

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

Irucka Embry, E.I.T. (EcoC<sup>2</sup>S)

2023-02-12

## Contents

<b>About the examples</b>	<b>1</b>
<b>Examples</b>	<b>1</b>
rectangular cross-section . . . . .	1
trapezoidal cross-section . . . . .	4
triangular cross-section . . . . .	14
circular cross-section . . . . .	17
parabolic cross-section . . . . .	18
Works Cited . . . . .	19
<b>EcoC<sup>2</sup>S Links</b>	<b>20</b>
<b>Copyright and License</b>	<b>20</b>

## 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 m3/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")
```

```

# 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

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.

# 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

```

```

# 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 <sup>2</sup>
## 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 <sup>3</sup> /s
## 10:	NA	dimensionless
## 11:	0.002	m/m
## 12:	NA	degrees Celsius
## 13:	NA	Kelvin
## 14:	NA	kg/m <sup>3</sup>
## 15:	NA	Pa * s or kg/m*s
## 16:	NA	m <sup>2</sup> /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 <sup>3</sup> /s
## 27:	1.653	m
## 28:	NA	m
## 29:	NA	pascal (N/m <sup>2</sup> )
## 30:	NA	pascal (N/m <sup>2</sup> )
##	Critical Value	Units

```
# 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.

```

```

# 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?
```

```
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?

```

```

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?

```

```

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

```
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 m3/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 m3/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
```

## Works Cited

Barbara A. Hauser, *Practical Hydraulics Handbook*, Second Edition, Boca Raton, Florida: CRC Press, Inc., 1996, pages 88-89.

Robert L. Mott and Joseph A. Untener, *Applied Fluid Mechanics*, Seventh Edition, New York City, New York: Pearson, 2015, pages 392-393.

Terry W. Sturm, *Open Channel Hydraulics*, 2nd Edition, New York City, New York: The McGraw-Hill Companies, Inc., 2010, page 153.

U.S. Department of Transportation Federal Highway Administration (FHWA), “Design Charts for Open-Channel Flow HDS 3”, August 1961, <https://www.fhwa.dot.gov/engineering/hydraulics/pubs/hds3.pdf>.

James D. Schall, Everett V. Richardson, and Johnny L. Morris, U.S. Department of Transportation Federal Highway Administration & National Highway Institute (NHI) and Office of Bridge Technology (HIBT), *Introduction to Highway Hydraulics: Hydraulic Design Series Number 4*, Fourth Edition, June 2008, pages 4-29 - 4-30, [https://www.fhwa.dot.gov/engineering/hydraulics/pubs/08090/HDS4\\_608.pdf](https://www.fhwa.dot.gov/engineering/hydraulics/pubs/08090/HDS4_608.pdf).

The NIST Reference on Constants, Units, and Uncertainty, Fundamental Constants Data Center of the NIST Physical Measurement Laboratory, “standard acceleration of gravity  $g_n$ ”, <https://physics.nist.gov/cgi-bin/cuu/Value?gn>.

Wikimedia Foundation, Inc. Wikipedia, 23 May 2019, “Manning formula”, [https://en.wikipedia.org/wiki/Manning\\_formula](https://en.wikipedia.org/wiki/Manning_formula).

## EcoC<sup>2</sup>S Links

EcoC<sup>2</sup>S Home – <https://www.ecoccs.com/>

About EcoC<sup>2</sup>S – [https://www.ecoccs.com/about\\_ecoc2s.html](https://www.ecoccs.com/about_ecoc2s.html)

Products – <https://www.questionuniverse.com/products.html>

EcoC<sup>2</sup>S Media – <https://www.ecoccs.com/media.html>

EcoC<sup>2</sup>S Resources – <https://www.ecoccs.com/resources.html>

R Trainings and Resources provided by EcoC<sup>2</sup>S (Iruka Embry, E.I.T.) – <https://www.ecoccs.com/rtraining.html>

## Copyright and License

All R code written by Iruka Embry is distributed under the GPL-3 (or later) license, see the [GNU General Public License {GPL}](#) page.

All written content originally created by Iruka Embry is copyrighted under the Creative Commons Attribution-ShareAlike 4.0 International License. All other written content retains the copyright of the original author(s).



This work is licensed under a [Creative Commons Attribution-ShareAlike 4.0 International License](#).