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", "pander")
# 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", "pander")
# 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.

pander(y, missing = "")
```

Parameters	Normal Value	Units
Flow depth (y)	1.632	m
Flow area (A)	8.069	m^2
Wetted Perimeters (P)	8.077	m
Top Width (B)	6.89	m
Bottom width (b)	3	m
Hydraulic Radius (R)	0.999	m
Hydraulic Depth (D)	1.171	m
Flow Mean Velocity (V)	1.859	m/s
Flow Discharge (Q)	15	m^3/s
Manning's roughness coefficient (n)	0.017	dimensionless
Slope (Sf)	0.001	m/m

Parameters	Normal Value	Units
Temperature	20	degrees Celsius
Absolute Temperature	293.1	Kelvin
Saturated Liquid Density	998.2	kg/m^3
Absolute or Dynamic Viscosity	0.001002	Pa * s or kg/m*s
Kinematic Viscosity	1.004e-06	m^2/s
Froude number (Fr)	0.5485	dimensionless
Reynolds number (Re)	1849747	dimensionless
symmetric side slope (m)	1.192	m/m
non-symmetric side slope (m1)		m/m
non-symmetric side slope (m2)		m/m
Wetted Length (w)	2.539	m
Wetted Length for a non-symmetric trapezoid (w1)		m
Wetted Length for a non-symmetric trapezoid (w2)		m
Section Factor (Z)	8.064	m
conveyance (K)	474.3	m^3/s
Specific Energy (E)	1.808	m
Velocity Head (Vel_Head)	0.1762	m
Maximum Shear Stress (taud)	0.01597	pascal (N/m^2)
Average Shear Stress (tau0)	0.009779	pascal (N/m^2)

```
# 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.

pander(y_c, missing = "")
```

Parameters	Normal Value	Critical Value	Units
Flow depth (y)	1.632	1.366	m
Flow area (A)	8.069	6.321	m^2
Wetted Perimeters (P)	8.077	7.25	m
Top Width (B)	6.89	6.256	m
Bottom width (b)	3		m
Hydraulic Radius (R)	0.999	0.872	m
Hydraulic Depth (D)	1.171	1.01	m
Flow Mean Velocity (V)	1.859	3.66	m/s
Flow Discharge (Q)	15	27.347	m^3/s
Manning's roughness coefficient (n)	0.017		dimensionless
Slope (Sf)	0.001	0.002	m/m
Temperature	20		degrees Celsius
Absolute Temperature	293.15		Kelvin
Saturated Liquid Density	998.158		kg/m^3
Absolute or Dynamic Viscosity	0.001002078		Pa * s or kg/m*s
Kinematic Viscosity	1.003928e-06		m^2/s
Froude number (Fr)	0.548	1	dimensionless
Reynolds number (Re)	1849747		dimensionless
symmetric side slope (m)	1.192		m/m
non-symmetric side slope (m1)			m/m
non-symmetric side slope (m2)			m/m
Wetted Length (w)	2.539		m
Wetted Length for a non-symmetric trapezoid (w1)			m
Wetted Length for a non-symmetric trapezoid (w2)			m
Section Factor (Z)	8.064	8.733	m
conveyance (K)	474.341		m^3/s
Specific Energy (E)	1.808	1.653	m
Velocity Head (Vel_Head)	0.176		m
Maximum Shear Stress (taud)	0.016		pascal (N/m^2)
Average Shear Stress (tau0)	0.01		pascal (N/m^2)

```
# 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?
```

```r
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.

pander(y, missing = "")
```

Parameters	Normal Value	Units
Flow depth (y)	2.152	ft
Flow area (A)	17.87	ft^2
Wetted Perimeters (P)	13.62	ft
Top Width (B)	12.61	ft
Bottom width (b)	4	ft
Hydraulic Radius (R)	1.312	ft
Hydraulic Depth (D)	1.417	ft
Flow Mean Velocity (V)	8.393	ft/sec (fps)
Flow Discharge (Q)	150	ft^3/sec (cfs)
Manning's roughness coefficient (n)	0.03	dimensionless
Slope (Sf)	0.02	ft/ft
Temperature	68	degrees Fahrenheit
Absolute Temperature	293.2	Kelvin
Saturated Liquid Density	1.937	slug/ft^3
Absolute or Dynamic Viscosity	2.093e-05	slug/ft*s
Kinematic Viscosity	1.081e-05	ft^2/s
Froude number (Fr)	1.243	dimensionless
Reynolds number (Re)	1018833	dimensionless
symmetric side slope (m)	2	ft/ft
non-symmetric side slope (m1)		ft/ft
non-symmetric side slope (m2)		ft/ft
Wetted Length (w)	4.812	ft
Wetted Length for a non-symmetric trapezoid (w1)		ft

Parameters	Normal Value	Units
Wetted Length for a non-symmetric trapezoid (w2)		ft
Section Factor (Z)	21.41	ft
conveyance (K)	1061	ft^3/sec (cfs)
Specific Energy (E)	3.247	ft
Velocity Head (Vel_Head)	1.095	ft
Maximum Shear Stress (taud)	2.682	lb/ft^2
Average Shear Stress (tau0)	1.635	lb/ft^2

```
# 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.

pander(y_cc, missing = "")
```

Parameters	Normal Value	Critical Value
Flow depth (y)	2.152	3.502
Flow area (A)	17.871	38.533
Wetted Perimeters (P)	13.624	19.661

Parameters	Normal Value	Critical Value
Top Width (B)	12.608	18.007
Bottom width (b)	4	
Hydraulic Radius (R)	1.312	1.96
Hydraulic Depth (D)	1.417	2.14
Flow Mean Velocity (V)	8.393	10.615
Flow Discharge (Q)	150	120.685
Manning's roughness coefficient (n)	0.03	
Slope (Sf)	0.02	0.003
Temperature	68	
Absolute Temperature	293.15	
Saturated Liquid Density	1.937	
Absolute or Dynamic Viscosity	2.092885e-05	
Kinematic Viscosity	1.080619e-05	
Froude number (Fr)	1.243	1
Reynolds number (Re)	1018833	
symmetric side slope (m)	2	
non-symmetric side slope (m1)		
non-symmetric side slope (m2)		
Wetted Length (w)	4.812	
Wetted Length for a non-symmetric trapezoid (w1)		
Wetted Length for a non-symmetric trapezoid (w2)		
Section Factor (Z)	21.415	21.276
conveyance (K)	1060.675	
Specific Energy (E)	3.247	3.737
Velocity Head (Vel_Head)	1.095	
Maximum Shear Stress (taud)	2.682	
Average Shear Stress (tau0)	1.635	

Units
ft
ft^2
ft
ft
ft
ft
ft
ft/sec (fps)
ft^3/sec (cfs)
dimensionless
ft/ft
degrees Fahrenheit
Kelvin
slug/ft^3
slug/ft*s
ft^2/s
dimensionless
dimensionless
ft/ft
ft/ft

Units
ft/ft
ft
ft
ft
ft
ft^3/sec (cfs)
ft
ft
lb/ft^2
lb/ft^2

```r
# 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.

pander(y_c45, missing = "")
```

Parameters	Normal Value	Critical Value	Units
Flow depth (y)	0.512	0.621	m
Flow area (A)	3.335	4.11	m^2
Wetted Perimeters (P)	7.448	7.756	m
Top Width (B)	7.024	7.242	m
Bottom width (b)	6		m
Hydraulic Radius (R)	0.448	0.53	m
Hydraulic Depth (D)	0.475	0.568	m
Flow Mean Velocity (V)	2.759	2.467	m/s
Flow Discharge (Q)	9.2	7.196	m^3/s
Manning's roughness coefficient (n)	0.03		dimensionless
Slope (Sf)	0.02	0.011	m/m
Temperature	20		degrees Celsius
Absolute Temperature	293.15		Kelvin
Saturated Liquid Density	998.158		kg/m^3
Absolute or Dynamic Viscosity	0.001002078		Pa * s or kg/m*s
Kinematic Viscosity	1.003928e-06		m^2/s
Froude number (Fr)	1.279	1	dimensionless
Reynolds number (Re)	1230324		dimensionless
symmetric side slope (m)	1		m/m
non-symmetric side slope (m1)			m/m
non-symmetric side slope (m2)			m/m
Wetted Length (w)	0.724		m
Wetted Length for a non-symmetric trapezoid (w1)			m
Wetted Length for a non-symmetric trapezoid (w2)			m
Section Factor (Z)	1.952	2.298	m
conveyance (K)	65.058		m^3/s
Specific Energy (E)	0.9	0.876	m
Velocity Head (Vel_Head)	0.388		m
Maximum Shear Stress (taud)	0.1		pascal (N/m^2)
Average Shear Stress (tau0)	0.088		pascal (N/m^2)

```
# 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", "pander")
# 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")
```

```r
# 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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