters (P), Top Width (B),
# Bottom width (b), Hydraulic Radius (R), Hydraulic Depth (D), Flow Mean
# Velocity (V), Flow Discharge (Q), Manning's roughness coefficient (n), Slope
# (Sf), Temperature, Absolute Temperature, Saturated Liquid Density, Absolute
# or Dynamic Viscosity, Kinematic Viscosity, Froude number (Fr), Reynolds
# number (Re), symmetric side slope (m), non-symmetric side slope (m1),
# non-symmetric side slope (m2), Wetted Length (w), Wetted Length for a
# non-symmetric trapezoid (w1), Wetted Length for a non-symmetric trapezoid
# (w2), Section Factor (Z), conveyance (K), Specific Energy (E), Velocity Head
# (Vel_Head), Maximum Shear Stress (taud), Average Shear Stress (tau0) along
# with the associated units are returned in a data.table.

y

##                                        Parameters Normal Value
##  1:                                Flow depth (y) 2.152071e+00
##  2:                                 Flow area (A) 1.787111e+01
##  3:                         Wetted Perimeters (P) 1.362436e+01
##  4:                                 Top Width (B) 1.260828e+01
##  5:                              Bottom width (b) 4.000000e+00
##  6:                          Hydraulic Radius (R) 1.311703e+00
##  7:                           Hydraulic Depth (D) 1.417410e+00
##  8:                        Flow Mean Velocity (V) 8.393437e+00
##  9:                            Flow Discharge (Q) 1.500000e+02
## 10:           Manning's roughness coefficient (n) 3.000000e-02
## 11:                                    Slope (Sf) 2.000000e-02
## 12:                                   Temperature 6.800000e+01
## 13:                          Absolute Temperature 2.931500e+02
## 14:                      Saturated Liquid Density 1.936747e+00
## 15:                 Absolute or Dynamic Viscosity 2.092885e-05
## 16:                           Kinematic Viscosity 1.080619e-05
## 17:                            Froude number (Fr) 1.242910e+00
## 18:                          Reynolds number (Re) 1.018833e+06
## 19:                      symmetric side slope (m) 2.000000e+00
## 20:                 non-symmetric side slope (m1)           NA
## 21:                 non-symmetric side slope (m2)           NA
```

```
## 22:                                Wetted Length (w) 4.812178e+00
## 23: Wetted Length for a non-symmetric trapezoid (w1)           NA
## 24: Wetted Length for a non-symmetric trapezoid (w2)           NA
## 25:                               Section Factor (Z) 2.141452e+01
## 26:                                   conveyance (K) 1.060675e+03
## 27:                              Specific Energy (E) 3.246896e+00
## 28:                         Velocity Head (Vel_Head) 1.094825e+00
## 29:                      Maximum Shear Stress (taud) 2.682039e+00
## 30:                      Average Shear Stress (tau0) 1.634722e+00
##                                       Parameters Normal Value
##                  Units
##   1:                ft
##   2:              ft^2
##   3:                ft
##   4:                ft
##   5:                ft
##   6:                ft
##   7:                ft
##   8:      ft/sec (fps)
##   9:    ft^3/sec (cfs)
## 10:       dimensionless
## 11:               ft/ft
## 12: degrees Fahrenheit
## 13:              Kelvin
## 14:           slug/ft^3
## 15:           slug/ft*s
## 16:              ft^2/s
## 17:       dimensionless
## 18:       dimensionless
## 19:               ft/ft
## 20:               ft/ft
## 21:               ft/ft
## 22:                  ft
## 23:                  ft
## 24:                  ft
## 25:                  ft
## 26:    ft^3/sec (cfs)
## 27:                  ft
## 28:                  ft
## 29:            lb/ft^2
## 30:            lb/ft^2
##                  Units
```

```
# list for y_cc_list$y access
y_cc_list <- Manningtrap(Q = 15, b = 3, m = m, Sf = 0.1/100, n = n, units = "SI",
    type = "symmetrical", output = "list")
```

```
##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is subcritical flow.
```

```r
# What is the critical depth for this given discharge?

y_cc <- Manningtrap_critical(Q = 150, b = 4, m = 2, Sf = 2/100, n = 0.03, units = "Eng",
    type = "symmetrical", critical = "accurate", output = "data.table")

##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is supercritical flow.
# Q = 15, b = 3 m, m = 1 / tand(40), Sf = 0.1 percent m/m, n = 0.017, units =
# SI units This will solve for y since it is missing and y will be in m

# Note: Flow depth (y), Flow area (A), Wetted Perimeters (P), Top Width (B),
# Bottom width (b), Hydraulic Radius (R), Hydraulic Depth (D), Flow Mean
# Velocity (V), Flow Discharge (Q), Manning's roughness coefficient (n), Slope
# (Sf), Temperature, Absolute Temperature, Saturated Liquid Density, Absolute
# or Dynamic Viscosity, Kinematic Viscosity, Froude number (Fr), Reynolds
# number (Re), symmetric side slope (m), non-symmetric side slope (m1),
# non-symmetric side slope (m2), Wetted Length (w), Wetted Length for a
# non-symmetric trapezoid (w1), Wetted Length for a non-symmetric trapezoid
# (w2), Section Factor (Z), conveyance (K), Specific Energy (E), Velocity Head
# (Vel_Head), Maximum Shear Stress (taud), Average Shear Stress (tau0) along
# with the associated units are returned in a data.table.

y_cc

##                                            Parameters Normal Value
##  1:                                     Flow depth (y)        2.152
##  2:                                      Flow area (A)       17.871
##  3:                              Wetted Perimeters (P)       13.624
##  4:                                      Top Width (B)       12.608
##  5:                                   Bottom width (b)            4
##  6:                               Hydraulic Radius (R)        1.312
##  7:                                Hydraulic Depth (D)        1.417
##  8:                             Flow Mean Velocity (V)        8.393
##  9:                                 Flow Discharge (Q)          150
## 10:                Manning's roughness coefficient (n)         0.03
## 11:                                         Slope (Sf)         0.02
## 12:                                        Temperature           68
## 13:                               Absolute Temperature       293.15
## 14:                           Saturated Liquid Density        1.937
## 15:                     Absolute or Dynamic Viscosity 2.092885e-05
## 16:                                Kinematic Viscosity 1.080619e-05
## 17:                                 Froude number (Fr)        1.243
## 18:                               Reynolds number (Re)      1018833
## 19:                           symmetric side slope (m)            2
## 20:                      non-symmetric side slope (m1)           NA
## 21:                      non-symmetric side slope (m2)           NA
## 22:                                 Wetted Length (w)        4.812
## 23: Wetted Length for a non-symmetric trapezoid (w1)           NA
## 24: Wetted Length for a non-symmetric trapezoid (w2)           NA
```

```
## 25:                               Section Factor (Z)       21.415
## 26:                                   conveyance (K)     1060.675
## 27:                              Specific Energy (E)        3.247
## 28:                         Velocity Head (Vel_Head)        1.095
## 29:                      Maximum Shear Stress (taud)        2.682
## 30:                      Average Shear Stress (tau0)        1.635
##                                         Parameters Normal Value
##     Critical Value              Units
##  1:          3.502                 ft
##  2:         38.533               ft^2
##  3:         19.661                 ft
##  4:         18.007                 ft
##  5:             NA                 ft
##  6:           1.96                 ft
##  7:           2.14                 ft
##  8:         10.615       ft/sec (fps)
##  9:        120.685     ft^3/sec (cfs)
## 10:             NA      dimensionless
## 11:          0.003              ft/ft
## 12:             NA degrees Fahrenheit
## 13:             NA             Kelvin
## 14:             NA          slug/ft^3
## 15:             NA          slug/ft*s
## 16:             NA             ft^2/s
## 17:              1      dimensionless
## 18:             NA      dimensionless
## 19:             NA              ft/ft
## 20:             NA              ft/ft
## 21:             NA              ft/ft
## 22:             NA                 ft
## 23:             NA                 ft
## 24:             NA                 ft
## 25:         21.276                 ft
## 26:             NA     ft^3/sec (cfs)
## 27:          3.737                 ft
## 28:             NA                 ft
## 29:             NA           lb/ft^2
## 30:             NA           lb/ft^2
##     Critical Value              Units
# This can also be done with the critical_depth function from the rivr package
# (below)
```

```
critical_depth(150, y_cc_list$y, 9.80665 * (3937/1200), 4, 2)
```

```
## [1] 2.40582
```

```
# 5) Example 2 -- Example Problem 4.5 from the Introduction to Highway
# Hydraulics: Hydraulic Design Series Number 4 Reference

# 'Determine the critical depth in a trapezoidal shaped swale with z = 1, given
# a discharge of 9.2 m^3/s and a bottom width, B = 6 m. Also, determine the
# critical velocity.

# What is the critical depth and critical velocity for this cross-section?
```

```r
y_c45 <- Manningtrap_critical(Q = 9.2, b = 6, m = 1, Sf = 2/100, n = 0.03, units = "SI",
    type = "symmetrical", critical = "accurate", output = "data.table")

##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is supercritical flow.

# Q = 15, b = 3 m, m = 1 / tand(40), Sf = 0.1 percent m/m, n = 0.017, units =
# SI units This will solve for y since it is missing and y will be in m

# Note: Flow depth (y), Flow area (A), Wetted Perimeters (P), Top Width (B),
# Bottom width (b), Hydraulic Radius (R), Hydraulic Depth (D), Flow Mean
# Velocity (V), Flow Discharge (Q), Manning's roughness coefficient (n), Slope
# (Sf), Temperature, Absolute Temperature, Saturated Liquid Density, Absolute
# or Dynamic Viscosity, Kinematic Viscosity, Froude number (Fr), Reynolds
# number (Re), symmetric side slope (m), non-symmetric side slope (m1),
# non-symmetric side slope (m2), Wetted Length (w), Wetted Length for a
# non-symmetric trapezoid (w1), Wetted Length for a non-symmetric trapezoid
# (w2), Section Factor (Z), conveyance (K), Specific Energy (E), Velocity Head
# (Vel_Head), Maximum Shear Stress (taud), Average Shear Stress (tau0) along
# with the associated units are returned in a data.table.

y_c45

##                                          Parameters Normal Value
##  1:                                   Flow depth (y)        0.512
##  2:                                    Flow area (A)        3.335
##  3:                             Wetted Perimeters (P)        7.448
##  4:                                    Top Width (B)        7.024
##  5:                                 Bottom width (b)            6
##  6:                             Hydraulic Radius (R)        0.448
##  7:                              Hydraulic Depth (D)        0.475
##  8:                            Flow Mean Velocity (V)        2.759
##  9:                              Flow Discharge (Q)          9.2
## 10:             Manning's roughness coefficient (n)         0.03
## 11:                                       Slope (Sf)         0.02
## 12:                                      Temperature           20
## 13:                             Absolute Temperature       293.15
## 14:                         Saturated Liquid Density      998.158
## 15:                   Absolute or Dynamic Viscosity  0.001002078
## 16:                              Kinematic Viscosity 1.003928e-06
## 17:                              Froude number (Fr)        1.279
## 18:                             Reynolds number (Re)      1230324
## 19:                          symmetric side slope (m)            1
## 20:                   non-symmetric side slope (m1)           NA
## 21:                   non-symmetric side slope (m2)           NA
## 22:                               Wetted Length (w)        0.724
## 23: Wetted Length for a non-symmetric trapezoid (w1)           NA
## 24: Wetted Length for a non-symmetric trapezoid (w2)           NA
## 25:                              Section Factor (Z)        1.952
## 26:                                 conveyance (K)       65.058
```

```
## 27:                          Specific Energy (E)          0.9
## 28:                     Velocity Head (Vel_Head)        0.388
## 29:                  Maximum Shear Stress (taud)          0.1
## 30:                  Average Shear Stress (tau0)        0.088
##                                            Parameters Normal Value
##     Critical Value            Units
##  1:          0.621                m
##  2:           4.11              m^2
##  3:          7.756                m
##  4:          7.242                m
##  5:             NA                m
##  6:           0.53                m
##  7:          0.568                m
##  8:          2.467              m/s
##  9:          7.196            m^3/s
## 10:             NA    dimensionless
## 11:          0.011              m/m
## 12:             NA  degrees Celsius
## 13:             NA           Kelvin
## 14:             NA           kg/m^3
## 15:             NA Pa * s or kg/m*s
## 16:             NA            m^2/s
## 17:              1    dimensionless
## 18:             NA    dimensionless
## 19:             NA              m/m
## 20:             NA              m/m
## 21:             NA              m/m
## 22:             NA                m
## 23:             NA                m
## 24:             NA                m
## 25:          2.298                m
## 26:             NA            m^3/s
## 27:          0.876                m
## 28:             NA                m
## 29:             NA   pascal (N/m^2)
## 30:             NA   pascal (N/m^2)
##     Critical Value            Units
# Using a trial and error solution, the critical depth is 0.6 m with a critical
# velocity of 2.3 m/s.
```

triangular cross-section

```
install.load::load_package("iemisc", "rivr")
# load needed packages using the load_package function from the install.load
# package (it is assumed that you have already installed these packages)


# 6) Problem 17 from Hauser (page 89)

# What is the Q (discharge) for this cross-section?
```

```r
Q <- Manningtri(y = 6, m = 4, Sf = 0.006, n = 0.025, units = "Eng")

##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is subcritical flow.
# y = 6 ft, m = 4 ft/ft, Sf = 0.006 ft/ft, n = 0.025, units = Eng units This
# will solve for Q since it is missing and Q will be in ft^3/s

# Note: Q (discharge), velocity (V), area (A), wetted perimeter (P), R
# (hydraulic radius), Re (Reynolds number), and Fr (Froude number) are returned
# as a R list

Q

## $Q
## [1] 1351.443
##
## $V
## [1] 9.385019
##
## $A
## [1] 144
##
## $P
## [1] 49.47727
##
## $R
## [1] 2.910428
##
## $B
## [1] 48
##
## $D
## [1] 3
##
## $Re
## [1] 2527665
##
## $Fr
## [1] 0.9552611
# What is the critical depth for this given discharge?

critical_depth(Q$Q, 6, 9.80665 * (3937/1200), 0, 4)

## [1] 5.89115
# 7) Example 2 from FHWA

# What is the y (flow depth) for this cross-section?
```

```r
y <- Manningtri(Q = 150, m = 2, Sf = 2/100, n = 0.03, units = "Eng")

##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is supercritical flow.
# Q = 150 cfs, m = 2, Sf = 2/100 ft/ft, n = 0.030, units = Eng units This will
# solve for y since it is missing and y will be in ft

# Note: y (flow depth), velocity (V), area (A), wetted perimeter (P), R
# (hydraulic radius), Re (Reynolds number), and Fr (Froude number) are returned
# as a R list

y

## $y
## [1] 2.975079
##
## $V
## [1] 8.473527
##
## $A
## [1] 17.70219
##
## $P
## [1] 13.30496
##
## $R
## [1] 1.330496
##
## $B
## [1] 11.90032
##
## $D
## [1] 1.48754
##
## $Re
## [1] 1043290
##
## $Fr
## [1] 1.224835
# What is the critical depth for this given discharge?

critical_depth(150, y$y, 9.80665 * (3937/1200), 4, 2)

## [1] 2.40582
```

circular cross-section

```r
library("iemisc")

# 8) Modified Practice Problem 14.32/14.34 from Mott (page 393)

# What is the Q (discharge) for this cross-section?

Q <- Manningcirc(d = 375 / 1000, y = 225 / 1000, Sf = 0.12 / 100, n = 0.015, units = "SI")

##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is subcritical flow.
# d = 375/1000 m, y = 225/1000 m, Sf = 0.12/100 m/m, n = 0.015, units = SI units
# This will solve for Q since it is missing and Q will be in m^3/s

# Note: Q (discharge), velocity (V), area (A), wetted perimeter (P), R (hydraulic radius), Re (Reynolds

Q

## $Q
## [1] 0.03536432
##
## $V
## [1] 0.5111079
##
## $A
## [1] 0.06919149
##
## $P
## [1] 0.6645578
##
## $R
## [1] 0.1041166
##
## $Re
## [1] 53006.61
##
## $Fr
## [1] 0.3761052
# 9) Problem 18 from Hauser (page 89)

# What is the Q (discharge) for this cross-section?

Q <- Manningcirc(d = 10 / 12, y = 3 / 12, Sf = 2 / 100, n = 0.025, units = "Eng")

##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
```

```
##
## This is subcritical flow.
# d = 10/12 ft, y = 3/12 ft, Sf = 2/100 ft/ft, n = 0.025, units = Eng units
# This will solve for Q since it is missing and Q will be in ft

# Note: Q (discharge), velocity (V), area (A), wetted perimeter (P), R (hydraulic radius), Re (Reynolds

Q

## $Q
## [1] 0.3155138
##
## $V
## [1] 2.292697
##
## $A
## [1] 0.1376169
##
## $P
## [1] 0.9660662
##
## $R
## [1] 0.1424508
##
## $Re
## [1] 30223.1
##
## $Fr
## [1] 0.9522204
```

parabolic cross-section

```
library("iemisc")

# 10) Modified Exercise 4.3 from Sturm (page 153)

# What is the B1 ("bank-full width") for this cross-section?

B1 <- Manningpara(Q = 32.2, y = 8, y1 = 5.1, Sf = 0.0092, n = 0.025, units = "SI")

##
## Flow IS in the rough turbulent zone so the Gauckler-Manning-Strickler equation
##  is acceptable to use.
##
##
## This is subcritical flow.
# Q = 32.2 m^3/s, y = 8 m, y1 = 5.1 m, Sf = 0.0092 m/m, n = 0.025, units = SI units
# This will solve for B1 since it is missing and B1 will be in m

# Note: B1 ("bank-full width"), velocity (V), area (A), wetted perimeter (P), R (hydraulic radius), Re
```

```
B1
```

```
## $B1
## [1] 0.982228
##
## $V
## [1] 4.907778
##
## $A
## [1] 6.561014
##
## $P
## [1] 16.10527
##
## $R
## [1] 0.407383
##
## $B
## [1] 1.23019
##
## $D
## [1] 5.333333
##
## $Re
## [1] 1991523
##
## $Fr
## [1] 0.6786177
```

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