

CEE 3804 Exam1 (Spring 2026)

Computer Applications in Civil Engineering

Take Home Exam: Open Book and Notes

Solution

Your Name _____

Your Signature * _____

* The answers in this exam are the product of my own work. I certify that I have not received nor I have provided help to others while taking this examination.

Directions:

Solve the problems. Copy and paste the VBA code and solutions such as graphs in a Word Document and convert to a single PDF file. **Make sure your code is not too small for me to be able to read it.** Minimum font size 12 is acceptable.

Problem 1 (50 points)

A common problem in Civil Engineering is to estimate the deflection of beams used in building construction projects.

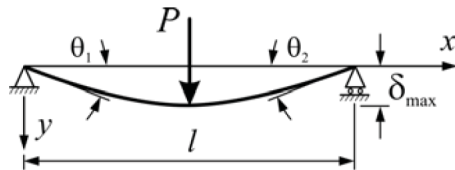


Figure 1. Beam deflection diagram when load is applied at the middle point of the beam (Source: [https://home.engineering.iastate.edu/~shermanp/STAT447/STAT Articles/Beam_Deflection_Formulae.pdf](https://home.engineering.iastate.edu/~shermanp/STAT447/STAT%20Articles/Beam_Deflection_Formulae.pdf))

The deflection of the beam at any station x measured from the left-hand side support (see Figure 1) is presented below. Note that the deflection formula below applies to values from the left support to the middle point of the beam where the load is applied. The deflections for values of x greater than $l/2$ are symmetrical to those estimated with the deflection formula below.

$$y = \frac{Px}{12EI} \left(\frac{3l^2}{4} - x^2 \right) \quad \text{for } 0 < x < \frac{l}{2}$$

Where:

y is the beam deflection in meters

P is the applied load at the center point of the beam (Newtons)

l is the length of the beam in meters

x is the station measured from the left beam support (meters)

I is the beam moment of inertia (m^4)

E is the modulus of elasticity (N/m^2). Note $1 \text{ N}/\text{m}^2 = \text{Pascal}$

The maximum deflection of the beam is:

$$y_{max} = \frac{Pl^3}{48EI}$$

Table 1. Typical Values of E for Various Materials

Material	E Value (N/m ²)
Steel	2E+11
Tungsten	4.1E+11
Cast Iron	8.5E+10
Magnesium	4.5E+10
Brass	1.06E+11
Copper	1.2E+11
Aluminium	7.1E+10

- a) **Create a VBA Subroutine** to estimate the value of the beam deflection (y) at any point (x) along the beam as a function of the parameters in the equation above. The values of P , l , I , x are provided in Excel by the user. The value of E is entered by the user in Excel using a data validation list with the names of the materials listed in Table 1. The VBA code assigns the corresponding value of E according to the material selected.

	A	B	C	D	E	F	G
1							
2	Beam Deflection Example			Beam deflection equation			
3	Prorammer: A. Trani			y=Px/12EI * (3l ² /4-x ²)			
4	Date: March 30, 2026						
5			Units	Maximum deflection equation			
6	Load (lb)	12000.00	Newtons	ymax = Pl ³ /48EI			Beam Material
7	Beam Material	Steel	dim				Steel
8	Moment of Inertia	0.0004	m ⁴				Tungsten
9	Beam Length	5.00	meters	Calculation			Cast Iron
10	Station	2.1	meters				Magnesium
11	Deflection	0.000376425	meters				Brass
12	Max. Deflection	0.000390625	meters				Copper
13	Repetitions	50	dim				Aluminum
14	Step Size for Calculation	0.050000001	meters				
15	Beam Station (m)	Beam Deflection (m)					

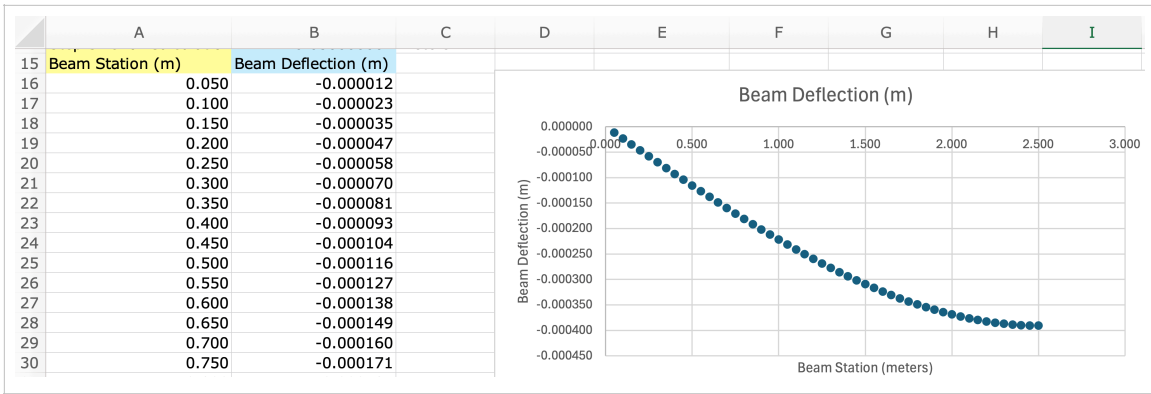


Figure 1. Excel Interface to Estimate A Single Point Load Beam Deflection.

```

(General)
Option Explicit

Dim P As Double
Dim EModulus As Double
Dim MI Inertia As Double
Dim station As Single
Dim beamLength As Single
Dim deflection As Double
Dim maxDeflection As Double
Dim beamStation As Double
Dim repetitions As Integer
Dim stepSize As Single
Dim beamDeflection As Double
Dim beamMaterial As String
Dim j As Integer
Dim cellnumber As String

Sub BeamCalculations()
' Calculate the deflection of a supported beam with a point load
' P = load (Newtons)
' EModulus = Modulus of Elasticity (Newtons/m^2)
' MI Inertia = Moment of Inertia (m^4)
' BeamLength = Beam length (meters)
' station = station along the beam to calculate the deflection (m)
' beamMaterial = material to estimate the modulus of elasticity

```

```
(General) | BeamCalculations
' Retrieve values of parameters in cells b6-b8

Sheets("Sheet1").Select

Range("b6").Select
P = ActiveCell.Value

Range("b7").Select
beamMaterial = ActiveCell.Value

Range("b8").Select
MIInertia = ActiveCell.Value

If beamMaterial = "Steel" Then
    EModulus = 200000000000#
Elseif beamMaterial = "Tungsten" Then
    EModulus = 410000000000#
Elseif beamMaterial = "Cast Iron" Then
    EModulus = 85000000000#
Elseif beamMaterial = "Magnesium" Then
    EModulus = 45000000000#
Elseif beamMaterial = "Brass" Then
    EModulus = 106000000000#
Elseif beamMaterial = "Copper" Then
    EModulus = 120000000000#
Elseif beamMaterial = "Aluminium" Then
    EModulus = 71000000000#
Else
    MsgBox " No value of Modulus of Elasticity Found"
End If

' Retrieve the value of n from cell B6

Range("B9").Select
beamLength = ActiveCell.Value

Range("B10").Select
station = ActiveCell.Value

' Calculate the beam deflection at station x

deflection = P * station / (12 * EModulus * MIInertia) * (3 / 4 * beamLength ^ 2 - station ^ 2)

' Write the value of deflection to the spreadsheet

Range("B11").Select          ' select cell to write beam deflection
ActiveCell.Value = deflection

' Calculate the maximum beam deflection

maxDeflection = P * beamLength ^ 3 / (48 * EModulus * MIInertia)
```

```

(General) | BeamCalculations

' Write the value of deflection to the spreadsheet
Range("B12").Select           ' select cell to write beam deflection
ActiveCell.Value = maxDeflection

Range("A16:B1000").Clear

' Start the loop to compute the beam deflection for n repetitions

Range("B13").Select
repetitions = ActiveCell.Value

' Calculate a suitable beam station step size (meters)

stepSize = 0.5 * beamLength / repetitions
beamStation = 0

Range("B14").Select           ' Select cell to write beam deflection step size
ActiveCell.Value = stepSize

For j = 1 To repetitions + 1   ' Adding one value to start from station zero

    cellnumber = "A" & (j + 15) ' assign the cell to write the beam station values
    Range(cellnumber).Select    ' select cell assigned in previous step
    ActiveCell.Value = beamStation ' assign the beam station (meters)

' Calculate the beam deflection

beamDeflection = -P * beamStation / (12 * EModulus * MInertia) * (3 / 4 * beamLength ^ 2 - beamStation ^ 2)
cellnumber = "B" & (j + 15)    ' assign the cell to write the beam deflection calculation
Range(cellnumber).Select       ' select cell
ActiveCell.Value = beamDeflection ' write value of deflection

    beamStation = beamStation + stepSize ' estimate the new beam station

Next j                          ' next value of the loop index

End Sub

```

Figure 1.1 VBA Subroutine to Estimate A Single Point Load Beam Deflection.

b) Test the code using the following numerical values:

$$P = 12,000 \text{ (Newtons)}$$

$$l = 5 \text{ meters}$$

$$x = 2.5 \text{ meters}$$

$$I = 0.0004 \text{ (m}^4\text{)}$$

Material = steel

Display the answer for y in the Excel interface.

Beam Deflection Example Prorammer: A. Trani Date: March 30, 2026		Beam deflection equation $y = Px/12EI * (3l^2/4 - x^2)$	
Load (lb)	12000.00	Units	Maximum deflection equation $y_{max} = Pl^3/48EI$
Beam Material	Steel	dim	Beam Material
Moment of Inertia	0.0004	m ⁴	Steel
Beam Length	5.00	meters	Tungsten
Station	2.5	meters	Cast Iron
Deflection	0.00039063	meters	Magnesium
Max. Deflection	0.00039063	meters	Brass
Repetitions	50	dim	Copper
Step Size for Calculation	0.0500	meters	Aluminum

Figure 1.2 Results of Beam Deflection Calculations. Steel Beam and $P=12,000$ N.

- c) Add VBA code to estimate the maximum deflection y_{max} . Write the solution of the maximum deflection to the Excel interface. Label appropriately.

```
' Calculate the maximum beam deflection
maxDeflection = P * beamLength ^ 3 / (48 * EModulus * MIertia)

' Write the value of deflection to the spreadsheet

Range("B12").Select           ' select cell to write beam deflection
ActiveCell.Value = maxDeflection
```

Figure 1.3 VBA Code to Estimate the Maximum Beam Deflection.

- d) Create more VBA code to produce a table with multiple values of deflection y for values of x (i.e., beam station) ranging from 0 to $l/2$. Select an appropriate step size to produce a table with a minimum of 50 points along the beam from 0 to $l/2$. Test the code using the following numerical values:

$$P = 15,000 \text{ (Newtons)}$$

$$l = 5 \text{ meters}$$

$$I = 0.0004 \text{ (m}^4\text{)}$$

Material = aluminium

```

stepSize = 0.5 * beamLength / repetitions
beamStation = 0

Range("B14").Select           ' Select cell to write beam deflection step size
ActiveCell.Value = stepSize

For j = 1 To repetitions + 1   ' Adding one value to start from station zero

    cellnumber = "A" & (j + 15) ' assign the cell to write the beam station values
    Range(cellnumber).Select    ' select cell assigned in previous step
    ActiveCell.Value = beamStation ' assign the beam station (meters)

    ' Calculate the beam deflection

    beamDeflection = -P * beamStation / (12 * EModulus * MIInertia) * (3 / 4 * beamLength ^ 2 - beamStation ^ 2)
    cellnumber = "B" & (j + 15) ' assign the cell to write the beam deflection calculation
    Range(cellnumber).Select    ' select cell
    ActiveCell.Value = beamDeflection ' write value of deflection

    beamStation = beamStation + stepSize ' estimate the new beam station

Next j                          ' next value of the loop index

End Sub

```

Figure 1.4 VBA Code to Generate Table of Numerical Results of the Beam Deflection.

e) Plot the values generated in the table (part d) and label appropriately.

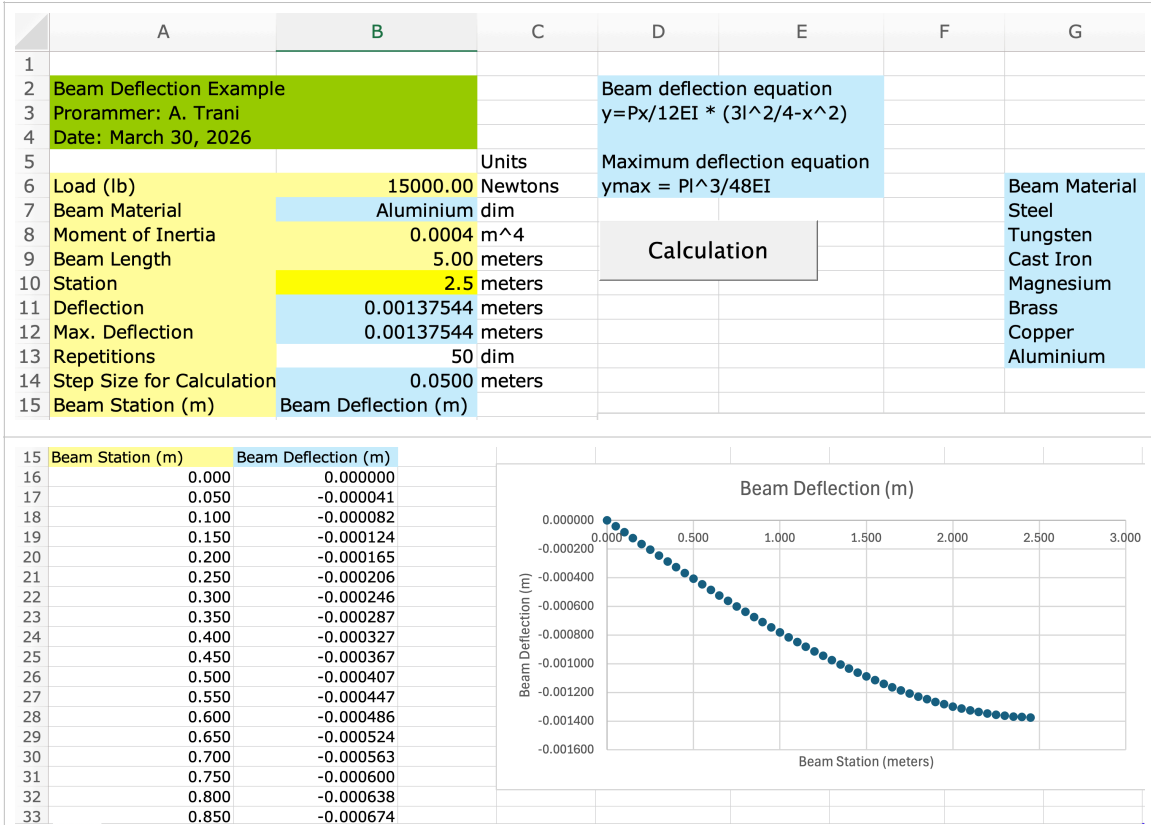


Figure 1.5 Interface and Table Results for Beam Deflection Calculations. Aluminum (or Aluminum) Beam.

Problem 2 (30 points)

A file containing access to drinking water is shown below. The file is provided in the assignments website. Use the file to answer the following questions.

Entity	Code	Year	Usage of safely managed drinking water services (%)
Afghanistan	AFG	2000	11.48
Afghanistan	AFG	2001	11.50
Afghanistan	AFG	2002	12.30
Afghanistan	AFG	2003	13.10
Afghanistan	AFG	2004	13.91

Figure 2. World Sanitation and Drinking Water Access. <https://ourworldindata.org/clean-water-sanitation>

The fields in the file are explained below.

Entity - country or region of the world

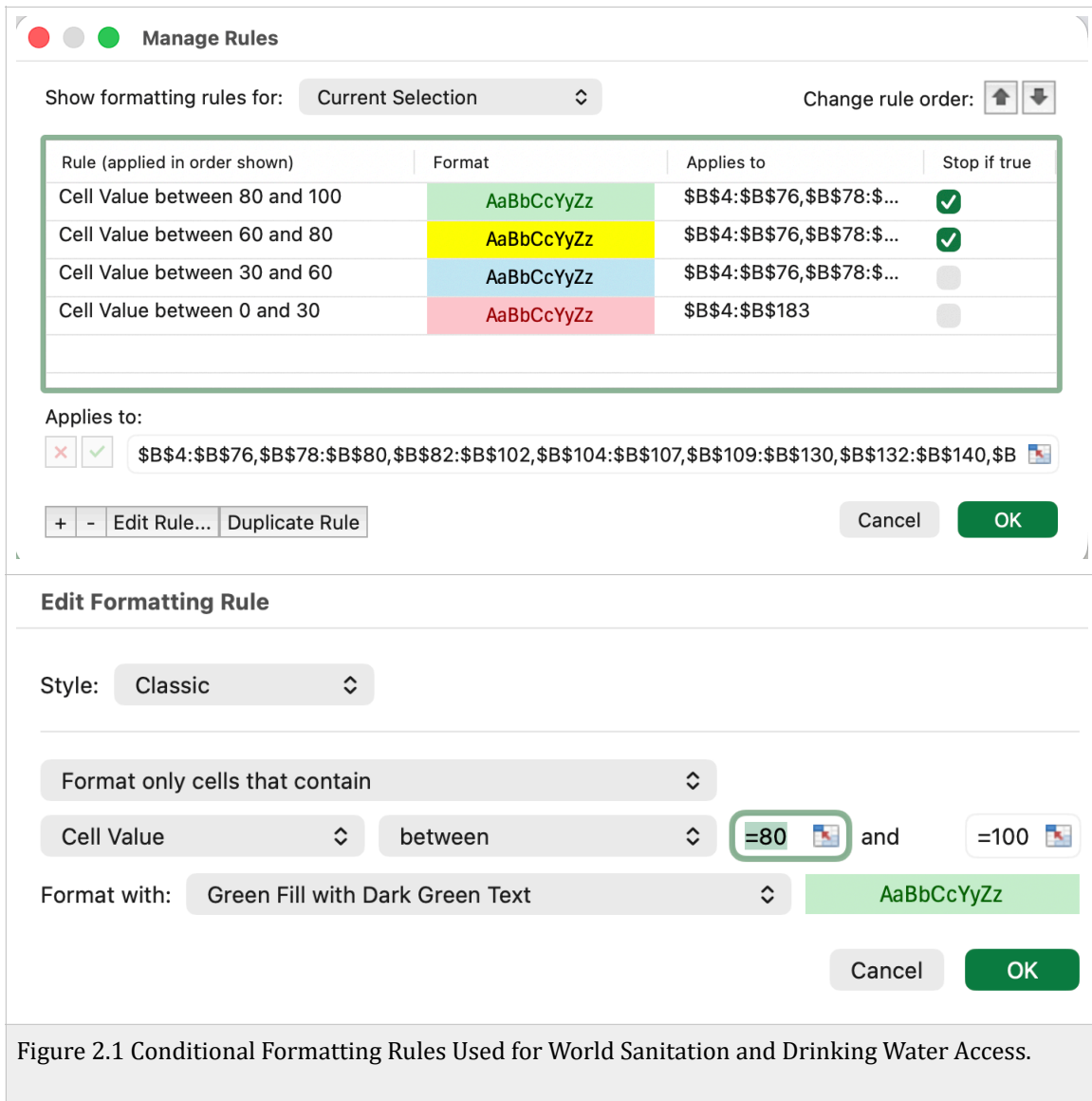
Code - country or region code

Year - year of the data collected

Usage of safely managed drinking water - Percent of the population with access to clean drinking water (%)

- a) Create a Pivot Table to summarize the average of managed drinking water services by entity. Use the year field as a filter in the pivot table.

Entity	Average of Usage of safely managed drinking water services
Afghanistan	29.91
Africa (WHO)	33.04
Albania	70.77
Algeria	68.97
American Samoa	90.54
Americas (WHO)	84.14
Andorra	90.64
Armenia	82.21
Austria	98.89
Azerbaijan	57.45
Bahrain	98.90
Bangladesh	59.14
Belarus	93.05
Belgium	99.56
Benin	17.54
Bhutan	66.65
Bonaire Sint Eustatius and Saba	100.00
Bosnia and Herzegovina	86.40



b) For the solution of the pivot table in part (a), do conditional formatting on the average of managed drinking water services by entity. Use the following scales:

- a. Red - lower or equal than 30%
- b. Light blue - > 30% and <= 60%
- c. Yellow - > 60% and <= 80%
- d. Green - >80%

Show me a screen capture of the first 15 entities and then average of managed drinking water services by entity for the year 2023.

See Figure 2.1

c) Create a pivot chart of then average of managed drinking water services by entity for the year 2020. Show me a screen capture of the pivot chart (the first 20 entities).

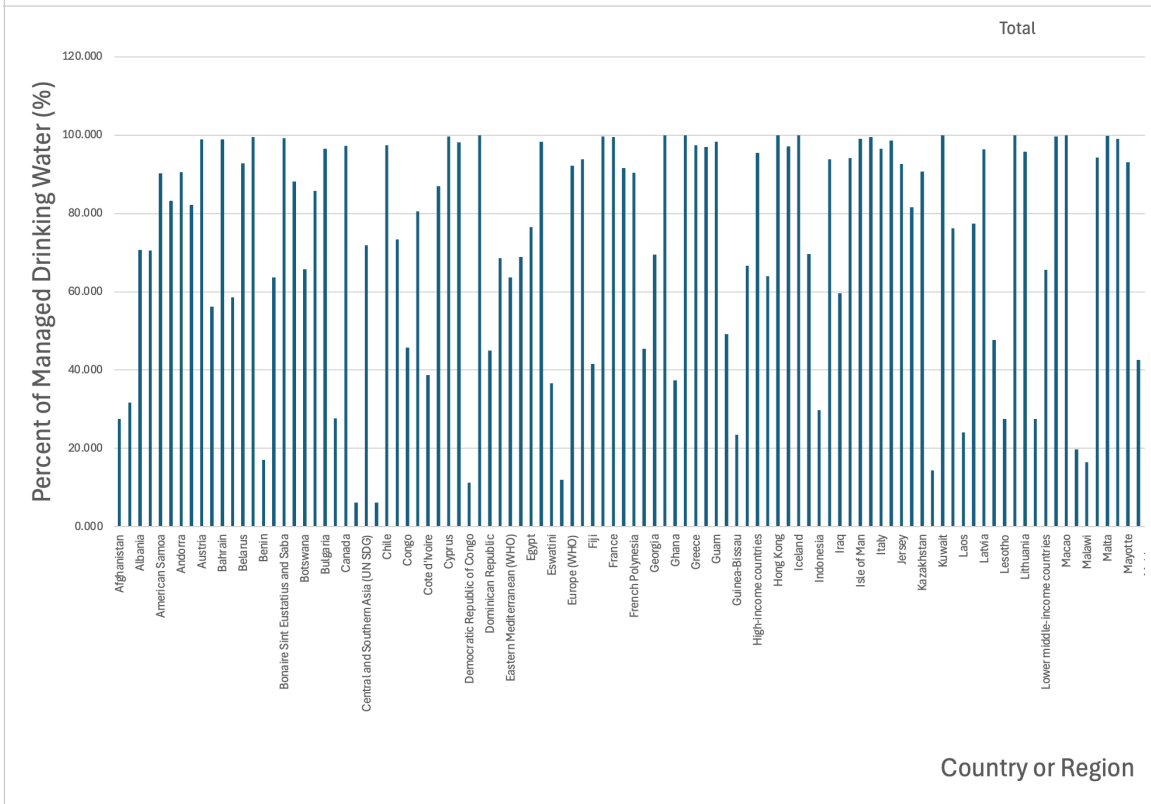
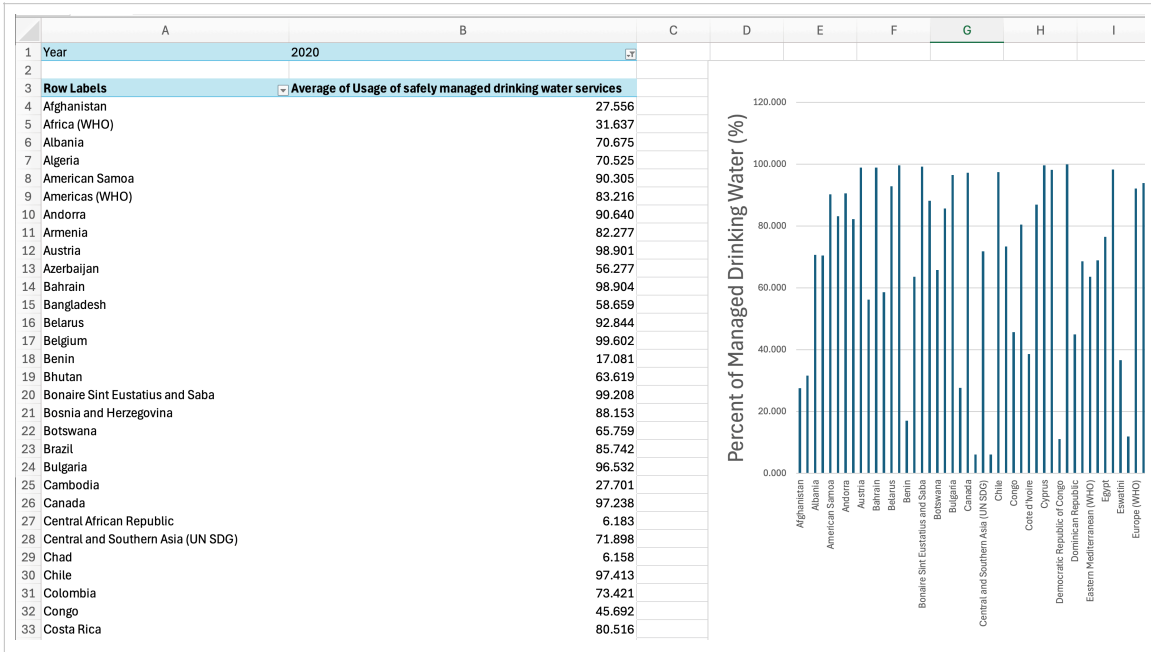


Figure 2.3 Pivot Chart for World Sanitation and Drinking Water Access.

- d) Find the country with the highest average of managed drinking water services by entity for the year 2023.

There are 13 countries or regions of the world with a perfect score (100%) in managed drinking water. Note that the United States is not in the top 30 countries. As civil engineers, we need to improve the drinking water infrastructure in the country.

1	Name of Country	Average of Usage in Year 2023
2	Bonaire Sint Eustatius and Saba	100.00
3	Gibraltar	100.00
4	Hong Kong	100.00
5	Hungary	100.00
6	Iceland	100.00
7	Kuwait	100.00
8	Liechtenstein	100.00
9	Macao	100.00
10	Monaco	100.00
11	New Zealand	100.00
12	Saint Barthelemy	100.00
13	San Marino	100.00
14	Singapore	100.00
15	Netherlands	99.96
16	Isle of Man	99.92
17	Denmark	99.92
18	Germany	99.92
19	Malta	99.84

Figure 2.3 Countries with Highest Values of Average of Usage of Managed Drinking Water Services in the Year 2023.

Problem 3 (20 points)

Provide quick answers or True or False.

Question	Answer
Can a number like 230 million be stored in a variant data type in VBA?	True. Variants are default data types in VBA and have flexibility to store any number.
Can a subroutine take two inputs and produce three outputs?	TRUE
Moore's Law states that the number of transistors in a computer chip triple every two years.	FALSE
Type of VBA data structure (i.e., variable type) that can hold integer values up to 1.2 million.	Long Integer
A civil engineering collecting pavement deflection data collects the following items: 1) a highway marker serial number (single precision), 2) the deflection at each point (double precision), and 3) the stress value at each point (double precision). If the number of data collection includes 35,000 highway marker serial numbers over a week period, estimate the number of bytes of computer memory required to hold all the calculations in memory.	Serial number = long integer (4 bytes) Deflection = double precision (8 bytes) Stress = double precision (8 bytes) Totally memory storage =700,000 bytes
R is a specialized language to do statistical analysis and computations.	TRUE
A VBA function can produce two outputs.	FALSE If you package the outputs into an array, a function may return multiple numerical values as outputs. Nevertheless, this is not good practice.
Keyword required in VBA to declare all variables inside a subroutine.	Option Explicit
Evelyn Berezin designed a computer reservation system for Delta Airlines.	False (She developed the Computer Reservation System - CRS- for United)