Preparing for Technical Training:

Essential Skills for Water/Wastewater Operators

Levels 1 and 2

Workplace Education Manitoba

August 2010

ACKNOWLEDGMENTS

Workplace Education Manitoba would like to express appreciation to the following for supporting the development of this curriculum:

Industry Workforce Development,
Entrepreneurship Training and Trade
and the Province of Manitoba

Workplace Education Manitoba would like to thank the individuals from across Manitoba who provided consultation, content and feedback.

For more information,
visit www.wem.mb.ca
or contact the Project Coordinator
Sheila Kingswell at info@wem.mb.ca.

Workplace Education Manitoba

COURSE CONTENTS:

This course consists of eight classes of five hours each. There is a pre-assessment, along with eight modules in total to complete with the learners.

LMA Consent Forms

- Have learners complete the Manitoba Competitive, Training and Trades Consents and Privacy Notice Forms and the Client Intake Information form.
- Copies of these are included in this package but the lasted version of these forms should be obtained from the WEM office.

Pre-assessment

- Administer the assessment which will help determine the starting point with the individual learners and the group.
- As each student finishes, correct the assessment with them, discuss what they thought their comfort areas were and where they thought they may need extra work to bring them up to a level to be able to proceed to more complex math.

9 Modules, each one contains:

- **Student module** titled “Module 1 – Basic Math Refresher”, for example.
  - Meant to be taught by a teacher or could be used as self study.
  - Contains information, examples and questions for the learner to complete with space to do the calculations.
  - Meant to be taught by a teacher one section at a time, then the student is given a bit of time to do one exercise, the teacher corrects it with the students and then moves on to teach the next bit.
  - Begins with a pre-test. If students do well on the pre-test they may be able to move on to the next module without having to do that module. It will also give them a sample of what they will be learning in the module. (No pre-test for module 5).
- **Teacher module** titled “Module 4 – Teacher Copy”, for example
  - Information to know or to share with the students.

Modules 3, 4, 6 and 7 also contain:

- **Practice Test** titled "Module 3 – Practice Test", for example
  - Multiple choice word problems based on the lessons from the module.
  - This can be given to the students in the last part of the class and then can be taken home to complete and corrected the next class.

- **Answer Key** titled "Module 3 – Answer Key", for example
  - Contains all the answers to the questions in the practice test along with how to do each problem.
  - This is meant to be given to the student to take home with the practice test so that they can check their answers and/or see how to solve the problems, which formula to use, etc. Have the students begin the practice test in class without the answer key.

***Note:** Modules 1, 2, 5, 8 and 9 do not have Practice Tests or Answer Keys

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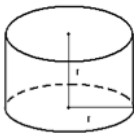
Also Included:

- **Glossary of Terms**
  - Can be given to students at the beginning of the course.
  - Contains the important terms from all eight modules.

- **Formula Sheet**
  - To be given with module three and used for the remainder of the course.
  - This is the same formula sheet that they will be given at RRC to use in their certification exams.

COURSE OUTLINE:

 **Class 1:**	- Introductions and fill out LMA Consents and Privacy Notice (1 hr) - Pre-assessment (go over results, share answers) (2 hrs) - Module 1 – Basic Math Refresher (2 hrs)
 **Class 2:**	- Correct the remainder of Module 1 (1 hr) - Module 2 – Fractions, Decimals and Percents (4 hrs)
 **Class 3:**	- Correct the remainder of Module 2 (1 hr) - Module 3 – Measurement Conversions – (3 hrs) - Practice Test – 1 hour, take home
 **Class 4:**	- Do some Module 3 Practice Test questions on the board (1 hr) - Module 4 – Linear, Area and Volume Calculations (3 hrs) - Practice Test – 1 hour, take home
 **Class 5:**	- Do some Module 4 Practice Test questions on the board (3 hrs) - Module 5 – Solving Equations (2 hrs) (very short unit!)
 **Class 6:**	- Module 6 – Chemical Measurements (3 hrs) - Practice Test (2 hrs)
 **Class 7:**	- Correct Module 6 Practice Test (1 hr) - Module 7 – Hydraulics (3 hrs) - Practice Test – 1 hour, take home
 **Class 8:**	- Correct Module 7 Practice Test (1 hr) - Module 8 – Wastewater (1 hr) (short unit) - Module 9 – Electricity (1 hr) (very short unit!) - Final Assessment (2 hrs)

IMPORTANT TO KNOW:

- Go to Wikipedia, the online encyclopedia and type in "**Sewage Treatment**" and "**Water Treatment**" for an excellent overview of Wastewater and Water Treatment processes.
- It would be helpful if all students had the same scientific calculator. Students are allowed and encouraged to use their calculators at all times to solve the math problems and will be allowed to use them in the RRC certification courses.
- Student should get to know and use their formula sheets. The formula sheet provided is the same one used for the RRC courses.
- There are approximately 120 multiple choice questions on the RRC exam. Less than 20 of them have been math questions.
- Understanding how to convert units using a ratio is extremely important because most questions will have some type of conversion in them.
- Understanding how to use a formula is also extremely important. Using the proper units in the formula and converting when necessary is essential.
- Correcting the Practice Test questions on the board with students is time consuming but extremely important for their learning.
- It would be helpful to pair up stronger students with weaker students for in class work.

IMPORTANT CONTACTS AND LINKS

Manitoba Conservation
Donna Garcia
Certification Program Coordinator
Phone No.: (204) 945-7065
E-Mail: donna.garcia@gov.mb.ca

Responsible for implementation of sub-programs under the *Water and Wastewater Facility Operators Regulation*.

- classification program for water and wastewater facilities;
- certification program for operators of water and wastewater facilities; and
- water and wastewater certification examination program.

Water and Wastewater Facility Operators Certification Program
http://www.gov.mb.ca/conservation/eal/certification/exams

Manitoba Conservation contracts with the Association of Boards of Certification (ABC) for the provision of an examination service.

- ABC's Need-to-Know Criteria describes the core competencies that are covered on the exams
- Sample exam questions

http://www.abccert.org/testing_services/certification_study_resources.asp

Preparing for Technical Training:

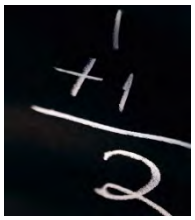
Essential Skills for Water/Wastewater Operators

MODULE 1

Basic Math Refresher

MODULE 1

MODULE 1: BASIC MATH REFRESHER



Objectives:

When you have completed this module, you will be able to:

- Identify key terms and concepts used in working with whole numbers
- Read place values
- Round whole numbers to specified place values
- Perform addition, subtraction, multiplication and division calculations using a calculator
- Calculate averages using a calculator
- Convert numbers written in scientific notation into long form and back
- Add and subtract numbers with Scientific Notation

Contents:

MODULE 1

PRE-TEST

Complete the following pre-test questions (you can use a calculator):

1. Round the following numbers to the nearest thousand.

   a. 98,500 _____ b. 739,601 _____

2. If 12 inches is one foot, how many inches is 41 feet?

3. Mass (lbs) = Flow (mg) x Dosage (mg/L) x 8.34
   What is the mass if the flow is 6 mg and the dosage is 100 mg/L?

4. How many 4 gallon containers can be filled with 3924 gallons of water?

5. Change the following from scientific notation to long form:

   a. 3.1189×10^{6} b. 9.97444×10^{-3}

6. Perform the following calculations and then change the final answer to scientific notation:

   a. 9,000 + 188,003 =

   b. 300 x 6 x 32 =

MODULE 1

WHOLE NUMBERS

Whole numbers are numbers we use everyday such as 1, 2, 3 and so on. They are called whole numbers because they are whole and not parts of a whole such as a decimal or a fraction.

Place Values:

Billions			Millions			Thousands			Ones		
Hundred Billions	Ten Billions	Billions	One Hundred Millions	Ten Millions	Millions	One Hundred Thousands	Ten Thousands	Thousands	Hundreds	Tens	Ones
		9,	**0**	**4**	**2,**	**1**	**3**	**7,**	**0**	**9**	**3**

Only use the word **"and"** to show the decimal place.

We can use a **comma** or a **space** between groups of three numbers to make them easier to read.

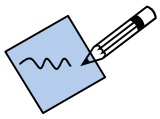
We read the number as: **nine billion, forty-two million, one hundred thirty-seven thousand, ninety-three.**

Notice that the commas in the words above are in the same places as the commas would be in the number!

Exercise 1:

What is the place value for the digit 6 in the following numbers?

1. 64 _____
2. 846 _____
3. 6,401,355 _____



Exercise 2:

What is the value of the underlined digit? Study the example.

1. 9,4<u>4</u>5,390 _____400,000_____
2. <u>5</u>60 _____
3. <u>2</u>,095 _____

ROUNDING WHOLE NUMBERS

To round a whole number to a given place, underline the digit to be rounded.
Then:

1. Look at the digit to the right of that place.
2. If the digit is 4 or less, round DOWN. Do not change the number in the place. Just replace each digit to the right of that place with zero.
3. If the digit is 5 or more, round UP. Increase the number in the place you are rounding to by 1. Replace each digit to the right of that place with a zero.

Example 1: Round 6,524 to the nearest ten.

- Underline the 2 because the 2 is in the tens place: 6,5<u>2</u>4
- Look at the digit to the right of the 2. Since it is 4, round down which means the 2 does not change.
- Change all digits to the right of the 2 to zero.

Answer: 6, 524 rounded to the tens place is 6,520.

Think about it: Is 24 closer to 20 or closer to 30? Closer to 20, so you round down!

Example 2: Round 1,895 to the nearest hundred.

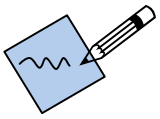
- Underline the 8 because it is in the hundreds place: 1,<u>8</u>95
- Look at the digit to the right of the eight. Since it is 9 (which is more then 5), you round the number up.
- Change the 8 to a 9 and change the rest of the numbers to the right to zero.

Answer: 1895 rounded to the nearest hundred is 1,900

Is 895 closer to 800 or closer to 900? Closer to 900 so you round up!

MODULE 1

Exercise 3:



Round to the nearest ten.

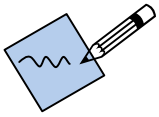
1. 15 _____

2. 947 _____

3. 456 _____

4. 321 _____

Exercise 4:



Round to the nearest hundred.

1. 880 _____

2. 1,439 _____

3. 441 _____

4. 9,077 _____

Exercise 5:

Round to the nearest thousand.

1. 1,642 _____

2. 28,148 _____

3. 90,852 _____

4. 42,632 _____

MODULE 1

BASIC OPERATIONS

Basic Operations are adding, subtracting, multiplying and dividing.

Examples:

1,493			763 ÷ 7	$7\overline{)763}$
344	7000	400		
+ 99	-1,456	x21	divide 763 by 7	763 divided by 7

ADDITION

In addition, two or more smaller numbers are combined to get a larger number known as the sum. You can arrange the numbers to be added in a column or type them into your calculator in any order.

Example: add 4,590 + 67 + 2

```
4  5  9  0
      6  7
+        2
_____________
4  6  5  9   ⇦ this is the sum
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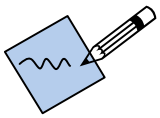


Exercise 6:

Use your calculator to find out which of these sums has been added correctly and circle those correct answers.

1.	2.	3.	4.	5.
78	65	34	123	4556
+45	+76	+87	+124	+8679
123	131	121	247	13225

Even when using your calculator, you still need to use your head. You should estimate what your answer is before entering the numbers into the calculator. That way, if you type something in the calculator and get a strange answer, you will know it is incorrect and that you must have made a mistake. Don't just write down the number your calculator gives you, you need to know if that answer makes sense!

Example: You type in the calculator 12 + 188 + 204 and get 2214. If you made a rough estimate BEFORE using the calculator, you know that your answer should come out to around 400, so you obviously made an error and need to re-do the question.

If three or more numbers are to be added, it is not necessary to enter the = key after each addition. The intermediate answers are displayed each time the + key is entered.

Exercise 7:

Try and pick the right answer by adding up the numbers in your head, then check using your calculator.

1. 29 + 61 + 11 =	41, 61, 81, 101
2. 22 + 19 + 51 =	62, 92, 112, 132
3. 31 + 28 + 32 =	61, 71 , 81, 91
4. 19 + 22 + 23 +18 =	82, 92, 102, 112
5. 63 + 39 + 59 =	131, 141, 161, 171
6. 19 + 22 + 31 + 48 =	110, 120, 130, 140
7. 21 + 18 + 22 + 17 + 23 =	91, 101 , 121 , 131

MODULE 1

Exercise 8:

Use addition to solve the following word problems. Watch for words like sum, total, combine, complete, entire and altogether because they usually mean to add. Be sure to include units with your answer.

1. The Thomas Water Treatment Plant employs 80 people and the Wilton Plant employs 111 people. What is the total number of employees at both plants?

   Answer: _____

2. Water Consumption Data:
   866 gallons per minute (GPM) were consumed in April, 1330 GPM were consumed in May and 933 GPM were consumed in June. Find the total for April, May and June.

   Answer: _____

3. Brent's employer makes the following deductions from his paycheck: $94 for union dues, $1657 for federal income tax, and $192 for pension. What is the sum of the deductions?

   Answer: _____

4. The following amounts of sludge were produced in a treatment plant each month for a year. What was the average monthly production of sludge in pounds?

Month	Sludge	Month	Sludge
January	124	July	104
February	108	August	116
March	118	September	129
April	175	October	121
May	163	November	117
June	98	December	114

   Answer: _____

5. Study the chart below and answer the following questions:

Plant Equipment	Horsepower (Hp)	Average Daily Operating Time (hrs)
Raw Water Pump	40	8
Flocculator Drive	10	24
Sedimentation Tank Drive	25	24
Filter Backwash Pump	50	6
Clearwell Pump	20	8

a. What is the combined horsepower used by the plant equipment listed?

Answer: _____

b. What is the combined daily operating time for just the pumps?

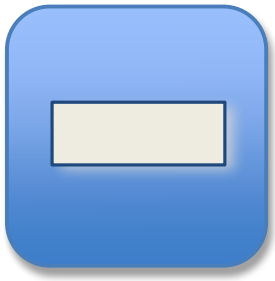
Answer: _____

6. A water utility serving residential, commercial and industrial users produces the average daily volumes of water listed below. Determine the total water produced.

Residential	1,760, 000 gpd
Commercial	280,000 gpd
Industrial	423,000 gpd

Answer: _____

SUBTRACTION



In subtraction, a smaller number is taken away from a larger number. The answer is known as the difference. Just like addition, you should write the numbers in a column.

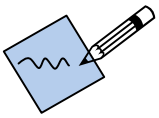
Example: Subtract 849 from 2913.

2913
− 849
2064 ⇦ This is the difference

To check your answer, add it to the number you subtracted and you should get the original number. Example: 2064 + 849 = 2913.

Subtraction using a calculator is performed similarly to addition. However, the number that you are <u>subtracting from</u> is entered first.

Exercise 9:



Use your calculator to complete the following subtraction exercises.

1. 106 subtracted from 1900 = _____
2. 18 and 45 subtracted from 445 = _____
3. 99 – 49 – 12 – 6 = _____
4. 76% reduced by 18% = _____
5. 34,000 – 5300 – 477 – 13 = _____
6. 900,100 – 45,000 – 11,250 – 10,000 = _____
7. 50 gpm – 32 gpm – 11 gpm = _____
8. 34,220 subtracted from 82,999 = _____

MODULE 1

Exercise 10:

Use subtraction to solve the following word problems. Watch for words like difference, balance, how much greater and how much less because they usually mean subtraction.

1. The Vale water treatment plant opened in 1976.

   a. How old was the plant in 2005?

   b. How old will the plant be in 2012?

2. The north side water main has a diameter of 18 inches. The south side water main has a diameter of 6 inches. What is the difference in inches between the two?

   Answer: _____

3. Sam makes $1245 every two weeks. His employer deducts $319 for taxes and $43 for union dues. How much does Sam get to take home every two weeks?

   Answer: _____

4. You need to buy pipes that total 103 feet long. All you can find at the plumbing store is 76 feet of pipe. How much more pipe do you need to buy?

   Answer: _____

5. In 1994 there were 5027 residents in your municipality. In 2000 there were 9409 residents. How many more residents are there in 2000?

   Answer: _____

6. The hardness of the water at the source is 375 mg/L and the ion exchange water softening plant desires a finished water hardness of 120mg/L. What is the difference in hardness?

   Answer: _____

7. If a water tank holds 7,500 L of water and 4,056 L is used on the first day and 3,106 L is used on the second day, how much water is left in the tank?

   Answer: _____

MULTIPLICATION

One way to think about a multiplication problem is to think of it as the repeated addition of the same number.

For example, 8 x 5 = 8 + 8 + 8 + 8 + 8 = 40. The answer in a multiplication problem is known as the product.

To multiply, line up the digits. Multiply. Begin with the ones digit. Write zeroes as placeholders in your answer.

Example: Multiple 170 by 5.

1 7 0
x 5
8 5 0 ⇦ This is the product

If three or more numbers are to be multiplied, it is not necessary to enter the = key after each multiplication calculation. The intermediate answers are displayed each time the multiplication key is entered.

Exercise 11:

Perform the following multiplication calculations.

1. 3 x 2100 = _____
2. 34 x 85 = _____
3. 7 x 8 x 21 x 43 = _____
4. 54,000 x 309 x 56 = _____
5. 460 x 10 = _____
6. 9000 x 800 = _____
7. 64 x 11 x 367 = _____
8. 19 x 45,610 = _____

Exercise 12:

Use multiplication to solve the following word problems. Except for product and times, there are no key words that tell you to multiply.

1. There are 12 inches in a foot. How many inches are there in 15 feet?

   Answer: _____

2. If, on average, there are 1,080,000 gallons per day (gpd) of water consumed, how many gallons will be consumed in two weeks?

   Answer: _____

3. The maximum flow rate of a chemical feed pump is 234 mL/min. How many mL would be pumped in one hour?

   Answer: _____

4. Mass (lbs) = Flow x Dosage x 8.34
   What is the mass if the flow is 2 mg and the dosage is 150 mg/L?

   Answer: _____

5. Valerie earns $600/week. There are 52 weeks/year. How much does Valerie earn in 1 year?

   Answer: _____

6. Calculate the volume of the 5 storage tanks below using the formula given.

   Volume (m^3) = Length x Width x Height

	Length	Width	Height	Volume?
Storage Tank 1	7 m	7 m	4 m	
Storage Tank 2	19 m	3 m	3 m	
Storage Tank 3	11 m	6 m	6 m	
Storage Tank 4	41 m	9 m	17 m	
Storage Tank 5	5 m	4 m	81 m	

MODULE 1

DIVISION

In a division problem, a number known as a dividend is separated into equal parts (divided) by a smaller number known as a divisor. The answer is known as the quotient.

Example: What is 846 divided by 6? You can set up this division problem in several ways:

$$6\overline{)846}\quad 141$$

$$\frac{846}{6} = 141 \quad \Leftarrow \text{This is the divisor}$$

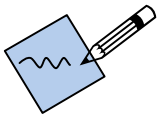
$$846 \div 6 = 141$$

On a calculator you follow the last setup: $846 \div 6 = 141$

To check your answer, go backwards and multiply 141 by 6 and you should get 846.

When using your calculator, enter the number that will be divided up first, then the number that it is being divided by.

Exercise 13:



Complete the following division problems.

1. 9 divided by 3 is _____
2. 8 into 64 equals _____
3. $285 \div 5 =$ _____
4. 420 divided into 20 equal parts is _____
5. 50 goes into 40,000 how many times? _____
6. $9\overline{)279}$ _____
7. $4\overline{)1448}$ _____

MODULE 1

Exercise 14:

Answer the following questions using division. Except for quotient, there are no key words that tell you to divide.

1. How many 2 gallon bottles can be filled with 880 gallons of water?

   Answer: _____

2. In one month (30 days) a wastewater treatment plant uses 20,340 kWh of electricity. How much does it use in one day?

   Answer: _____

3. There are 1,760 yards in a mile. How many miles are there in 40,480 yards?

   Answer: _____

4. In eight hours of work Ken made $136. How much does Ken make per hour?

   Answer: _____

5. Gallons per capita per day (gpcd) = $\frac{\text{Water produced}}{\text{Total population served}}$

   {"Per capita" means per person}

   a. What is the gpcd if there was 2,440,000 gpd of water produced for a total population of 8400 people?

   Answer: _____

SIMPLE AVERAGE

Finding the average (or mean) value of a group of numbers is a two-step problem. First find the sum of all the numbers. Then divide the sum by how many numbers are in the group.

Sum ÷ How many numbers = Average

On a calculator you can add up the numbers, then divide – without clearing between steps.
94 + 88 + 90 + 96 = 368 ÷ 4 = 92

Exercise 15:

Use your calculator to find the average for each set of numbers below.

1. 5, 6, 7, 8 = _____

2. 98, 99, 100 = _____

3. 45, 50, 55, 60, 65, 70 = _____

4. 20 400, 11, 999, 18 721, 4 000 = _____

5. 1 200 000, 98 = _____

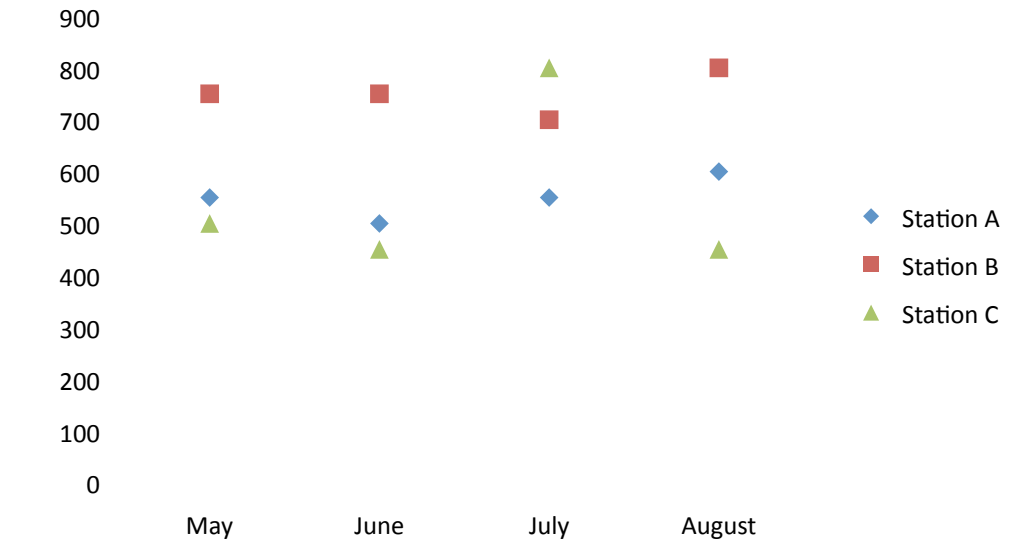
6. 444, 555, 666, 777, 888, 999 = _____

7. 15, 16, 17, 18, 19, 20, 21, 22, 23 = _____

Exercise 16:

Use your calculator to solve the following problems.

1. The table shows the kilowatt hours (KWH) of electricity used by three water stations during four months.



a. Find the total KWH for each station.

b. Find the average monthly usage for each station.

2. Use the chart below to answer the questions:

	Gallons used on June 3	Gallons used on June 4
Town of Wanton	533, 700	600,000
Town of Bleeker	1,300,670	1,457,000
Town of Nesbit	784,000	600,400
Town of Zelman	340,000	509,333

a. What was the average amount of water used in Wanton on June 3 and 4?

b. What is the average amount of water used in Nesbit on June 3 and 4?

c. What is the average amount of water used for all four towns on June 3?

d. What is the average amount of water used for all four towns on June 4?

3. Claire travels to work at an average speed of 83 km/hr. How many hours would it take her to travel 1162 km?

4. Calculate the average pH given the following data. Circle your answer.

1	2	3	4	5	6	7	8
7.45	7.49	7.56	7.63	7.60	7.54	7.52	7.41

a. 7.4

b. 7.5

c. 30.1

d. 60.2

SCIENTIFIC NOTATION

Performing math functions on a calculator with very large or very small numbers may not be possible. Calculations on a calculator are limited by the number of digits the calculator can display. For very large or very small numbers we use scientific notation. This is a shorthand way for writing very small or very large numbers. For example:

Coefficient (always a number between 1 and 10) → 2.34×10^{3} ← **Exponent (we say "10 to the power of 3" which is the number of times 10 is multiplied by itself)**

CONVERTING BETWEEN SCIENTIFIC NOTATION AND LONG FORM

- The exponent equals the number of spaces the decimal point is moved.
- A negative exponent means we move the decimal point to the left to change the number to long form. Example: 2.4×10^{-2} change the number to long form = 0.024
  (A negative exponent means the number is small)
- A positive exponent means we move the decimal point to the right to change the number to long form. Example: 2.4×10^{2} change the number to long form = 240
  (A positive exponent means the number is large)

Exercise 17: 

Change the following from scientific notation to long form.

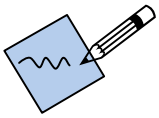
1. 3.67×10^{6}

2. 1.00345×10^{-4}

3. 7.90×10^{-2}

4. 8.0222×10^{9}

5. 9.5×10^{4}

Exercise 18: 

Change the following from long form to scientific notation.

1. 0.042

2. 456

3. 0.00093

4. 0.0300078

5. 11,42109

ADDING AND SUBTRACTING WITH SCIENTIFIC NOTATION:

You can only add and subtract numbers in scientific notation if the exponents are the same. To add follow these steps:

1. Add the decimal numbers only
2. Write the answer with the same exponent as in the question.

Both exponents are the same

Example: $2.221 \times 10^4 + 3.34 \times 10^4$

Step 1: $2.221 + 3.34 = 5.561$
Step 2: 5.561×10^4

If the exponents are not the same you must write the numbers out in long form before adding or subtracting.

Example: $2.221 \times 10^3 + 3.34 \times 10^4$

$2.221 \times 10^3 = 2,221$
$3.34 \times 10^4 = 33,400$

$2,221 + 33,400 = 35,621$ or 3.5621×10^4

MODULE 1

Exercise 19:

Add or subtract the following numbers and state the final answer in scientific notation.

1. 0.000032 + 0.0021 = _____

2. 900,000 + 9876 = _____

3. 49,011 + 0.00236 = _____

4. $6.5505 \times 10^{6} - 3.54 \times 10^{6}$ = _____

5. $8.822 \times 10^{2} + 0.000388$ = _____

6. $4.6006 \times 10^{4} + 1.7660 \times 10^{2}$ = _____

7. $5.5555 \times 10^{-1} - 4.4444 \times 10^{-3}$ = _____

Preparing for Technical Training:

Essential Skills for Water/Wastewater Operators

MODULE 2

Fractions, Decimals & Percents

MODULE 2: FRACTIONS, DECIMALS AND PERCENTS

Objectives:

When you have completed this section, you will be able to:

- Identify the numerator and denominator in a fraction
- Enter fractions into the calculator
- Explain proper, improper and mixed number fractions
- Convert fractions to decimals
- Round decimals
- Convert percentages to decimals
- Convert decimals to percentages
- Use a calculator to multiply and divide percentages

Contents:

MODULE 2

PRE-TEST

Complete the following sample questions from this module:

1. Change the following fractions to decimals:

   a. ½ =

   b. 9/10 =

   c. 4/5 =

   d. 1 11/16 =

2. Change the following percents to decimals:

   a. 90% =

   b. 100% =

   c. 56.5% =

   d. 800% =

3. Change the following decimals to percents:

   a. 1.11 =

   b. 5.590 =

   c. 0.67 =

   d. 0.02 =

4. Do the following calculations:

   a. 450 x 80% =

   25 x 50% =

5. The velocity of water through a 24 inch pipe is 12 feet per second (fps). What is the new velocity if it was reduced by 12%?

6. If 154 is 80%, what is 100%?

7. Convert a solution that has 80,350 ppm to percent.

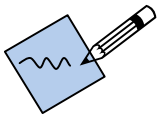
MODULE 2

FRACTIONS:

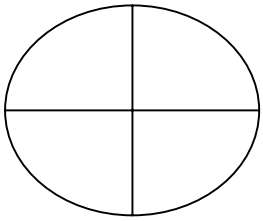
A fraction is two numbers that show a part of some whole. The top number of a fraction is called the numerator. The numerator tells you how many parts you have. The bottom number is called the denominator. The denominator tells you how many parts are in the whole.

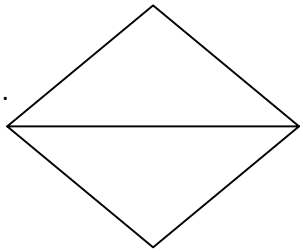
In the fraction $\frac{3}{8}$, 3 is the numerator and 8 is the denominator. You have 3 parts. The whole has 8 parts. It looks like this:

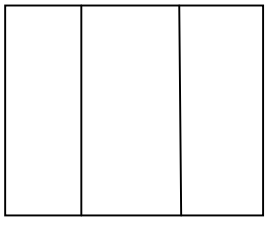
Exercise 1:

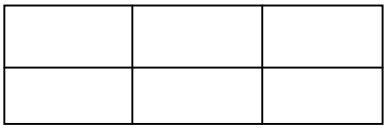


For each picture, shade in the correct amount according to the fraction given.

1.  **¼**

2.  **½**

3.  **2/3**

4.  **4/6**

MODULE 2

Exercise 2:

Draw and shade in shapes that match the following fractions.

1. 5/8

2. 7/10

3. 3/4

4. 1/6

Proper Fraction:

The numerator (top) is always less than the denominator (bottom).

Example: 1/3, 8/9, 1/2

Improper Fraction:

The numerator is as big as or bigger than the denominator.

Example: 3/3, 9/8, 2/1

Mixed Number:

A whole number and a proper fraction are written next to each other.

Example: 3 ½, 4 ¼, 11 3/5

Working with Fractions:

Common fractions are tricky on a calculator. Fraction problems are simpler if you convert the fractions to decimals. Like decimals, fractions show part of a whole.

MODULE 2

CHANGING FRACTIONS TO DECIMALS

Think of a fraction as a division problem. The fraction line is like a division sign. To change a fraction to a decimal on your calculator, you divide:

Numerator (top) ÷ Denominator (bottom) = Decimal fraction

Example 1: Change the proper fraction ¾ to a decimal fraction.

3 ÷ 4 = 0.75

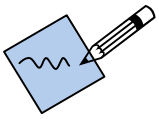
Example 2: Change the improper fraction 5/4 to a mixed decimal.

5 ÷ 4 = 1.25

Example 3: Change the mixed number 3 ¼ to a mixed decimal.

First convert the fraction to a decimal. Then add the whole number to the final answer.
1 ÷ 4 = 0.25 add in the 3 = 3.25

Exercise 3:



Change the following fractions to decimals.

1. 1/8 = _____
2. 4/5 = _____
3. 11/10 = _____
4. 6/4 = _____
5. 3/3 = _____
6. 8/8 = _____
7. 4 ¼ = _____
8. 10 ¾ = _____
9. 121 ½ = _____
10. 45 2/5 = _____
11. 18 4/9 = _____
12. 75 2/7 = _____

MODULE 2

ROUNDING DECIMALS

When using a calculator you may get an answer to a question that has 10 numbers to the right of the decimal. If the numbers in the question have two places after the decimal then you should round the answer to two places. The general rule is that your answer should have the same number of places to the right of the decimal as the original decimal number in the question (the decimal number with the least amount of places after the decimal. Let the numbers in the question dictate where you should round off. But, when performing a multi-step calculation, do not round off the numbers until the final answer. Rounding off at each step of the calculation will give you an inaccurate final answer.

Whole Number					**AND**	**Decimal Fraction**			
Ten Thousands	**Thousands**	**Hundreds**	**Tens**	**Ones**	**Decimal Point**	**Tenths**	**Hundredths**	**Thousandths**	**Ten Thousandths**
					•				

To round off a number, underline the number to be rounded then:

- Look at the digit to the right of that place.
- If the digit is 4 or less, round DOWN. Do not change the number in the place. Drop the digits to the right of that place.
- If the digit is 5 or more, round UP. Increase the number in the place you are rounding to by 1. Drop the digits to the right of that place.

MODULE 2

Exercise 4:

Round off the following numbers.

Round to the hundredths place

1. 2.89023 _____

2. 366.00034 _____

Round to the ten thousandths place

3. 19.00382 _____

4. 387.788880 _____

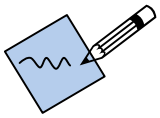
Round to the tenths place

5. 101.990 _____

6. 454.023 _____

MODULE 2

Exercise 5:



Perform the following calculations and round off the answer to the same number of places as the decimal number in the question with the least amount of decimal places.

1. 16. 204 x 8.99 = Answer = 145.67
2. 1.009 x 15.00901= _____
3. 177.03 x 6.4441 = _____
4. 99.3655 x 490.1 = _____
5. 663.33 ÷ 11.1 = _____
6. 3002.944 ÷ 17.5 = _____
7. 45.82210 ÷ 6.7 = _____
8. 21.021 x 735 = _____
9. 12.099 x 11.45 ÷ 0.98 = _____
10. 772.5 x 17.5 x 94.32 = _____

PERCENTS

Common fractions, decimals and percents all express parts of something. Percent means parts out of 100, so a whole percent stands for hundredths.

Example: 25% means the same as 25/100 (reduced to ¼) and it also means the same as 0.25

You don't need a calculator to change decimals to percents or percents to decimals.

CHANGING PERCENTS TO DECIMALS

Divide by 100 (move the decimal 2 places to the left)

In a whole number, the decimal is to the right of the number, even though we never write it. 43% is really 43.%}

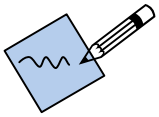
4 3 % (move the decimal two spaces to the left) **4 3 .** = 0.43

CHANGING DECIMALS TO PERCENTS

Multiply by 100 (move the decimal 2 places to the right) and add a percent sign

0.43 (move the decimal 2 places to the right) **0 . 4 3** = 43%

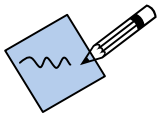
Exercise 6:



Write each percent as a decimal. (Move the decimal 2 places to the left)

1. pump efficiency of 85% = _____
2. 4% = _____
3. 140% = _____
4. 2.9% = _____
5. 11.25% = _____
6. 17% = _____
7. pump efficiency of 64.5% = _____
8. 99% = _____
9. 300% = _____
10. motor efficiency of 75% = _____

Exercise 7:



Write each decimal as a percent. (Move the decimal two places to the right)

1. 0.06 = _____
2. 0.425 = _____
3. 0.005 = _____
4. 2.5 = _____
5. 0.0012 = _____
6. 0.6 = _____
7. 1.25 = _____
8. 0.13 = _____
9. 7.604 = _____
10. 0.047 = _____

MULTIPLYING AND DIVIDING PERCENTS:

In order to multiply percents you must change them to a decimal first, then multiply. You can easily multiply percents using the % key on your calculator. It lets you enter percents without changing them to decimals first. Also, you probably won't need to press = to get the answer. Dividing by a percentage works in a similar way.

Example: Try both ways on your calculator to see which gives you the correct answer of 372.

Method A: 465 x 80 %

Method B: 465 x 80 % =

Exercise 8:

Solve the following multiplication problems using the method that works correctly on your calculator.

1. 240 x 50% = _____

2. 35 x 15% = _____

3. 12.5% of 54.4 = _____

4. 4% of 875 = _____

5. 150% of 200 = _____

6. 3.99 x 20% = _____

MODULE 2

Exercise 9:

Solve the following division problems using the method that works.

1. 240 ÷ 50% = _____

2. 12 ÷ 75% = _____

3. 135 ÷ 16% = _____

4. 56 ÷ 8% = _____

5. 125 ÷ 1% = _____

6. 4.44 ÷ 80% = _____

Exercise 10:

Answer the following problems.

1. Horner Wastewater Treatment Station spends 46% of its annual budget on salaries. Their budget is $1,200,000. How much do they spend on salaries?

   Answer: _____

2. Wastewater is flowing through a sewer pipe at 8455 gpm. If the flow is obstructed by 34%, what is the new flow?

   Answer: _____

3. Cindy paid 7% tax when she purchased her toilet. If her toilet cost $218, how much tax did she pay?

   Answer: _____

4. The velocity of water through a 24 inch pipe is 6 feet per second (fps). What is the new velocity if it was reduced by 12%?

   Answer: _____

5. The detention time for water in the old sedimentation basins is 5.28 hours. The new basins have a detention time of 50% longer. What is the detention time of the new basins?

   Answer: _____

6. Water has a pH of 6.8. If the pH increases by 30%, what is the new pH?

   Answer: _____

7. If a reservoir has its overflow 12 m above the bottom and there is 7 m of water in the reservoir, what percentage of its maximum capacity does the reservoir contain?

   Hint: If $\frac{12\text{ m}}{7\text{ m}} = \frac{100\%}{?}$

   Answer: _____

8. A water storage tank can hold 40 gallons of water. If the tank has 18 gallons of water in it, what percentage of its maximum capacity does the tank contain?

   Answer: _____

9. A distribution system has 100 km of 200 mm pipe, 135 km of 150 mm pipe, and 170 km of 100 mm pipe. What is the percentage (length) of 150 mm pipe?

   a. 66.7%
   b. 50%
   c. 45%
   d. 33.3%

10. If a water meter was tested and read 22,009 litres, but the actual usage was 23,400 litres, what was the accuracy of the meter as a percentage?

    a. 102%
    b. 99%
    c. 94%
    d. 88%

11. What percent is 34,411 of 74,818?

    a. 34.411%
    b. 45.993%
    c. 74.818%
    d. 217.42%

12. If there are 100 m^3 of water in a tank and the tank is capable of holding 1000 m^3, the tank is filled to what percent of its capacity?

    Answer: _____

Preparing for Technical Training:

Essential Skills for Water/Wastewater Operators

MODULE 3

Measurement Conversions

MODULE 3

MODULE 3: MEASUREMENT CONVERSIONS

Objectives:

When you have completed this section, you will be able to:

- Use the metric conversion factors on the formula sheet to convert within the metric system
- Locate the decimal in a whole number
- Divide and multiply by moving the decimal
- Convert between the Imperial and metric systems of measurement using the formula sheet
- Convert time (days, hours, minutes, seconds)
- Convert temperature between the Fahrenheit and Celsius scales
- Convert compound units

Contents:

MODULE 3

PRE-TEST

Complete the following pre-test questions using the conversions and formulas below:

10 mm = 1 cm	**1 kW = 1000 watts**	**1 day = 24 hrs. = 1440 min. = 86,400 sec.**
1000 mm = 1 m	**1 g = 1000 mg**	**Fahrenheit = (^oC x 9/5) + 32^oF**
1000 ml = 1 L	**1 kg = 1000 g**	**Celsius = (^oF - 32^oF) x 5/9**
1000 L = 1 m³		

1. Convert the following measurements:

   a. 20 cm = _____ mm

   b. 19 mm = _____ cm

   c. 1000 L = _____ ml

   d. 80 m³ = _____ L

   e. 345.7 g = _____ kg

   f. 3000 watts = _____ kW

   g. 92.109 kg = _____ g

   h. 4 m³ = _____ ml

2. Garberville's water treatment plant removes 25 kg of total suspended solids (TSS) from the incoming raw water prior to the filtration process. Dayton's water treatment plant removes 27,000 g of TSS. Which plant removes more?

3. Use a ratio to calculate how many minutes there are in 7 days.

4. How many seconds are there in 1100 minutes?

5. Convert the following temperatures:

   a. 80 ^oF = _____ ^oC

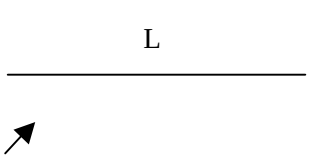
   b. 18 ^oC = _____ ^oF

THE METRIC SYSTEM

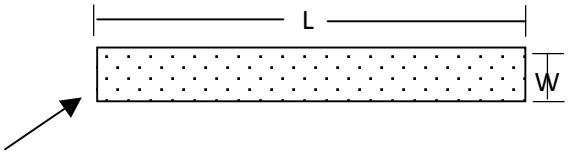
The metric system is a system of units and measurements based on multiples of 10. The metric system is also referred to as the International System of Units (SI).

Length:

The distance between two points. The basic unit for length is the metre.



Linear measurement (has length only)



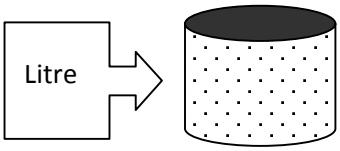
Squared ² measurements (have length and width)

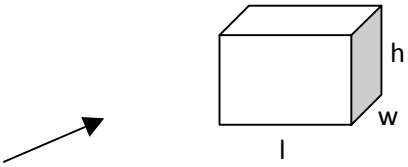
Weight:

The measure of the amount of material in an object. In the metric system, the main unit for weight is the gram.

Volume:

The amount of space occupied by an object and is measured in cubic units (for example, mm^3). The basic unit is the litre or cubic metre (m^3)





Cubic ³ measurements (have length and width and height)

The skill of converting within the metric system is a very practical one. Before we can work with measurements we must be sure the measurements are all in the same unit value. As well, we cannot use a formula unless the units given are the same as those needed for the formula. For example, we can only subtract litres from litres, multiply metres by metres, and add milligrams to milligrams, and if a formula required length and width in metres, we cannot put centimetres into the formula and get a correct answer. So, before doing any calculations with measurements, convert the units as needed so that the unit values are the same. Two different methods for conversion will be presented in this module.

MODULE 3

FORMULA SHEET

To convert within in the metric system you can use the "Metric Conversion Factors" section on the Formula Sheet which will be provided by your instructor.

Remember, in a whole number the decimal is to the right of the number, even though we never write it. Example: 10 is really 10. and 8000 is really 8000.

You can use your calculator to multiply and divide but you can also move the decimal to multiply and divide. When you multiply you move the decimal to the right and when you divide you move the decimal to the left. For example, to multiply 10 by 1000 you move the decimal 3 space to the right (3 spaces for the 3 zeros in the number 1000):

Move the decimal three places: 10. → . add zeroes: 10 0 0 0 .

Therefore, 10 multiplied by 1000 = 10,000

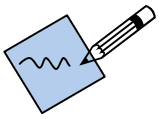
When you want to divide 10 by 100 you would move the decimal two spaces to the left (2 spaces for the <u>2 zeros</u> in the number 100):

Move the decimal two places: . 1 0 . ←

Therefore, 10 divided by 100 = 0.10

MODULE 3

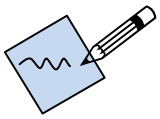
Exercise 1:



Practice moving the decimal.

1. 1000 move the decimal 2 spaces to the right = _____
2. 1000 move the decimal 2 spaces to the left = _____
3. 54.36 move the decimal 1 space to the right = _____
4. 54.36 move the decimal 1 space to the left = _____
5. 0.0299 move the decimal 3 spaces to the right = _____
6. 1000 multiplied by 100 = _____
7. 1000 divided by 100 = _____
8. 54.36 multiplied by 10 = _____
9. 54.36 divided by 10 = _____
10. 0.0299 multiplied by 1000 = _____

Exercise 2:



Use the formula sheet to perform the following length conversions.

1. 10 cm = _____ m
2. 1000 mm = _____ cm
3. 540 mm = _____ cm
4. 94.7 sq. m = _____ ha
5. 0.00156 km = _____ m

MODULE 3

Exercise 3:

Use the formula sheet to perform the following weight and volume conversions.

Important Conversion

You will use this conversion often throughout the modules

$1\ m^3 = 1000\ L$

1. 1000 L = _____ m^3

2. 0.25 L = _____ mL

3. 15 cu. m/day = _____ L/day

4. 0.056 ml = _____ L

5. 84.67 watts = _____ kW

6. 11.1 mg = _____ kg

7. 1000 L = _____ cu. m

8. 8,200 L/sec = _____ m^3/sec

9. 45 mg = _____ kg

10. 90,478 L = _____ m^3

SET UP THE CONVERSION AS A RATIO

Sometimes it is hard to know if you need to multiply or divide in order to convert from one unit to another. An easier way is to use the formula sheet and set up the conversion as a ratio to help find the unknown.

Example 1: 47 cm = _____mm

What you know: From your formula sheet you know that 10 mm = 1 cm

Step 1: Put this as a ratio, with all mm on one side of the equal sign and all cm on the other side:

$$\frac{47\text{ cm}}{1\text{ cm}} = \frac{?\text{ mm}}{10\text{ mm}}$$

All cm on this side

All mm on this side

← **Put what you're looking for on the top**

← **Put what you know on the bottom**

Step 2: Cross multiply the two numbers diagonally and then divide by the third number

$$\frac{47\text{ cm}}{1\text{ cm}} = \frac{?\text{ mm}}{10\text{ mm}}$$

Multiply 47 x 10 Then divide the answer by 1

Answer: 47 x 10 = 470
470 ÷ 1 = 470 mm

Let's do a few more to practice:

Example 2: 0.84 hectare = _____ m²

What we know: The formula sheet states that 10,000 m² = 1 hectare

$$\frac{0.84\text{ hectare}}{1\text{ hectare}} = \frac{?\text{ m}^2}{10{,}000\text{ m}^2}$$

Cross multiply and divide: 10,000 x 0.84 = 8400
8400 ÷ 1 = 8400 m²

Example 3: 72 mg/day = _____ g/day

NOTE: The "/day" does not change the conversion because the "per day" part of the units don't need to be converted. Ignore it until the final answer!

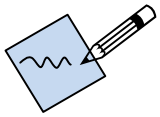
What we know: From the formula sheet we know that 1 g = 1000 mg

$$\frac{72\ \text{mg}}{1000\ \text{mg}} = \frac{?\ \text{g}}{1\ \text{g}}$$

Cross multiply and divide: 1 x 72 = 72

72 ÷ 1000 = 0.072 g/day

Exercise 4:



Use the method that works best for you to correctly solve the following conversions.

1. 0.954 watts = _____ kW
2. 0.987 ml = _____ gallons
3. 18,000 mL/h = _____ L/h
4. 1 m^3 = _____ L
6. 1 psi = _____ kPa
6. 0.05 cu. m = _____ L
7. 1 kW = _____ watts
8. 2 L of water = _____ kg
9. 0.5 kg of water = _____ L
10. 1.5 m of hydraulic head = _____ kPa

MODULE 3

Exercise 5:

Solve the following problems. Be sure to convert your units before doing any calculations.

1. 50 g – 275 mg = _____ g

2. Janna needs to buy 6 m of plumbing pipe. The plumbing store sells pipe in 800 cm lengths. Will this be enough?

   Answer: _____

3. Ed must buy a hot water tank that holds at least 150 L of water. All he can find at the store are tanks that hold 160,000 mL of water. Should he buy one?

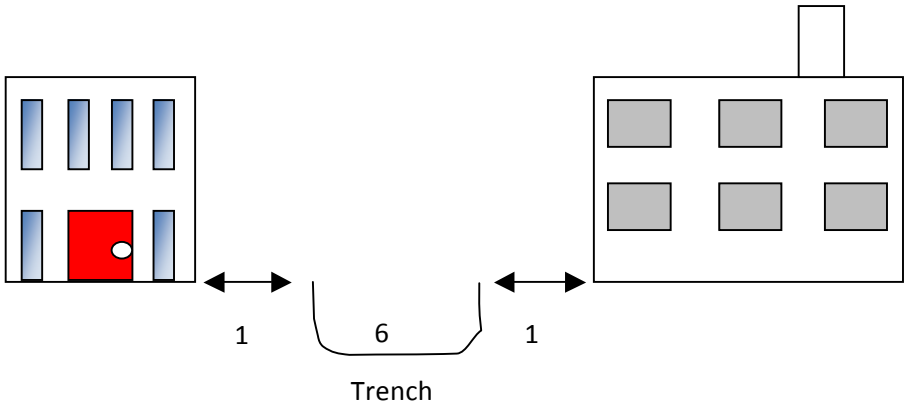
   Answer: _____

4. 80 kW + 7000 watts = _____ kW

5. 0.933 mg x 30 g = _____ g

6. Between two buildings a trench is dug 6 m wide. There must be 1 m left on both sides of the trench for workers to walk. If the buildings are 763 cm apart, will there be 1 m of walking room on both sides?

   Answer: _____



7. 17 mg + 8 g + 0.024 kg = _____g

8. 2 L of algaecide must be added to clean a tank containing 26,000 gallons of water. You have 2-1000 mL bottles of algaecide in the chemical supply room. Do you need to go buy more?

   Answer: _____

9. Garberville's water treatment plant removes 25 kg of total suspended solids (TSS) from the incoming raw water prior to the filtration process. Dayton's water treatment plant removes 27,000 g of TSS. Which plant removes more?

   Answer: _____

10. The sewer treatment tank in Cumberland is 14.38 m long. They purchased a new one that is 0.01920 km long. Which is longer, the old sewer treatment tank or the new one?

    Answer: _____

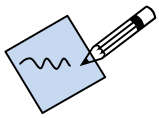
11. A 20 metre tall storage tank is filled with water. A pressure gauge placed at the bottom would read what in kPa? (use the hydraulic head conversion factor on the back page of the formula sheets)

    Answer: _____

THE IMPERIAL SYSTEM

Imperial units are the units that were commonly used in the British Commonwealth Countries. 98% of the world's population converted or are in the process of converting to the Metric System of Measurement (SI) but the U.S. still uses a system very similar to the Imperial System. In this system of measurement you cannot simply move the decimal to the right or left to convert within the system or to convert between the metric and Imperial systems; you must use the formula sheet to do conversions. These conversions will also be provided to you during your RRC course and exam.

Exercise 6:



Use the formula sheet to perform the following conversions.

1. 18.25 ml/min = _____ litres/min

2. 100 lbs = _____ g

3. 100 lbs = _____ kg

4. 7 in^2 = _____ cm^2

5. 0.5 gallons/min = _____ Lpm

6. 0.017 in. = _____ cm

7. 1 lb = _____ grams (gm on the formula sheet)

TIME CONVERSIONS

It is important to know how to convert between days, hours, minutes and seconds. Use the conversions on your formula sheet:

1 day = 24 hours = 1440 minutes = 86,400 seconds

Example 1: How many minutes in 18 hours?

Set up a ratio	$\frac{24 \text{ hours}}{18 \text{ hours}} = \frac{1440 \text{ minutes}}{?}$
Cross multiply and divide by the third number	1440 x 18 ÷ 24
Our unknown is	**1080 minutes**

TEMPERATURE CONVERSIONS

Two scales are commonly used to measure temperature; degrees Fahrenheit (^{o}F) and degrees Centigrade (^{o}C), usually called Celsius. Centigrade is the metric scale and Fahrenheit is what is used in the U.S. In the Centigrade scale, water freezes at 0^{o} and boils at 100^{o}. In the Fahrenheit scale, water freezes at 32^{o} and boils at 212^{o}.

Use the temperature conversions on your formula sheet to convert from one temperature scale to the other:

Fahrenheit = (^{o}C x 9/5) + 32

(punch 9 ÷ 5 into the calculator and this is just 1.8)

Celsius = (^{o}F – 32) x 5/9

(punch 5 ÷ 9 into the calculator and this is just 0.5555555556)

Example 1: Convert 22 ^{o}C into ^{o}F

Plug 22 ^{o}C into the Fahrenheit equation

$^{o}F = (22 \times 9/5) + 32$

$^{o}F = (22 \times 1.8) + 32$

$^{o}F = (39.6) + 32$

$^{o}F = 71.6$

Example 2: Convert 212 ^{o}F to ^{o}C

Plug 212 ^{o}F into the Celsius equation

$^{o}C = (212 - 32) \times 5/9$

$^{o}C = (180) \times 0.555555556$

$^{o}C = 100$

Exercise 7:

Perform the following time and temperature conversions.

1. 17 ^{o}C to ^{o}F

   Answer: _____

2. 793 minutes to hours and minutes

   Answer: _____

3. 125 minutes to days

   Answer: _____

4. 82 ^{o}F to ^{o}C

   Answer: _____

5. 2 days to minutes

   Answer: _____

6. 680 minutes to hours and minutes

   Answer: _____

7. 0 ^{o}C to ^{o}F

   Answer: _____

8. 60,000 seconds to hours

   Answer: _____

9. 4 ^{o}C = _____ ^{o}F

10. 80 hours = _____ days.

MODULE 3

CONVERTING COMPOUND UNITS

Water system operators will often have to convert compound units in flow rate and velocity questions. Some examples are:

ml/s ⟶ L/min lpm ⟶ lpd

ml/s ⟶ L/s mg/L ⟶ kg/L

Example: The velocity of water in a pipe is 49 m/minute. Velocity is normally expressed in metres per second, so convert the answer into m/s.

1. Write the numbers with units in the original measurement as a fraction

$$\frac{49 \text{ metres}}{1 \text{ minute}}$$

2. Find a conversion factor between the given units (minute) and the desired units (seconds), and write it as a fraction. You must put the given units in the opposite position from where they are in the original measurement.

   Conversion factor (look on the formula sheet): we know that 60 seconds = 1 minute so we need to write it as a fraction.

So **Original** $\frac{49 \text{ metres}}{1 \text{ minute}}$ x **Conversion Factor** $\frac{1 \text{ minute}}{60 \text{ seconds}}$

put "minutes" on top in the conversion because they are on the bottom in the original measurement

3. Multiply across the top and multiply across the bottom. Divide the bottom into the top.

$$= \frac{49 \text{ metres} \times 1 \text{ minute}}{1 \text{ minute} \times 60 \text{ seconds}} = \frac{49 \text{ metres } \cancel{\text{minute}}}{60 \text{ seconds } \cancel{\text{minute}}} = 0.817 \text{ metres/second}$$

Multiply across top and bottom

Divide 49 by 60
The "minutes" cancel out

Final Answer!

Example 2: Change 3785 litres per minute (lpm) to cubic metres per second (m^3/s).

1. Write the original measurement as a fraction

$$\frac{3785\ L}{1\ min.}$$

2. Find a conversion factor that converts between litres and cubic metres AND one that converts between minutes and seconds.

Conversion Factors: 1000 L = 1 m^3 AND 60 s = 1 min.

Original		Conversion Factor		Conversion Factor
$\frac{3785\ L}{1\ min.}$	x	$\frac{1\ m^3}{1000\ L}$	x	$\frac{1\ min}{60\ s}$

put Litres on the bottom because it's on top in the original measurement

put minutes on the top because it's on the bottom in the original measurement

3. Multiply across the top and bottom and then divide:

$$= \frac{3785\ \cancel{L}\ m^3\ \cancel{min.}}{60{,}000\ \cancel{L}\ s\ \cancel{min}.} = \mathbf{0.063\ m^3/s}$$

Divide 3785 by 60,000

The Litres and minutes cancel each other out

MODULE 3

Exercise 8:

Convert the following units. Use your formula sheet to find the conversion factors.

1. A pump is discharging 165 L/s. What is this in L/hr?

   Answer: _____

2. Water flows with a velocity of 2 m/s. Convert that to m/day.

   Answer: _____

3. Water is draining at a rate of 17,350 L/hour from a reservoir. How much water is flowing out in m^3/hour?

   Answer: _____

4. A ferric chloride pump is calibrated by timing to deliver 470 mL in 15 seconds. How much coagulant is being added in litres per minute?

   a. 1.88 lpm
   b. 0.188 lpm
   c. 18.8 lpm
   d. 188 lpm

5. Convert 0.53 m^3/s to lpm.

   Answer: _____

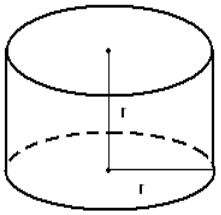
Preparing for Technical Training:

Essential Skills for Water/Wastewater Operators

MODULE 4

Linear, Area and Volume Calculations

MODULE 4: LINEAR, AREA, AND VOLUME CALCULATIONS



Objectives:

When you have completed this section, you will be able to:

- Define perimeter and calculate the perimeter of objects
- Rearrange the perimeter equation to solve for an unknown
- Define key terms related to circles
- Calculate the circumference of circles using an equation
- Calculate the area of different shapes using the proper equation
- Calculate the volume of different shapes using the proper equation
- Explain the difference between linear, squared and cubed dimensions

Contents:

MODULE 4

PRE-TEST

Complete the pre-test questions below using the formula sheet supplied by your instructor (given to you in Module 3):

1. What is the area of a rectangular storage area that measures 80 m in length, 35.7 m in width and 12 m in height?

2. What is the circumference of a circular clarifier with a diameter of 2400 cm?

3. Calculate the volume of a cylindrical tank with a diameter of 3 m and a height of 2.2 m?

4. A lift station wet well is 5 ft. long and 14 feet wide. What is the surface area of the wet well?

5. What is the cross section area of a sewer pipe that has a diameter of 3 in?

6. The bottom portion of a tank is a cone. If the diameter is 50 m and the height is 3 m, what is the cubic metre capacity of the cone portion of the tank?

MODULE 4

LINEAR MEASUREMENTS

One-dimensional objects are referred to as linear. The length of a water main is a linear dimension. The length of a weir is also a linear dimension.

PERIMETER

This is a special linear dimension. It is defined as the distance around the outside of an object. To calculate the perimeter of any area or object, add the length of each of its sides:

Important Conversion

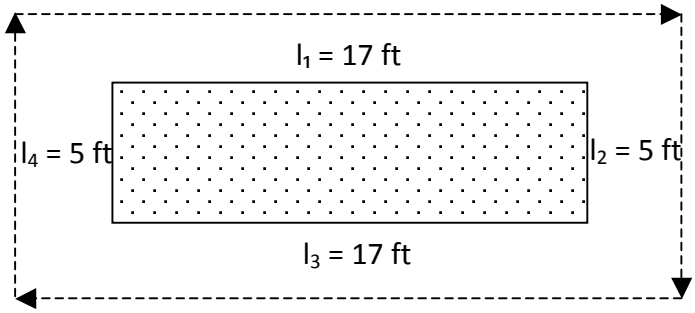
Perimeter (P) =

$$l_1 + l_2 + l_3 + l_4 + \ldots$$

The number of terms added for the perimeter equation depends on how many sides the object has.

Example: A rectangle is 17 feet long and 5 feet wide. What is the perimeter?

Draw a picture of the rectangle and label the sides:



The linear distance around the perimeter of the rectangle can be calculated by adding each length and width dimension as shown below:

$$P = 17 \text{ ft} + 5 \text{ ft} + 17 \text{ ft} + 5 \text{ ft} = 44 \text{ ft}$$

USING THE PERIMETER EQUATION TO FIND LENGTH

The perimeter equation can also be used to determine the length of one of the sides. To determine the length of the unknown side, subtract the total of all other sides from the perimeter.

Example:

The perimeter of an object with 4 sides is 20 feet. The length of the 3 other sides totals 13 feet. The length of the 4th side must be:

$$20 \text{ ft} - 13 \text{ ft} = 7 \text{ ft.}$$

Exercise 1:

Solve the following linear measurement problems.

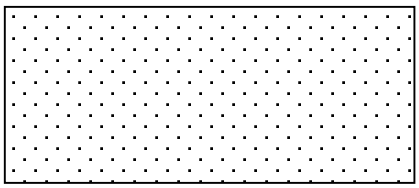
1. What is the perimeter of a square with each side 4 m long?

   Answer: _____

2. What is the perimeter of a 5 sided object with dimensions 4 cm, 7 cm, 8.6 cm, 6.2 cm, 9 cm?

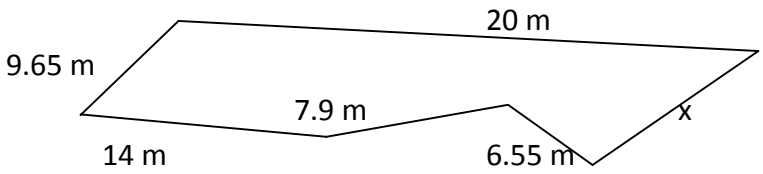
   Answer: _____

3. What is the unknown length of the following object if the perimeter is 10 inches?



   Answer: _____

4. What is the unknown length of the object if the perimeter is 71.32 m?

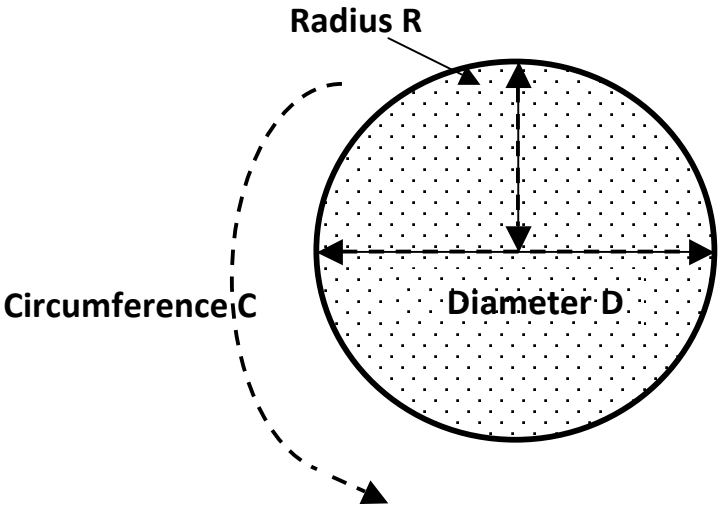


Answer: _____

CIRCUMFERENCE

The distance around the outside of a circle is called the circumference. Circumference is a special term for the perimeter of a circle. The circumference can be calculated by multiplying the diameter of the circle by a constant called Pi, the Greek letter. The symbol for Pi is π. Pi is a constant with a value of 3.14.

The parts of a circle are shown below:



The equation for calculating circumference of a circle is:

Circumference of a circle (C) = π x D

C = 3.14 x D OR C = 3.14 D

C = 3.14 D

Note: Often the "x" for multiplication is left out of an equation so as not to confuse it with the unknown x. You must know that the 3.14 and the D are multiplied.

Example 1: A circle has a diameter of 45 inches. What is the circumference?

Circumference (C) = 3.14 x 45 inches

C = 141.3 inches

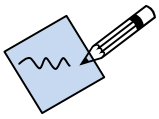
Example 2: A circle has a radius of 890 inches. What is the circumference?

Radius is half the diameter so you must multiply radius by 2 before using the equation.

D = 890 inches x 2
D = 1780 inches

C = 3.14 x 1780 inches
C = 5589.2 inches

Exercise 2:



Solve the following circumference problems.

1. What is the circumference of a circle with a diameter of 31 cm?

   Answer: _____

2. What is the circumference of a storage tank with a radius of 11 m?

   Answer: _____

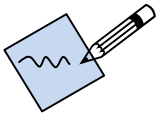
3. What is the circumference of a circular clarifier (in metres) that has a diameter of 166 cm?

   Answer: _____

4. What is the circumference of a pipe (in inches) that has a radius of 0.5 feet?

   Answer: _____

Exercise 3:



Solve the following linear measurement word problems.

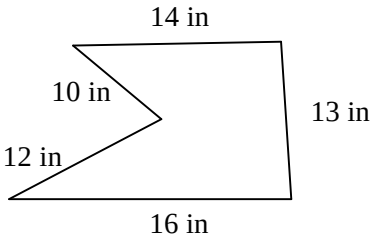
1. Find the P of a circle with D = 56 m

   Answer: _____

2. P of a circle with D = 12.2 inches

   Answer: _____

3. P = _____



4. Perimeter of a circle with R = 3.35 ft

   Answer: _____

5. Circumference of a circle with R = 900.25 cm

   Answer: _____

6. Perimeter of a square with a side 7 km long

   Answer: _____

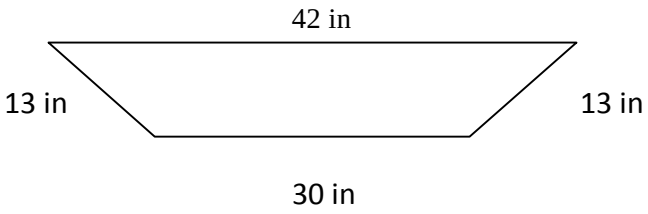
7. Rectangle: l = 54.9 ft
   w = 34.9 ft

   P = _____

8. Rectangle: l = 59.11 m
   w = 19.33 m

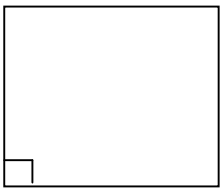
   P = _____

9.



P = _____

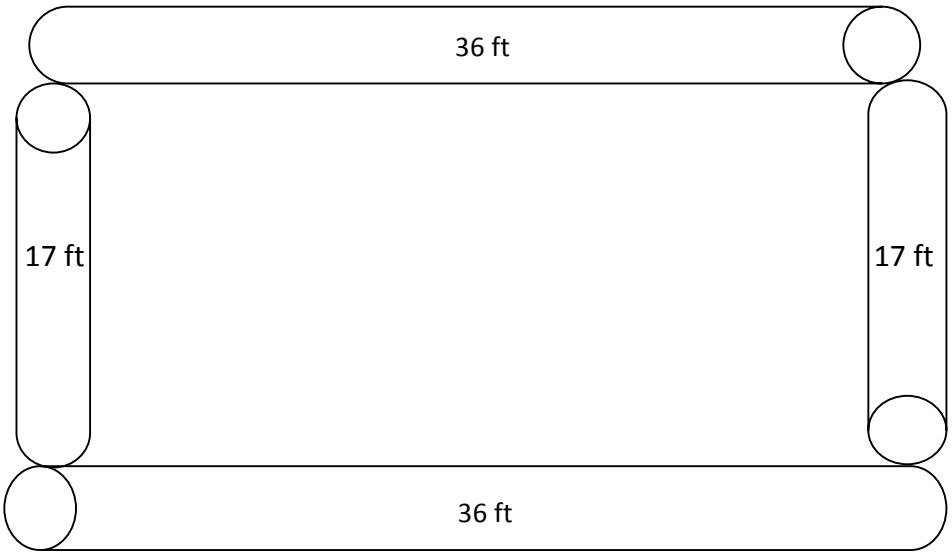
10.



Square with s = 22 ft

P = _____

11. Pipe is laid around the inside perimeter of a building. What are the total linear dimensions of the pipe?

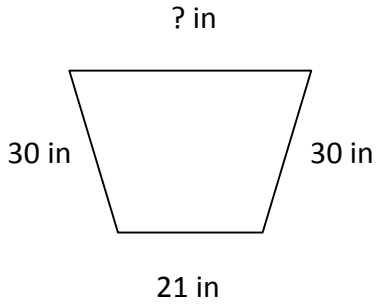


Answer: _____

12. The lengths of a fenced area are: 34 m, 59.5 m, 56 m, 112 m, and 17 m. What is the perimeter of the fenced area?

    Answer: _____

13. Calculate the length of the unknown side if the perimeter is 116 inches.



    Answer: _____

14. If the perimeter of a square is 84 feet, what is the length of each side?

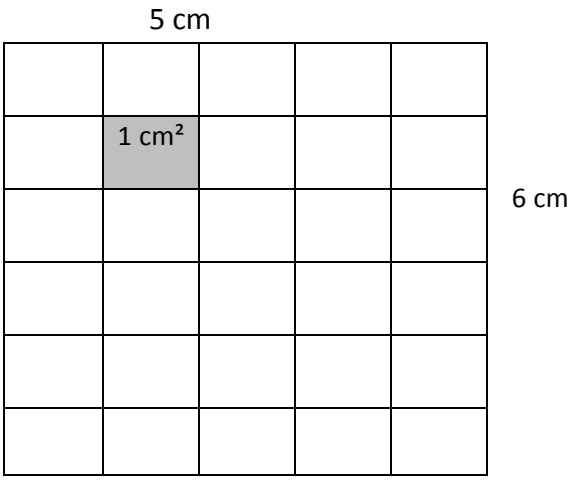
    Answer: _____

AREA

Area is the amount of surface within a figure. Area is described using square units (ft², m², in², etc.). For example: If the figure is a room, the area is the floor. If the figure is a roof, the area is the shingled surface. If the figure is property, the area is the ground within the property lines.

AREA OF A RECTANGLE

Find the area of this rectangle.



Important Conversion

Area of a Rectangle =

length x width

The measurements of this rectangle are given in centimetres. To measure the area, we will use squares which are 1 cm by 1 cm (1 square centimetre, or 1 cm²). How many square centimetres will fit on the surface of this rectangle? Count the 1 cm squares drawn within the rectangle.

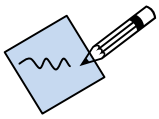
The area of this rectangle is _____ square centimetres

This is written as _____ cm²

There is a quick method for counting the square units. Simply multiply the length of the rectangle (6 cm) by the width (5 cm) and the answer is the area!

A = 6 cm x 5 cm
A = **30 cm²**

MODULE 4



Exercise 4:

Find the area of the following rectangles. Be sure to include the correct units in your answer.

1. l = 12 m
   w = 7 m
   Answer: _____

2. l = 829 km
   w = 730 km
   Answer: _____

3. l = 64 ft
   w = 44 ft
   Answer: _____

4. l = 4 in
   w = 2.65 in
   Answer: _____

5. l = 21 cm
   w = 18 cm
   Answer: _____

AREA OF A SQUARE

Squares are rectangles with all four sides the same. So to find the area of a square you use the same formula of length x width. But since the length and width of a square is the same (because all sides are equal in length) the formula is usually written as side x side or side^2

Important Conversion

Area of a Square =

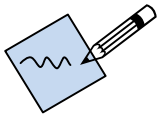
side x side

Example: Find the area of a square piece of property. One side of the property is 75 m long.

Area of a square = 75 m x 75 m
Area of a square = **5,625 m^2**

MODULE 4

Exercise 5:



Find the area of each square described.

1. s = 5 m

   Answer: _____

2. s = 25 km

   Answer: _____

3. s = 3.44 mm

   Answer: _____

4. s = 90 cm

   Answer: _____

AREA OF A CIRCLE

The area of a circle can be calculated using the following equation: The units are squared.

where $\pi = 3.14$
R = the radius of the circle

Important Conversion

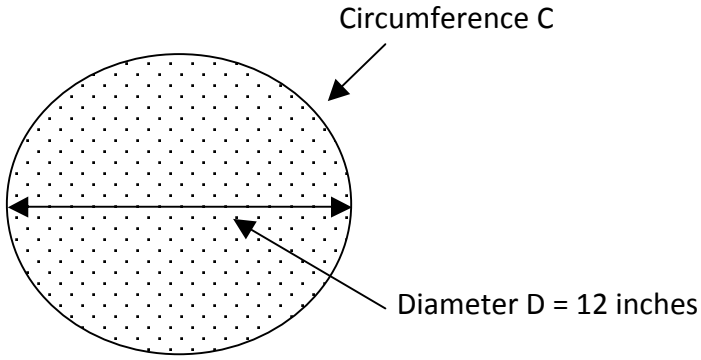
Area of a Circle=

$$\pi R^2$$

The diameter of a circle is twice as much as the radius so if the question gives you diameter, you must divide it in half before using the equation.

Beware of the units! If the radius is given in inches and the question wants the area in ft², you must convert inches to feet before using the equation.

Example: The circle is shown below with the known diameter. Calculate the area.



Change diameter to radius first

$$R = \frac{12 \text{ in}}{2}$$

$$R = 6 \text{ in}$$

Put the numbers into the formula $A = \pi R^2$

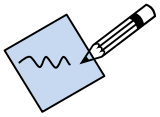
$$A = 3.14 (6 \text{ in})^2$$

$A =$ **113.04 in²**

$(6)^2$ just means 6 x 6!

To square a number on the calculator press the number and then press the x^2 button and the calculator will automatically display the answer.

MODULE 4



Exercise 6:

Solve the following problems involving circles.

1. Area = ? cm²
   Radius = 80 cm

   Answer: _____

2. A = ? km²
   D = 1.7 km

   Answer: _____

3. A = ? cm²
   R = 20 mm *change mm to cm first

   Answer: _____

4. A = ? feet²
   R = 6 in

   Answer: _____

5. A = ? m²
   D = 17.93 m

   Answer: _____

AREA OF A TRIANGLE

The area of a triangle is always half the area of a rectangle, as shown in the diagram below. Therefore, the area equation is half the l x w. But, instead of using length and width we use base (B) and height (H). The units are squared.

Important Conversion

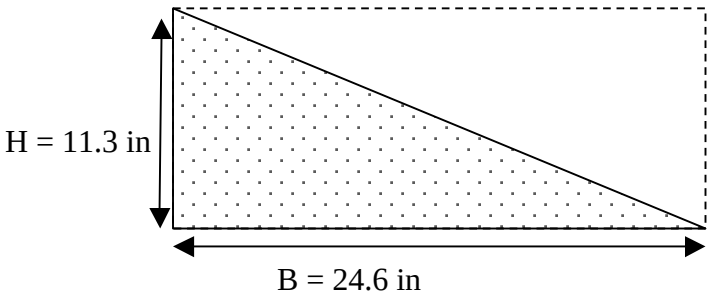
Area of a Triangle =

$$\frac{1}{2}(B \times H) \quad \text{OR} \quad \frac{B \times H}{2}$$

In the first equation you multiply base and height and then multiply it by ½ which is 0.5! This equation is given on your formulas sheet.

The second equation means the same as the first because multiplying something by 0.5 is the same as dividing it by 2. So in the second equation you first multiply base and height and then divide the answer by 2.

Example: Find the area of the triangle below



A triangle is really half a rectangle

A = ½(B x H)

A = ½ (24.6in x 11.3in)

A = ½ (277.98 in²)

A = 138.99 in²

MODULE 4

Exercise 7:

Solve the following triangle problems.

1. A = ? in²
   B = 81 in
   H = 9 in
   Answer: _____

2. A = ? ft²
   B = 3 in
   H = 4 in
   Answer: _____

3. A = ? m²
   B = 74 m
   H = 200 cm
   Answer: _____

4. A = ? in²
   H = 1 ft
   B = 3 ft
   Answer: _____

5. A = ? cm²
   H = 300 cm
   B = 455 cm
   Answer: _____

Exercise 8:

Solve the following word problems involving area. Be sure to use the correct formula!

1. What is the surface area of a trickling filter with a radius of 7 in?

   Answer: _____

2. What is the area of a tank with a diameter of 4 m?

   Answer: _____

3. A triangular portion of the treatment grounds is not being used. If the height is 170 feet and the base is 200 feet, what is the area?

   Answer: _____

4. What is the square foot area of a triangle with a base of 6 feet and a height of 3 feet?

   Answer: _____

5. A treatment plant has three drying beds, each of which is 50 ft long and 15 ft wide. How many square feet do the drying beds occupy?

   Answer: _____

6. A lift station wet well is 10 ft. long and 10 feet wide. What is the surface area of the wet well?

   Answer: _____

7. What is the surface area of a lagoon with a length of 240 ft and a width of 113 ft?

   Answer: _____

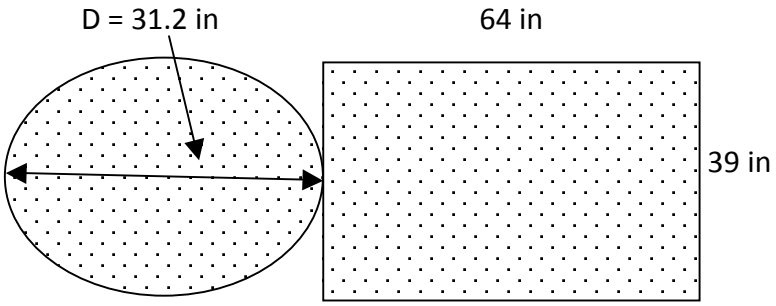
8. Calculate the surface area of a circular clarifier having a diameter of 4.5 m.

   Answer: _____

9. What is the cross section area of a pipe that has a diameter of 8 in?

   Answer: _____

10. Determine the total area of the shape below:



   Answer: _____

VOLUME

Volume has two definitions that are important to understand when performing water system calculations.

These definitions are:

1. *Volume is the amount of space occupied by a three-dimensional object, often expressed in cubic units such as cubic metres (m^3).*

2. *Volume is the holding capacity for liquid of a space or object, often expressed in units such as litres (l) .*

Therefore, water can be expressed as a space measurement (cubic metres) or a as a liquid measurement (litres).

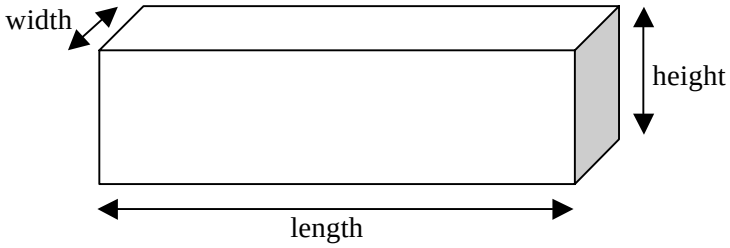
VOLUME OF RECTANGULAR OBJECTS

This is a simple calculation of length x width x height of the object with the units cubed.

Important Conversion

Volume of a Rectangular Object =

L x W x H



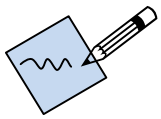
Example: A clearwell measures 40 feet long, 30 feet wide and 26 feet high. What is the volume of the clearwell in cubic feet?

Volume = L x W x H

Volume = 40 ft x 30 ft x 26 ft

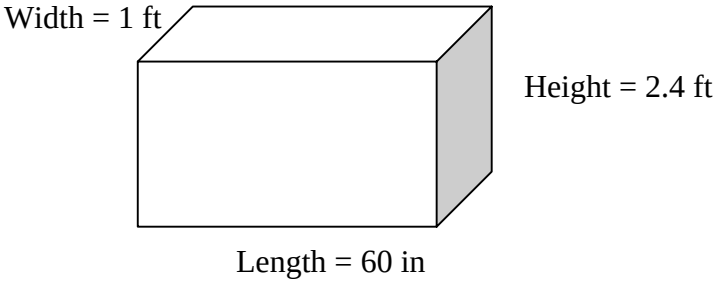
Volume = 31,200 ft^3

Exercise 9:



Calculate the volume for the following rectangular objects. Be careful with the units!

1. What is the volume in ft³ for the following object?



Answer: _____

2. Volume = _____ m³

   Length = 74.23 cm
   Width = 60.09 cm
   Height = 48.80 cm

3. Volume = _____ m³

   Length = 5552 cm
   Width = 7900 mm
   Height = 7200 mm

VOLUME OF CYLINDERS

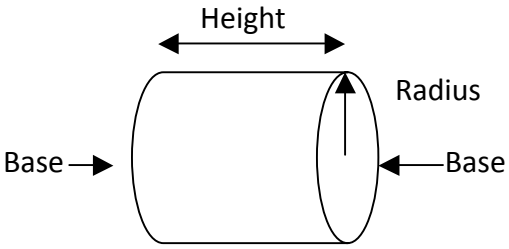
In water systems, pipes and circular tanks have the shape of cylinders. The volume of a cylinder is calculated by multiplying Pi and Radius squared and then multiplying that answer by the height of the cylinder.

Important Conversion

Volume of a Cylinder =

$$\pi R^2 \times H$$

Example: A water main is 8 inches in diameter and 1200 feet long. What is the volume of the water main in cubic feet?



Volume = $\pi R^2 \times H$

Find the Radius by dividing the diameter (8 in) by 2: 8 in ÷ 2 = 4 in

Convert 4 inches into feet: $\frac{4 \text{ in}}{12 \text{ in}} = \frac{? \text{ ft}}{1 \text{ ft}}$ **Don't round off yet, leave the whole #**

Cross multiply and divide by the third number: 4 in x 1 ft ÷ 12 in = 0.333333 ft.

Place all numbers into formula: Volume = 3.14 $(0.333333 \text{ ft})^2$ x 1200 ft
Do the square first: $(0.333333)^2 = 0.1111108 \text{ ft}^2$
Calculate: Volume = 3.14(0.1111108 ft^2) x 1200 ft
Volume = 418.67 ft^3
Could round to two digits after the decimal or to the whole number 419 ft^3

MODULE 4

Exercise 10:

Calculate the volume for the following cylinders. Be careful with the units!

1a. Volume = _____ m^3 b. How many litres would this cylinder hold?

R = 17 m
H = 4000 cm

Answer: _____

2a. Volume = _____ m^3 b. How many litres would this cylinder hold?

D = 2.7 m
H = 11 m

Answer: _____

3a. Volume = _____ m^3 b. What is the volume in cm^3?

R = 83000 mm
H = 66000 cm

Answer: _____

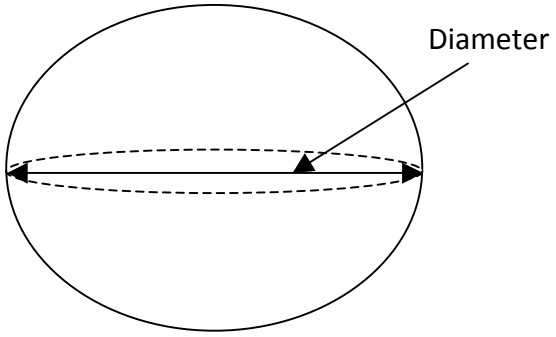
4. A pump is discharging 165 L/s into a cylindrical reservoir, 20 m in diameter and 5 m deep. How many hours will it take to fill the reservoir?

a. 0.13 h
b. 2.6 h
c. 1.3 h
d. 26 h

VOLUME OF SPHERES AND CONES

Process treatment units and water storage tanks are sometimes in the shape of spheres and cones. The equations for calculating the volume of these shapes are shown below:

Sphere: a ball shaped three-dimensional object.



Important Conversion

Volume of a Sphere =

$$\frac{4\pi R^3}{3}$$

Example: A sphere-shaped water storage tank has a diameter of 25 feet. What is the volume of the tank in cubic feet?

Volume $= \frac{4\pi R^3}{3}$

Volume $= \frac{4\ (3.14)(12.5\ ft)^3}{3}$

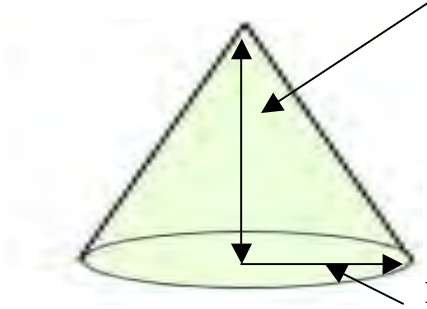
Do (12.5 ft)³ first: 12.5 ft x 12.5 ft x 12.5 ft = 1953.125 ft³

Multiply across the top and then divide by 3: Volume $= \frac{4(3.14)(1953.125)}{3}$

Volume = **8177 ft³**

Cone: an object with a circular base at one end and a point at the other end.

Height (from the center of the circular base to the point)



Radius

Important Conversion

Volume of a Cone =

$$\mathbf{1/3\ \pi R^2 H}$$

Example: The radius of a cone is 10 ft. and the height is 22 feet. Find the volume in cubic feet.

Volume = 1/3 $\pi R^2 H$

Volume = 1/3(3.14)$(10\text{ ft})^2(22\text{ ft})$

Do $(10)^2$ first: 10 x 10 = 100 ft^2

Plug the numbers in and multiply across: Volume = 1/3(3.14)$(100\text{ ft}^2)(22\text{ ft})$

Volume = 2303 ft^3

Exercise 11:

Find the volume for the following spheres and cones. Pay attention to the units!

1. Volume of sphere = _____ gallons

   R = 4000 cm

2. Volume of sphere = _____ m^3

   D = 19.68 ft

3. Volume of cone = _____ ft^3

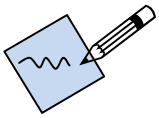
   H = 12 ft
   R = 30 inches

4a. Volume of cone = _____ m^3

   D = 39 m
   H = 11 m

b. How many litres will the cone hold?

   Answer: _____



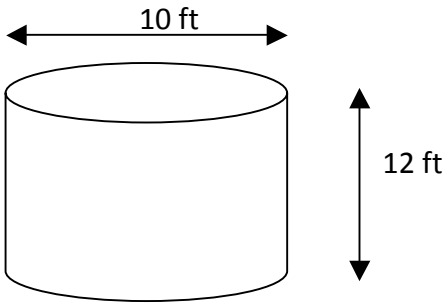
Exercise 12:

Use the volume equations on your formula sheet to solve the following word problems.

1. The diameter of a treatment process tank is 80 ft. If the water depth in the tank is 12 feet, how many cubic feet of water are in the tank?

   Answer: _____

2. Calculate the cubic feet capacity of the tank shown below:

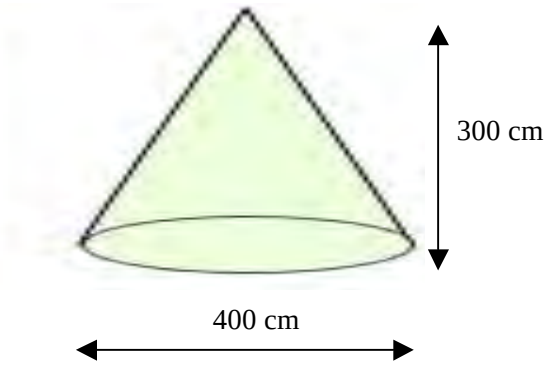


Answer: _____

3. The bottom portion of a tank is a cone. If the diameter is 50 m and the height is 3 m, what is the cubic metre capacity of the cone portion of the tank?

Answer: _____

4a. Calculate the cubic metre volume of the cone shown below:



Answer: _____

b. How many litres of water can this cone hold?

Answer: _____

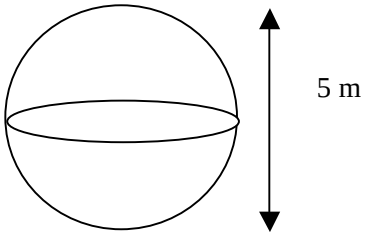
5a. A rectangular treatment unit measures 30 ft. x 40 ft. x 18 m. What is the volume in cubic feet?

Answer: _____

b. What is the volume in cubic metres?

Answer: _____

6. Calculate the cubic feet volume of the sphere shown below:

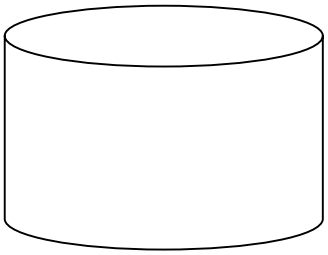


Answer: _____

7. A cylindrical water tank at a treatment plant is about 30 m long and has a radius of 5 m. If 1000 L = 1 cubic metre, how many litres of water will the tank hold?

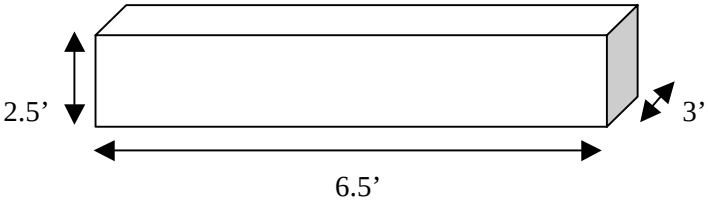
Answer: _____

8. Diameter 2.5 m Volume = _____ m³

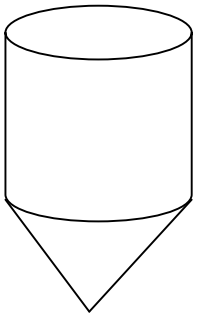


Depth 4.5 m

9. Volume = _____cubic feet



10. A circular clarifier has a conical bottom. The top portion has a diameter of 18 metres and a height of 75 metres. The conical bottom has a height of 10 metres. Find the volume of the tank in m³



Answer: _____

11. Calculate the number of cubic yards excavated from a trench with dimensions of 250 feet long, 20 feet wide and 9 feet deep.

    Answer: _____

12. Calculate the volume in cubic metres of a water main 4 feet in diameter and 1350 feet long.

    Answer: _____

13. An aeration basin has a volume of 360 m^3. The suspended solids concentration in the mixed liquor is 2400 mg/L. How many kg of mixed liquor suspended solids are in the tank?

    Answer: _____

Preparing for Technical Training:

Essential Skills for Water/Wastewater Operators

MODULE 5

Solving Equations

MODULE 5: SOLVING EQUATIONS

Objectives:

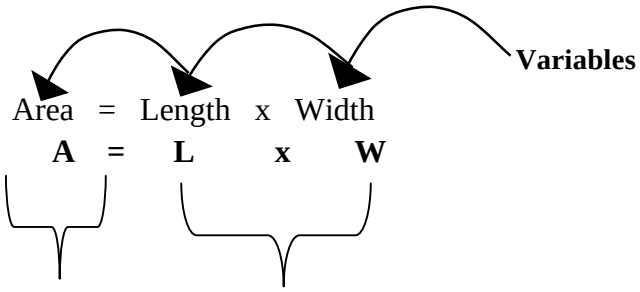
When you have completed this section, you will be able to:

- Understand and identify an equation
- Use BEDMAS for the Order of Operations when solving equations
- Rearrange equations to solve for any unknown
- Explain the important steps to follow when solving word problems

Contents:

UNDERSTANDING AN EQUATION

An equation is a mathematical sentence stating that two quantities are equal. It has an equal sign. The equations that you have been using to calculate perimeter, area and volume are called open equations because they contain one or more variables (unknowns) which are represented by letters (such as A, L, V, etc.).



ORDER OF OPERATIONS

Once we place the numbers into an equation, we then need to multiply, divide, add, find the square, or do other operations in the equation. Knowing which operation to do first, second and so on is important for solving the equation correctly. The Order of Operations helps us do that. To remember the order in which we must do the operations, we use the following:

B E D M A S

B = Brackets ( )

E = Exponents ²

D = Division ÷

M = Multiplication x

D and M are interchangeable
Multiply and divide from left to right

A = Addition +

S = Subtraction -

A and S are interchangeable
Add and subtract last from left to right

Example 1: solve the following equation using the Order of Operations

Put your numbers into the equation	G = 4 x 5 + 6
Multiply first	G = 20 + 6
Then add	**G = 26**

Example 2:

Put your numbers into the equation	$N = 72 + 100 \div (9)^2$
Square the 9 first	$N = 72 + 100 \div 81$
Divide	$N = 72 + 1.2345679$
Then add	**N = 73.234567**

The general rule for division in equations such as examples 3 and 4 below is to do the top of the equation according to the Order of Operations and do the bottom according to the Order of Operations and then divide at the end.

Example 3:

Put your numbers into the equation	$Y = \frac{3 \times 4}{1 \times 7}$
Multiply the top and multiply the bottom	$Y = \frac{12}{7}$
Then divide	**Y = 1.7142857**

Example 4:

Put your numbers into the equation	$E = \frac{(67 - 50) \times 100}{20}$
Do what is in brackets first	$E = \frac{(17) \times 100}{20}$
Multiply the top	$E = \frac{1700}{20}$
Divide	**E = 85**

MODULE 5

REARRANGING EQUATIONS

An equation such as Area = Length x Width allows you to find the area of a rectangle. In this problem, the length and width will be provided for you. But this equation can also help you find the Length of a rectangle, as long as you are given the Area and Width. It can also help you find the Width of the equation, as long as the Area and Length are given. We can solve for all unknowns in an equation by rearranging the equation.

The rules for this are:

*For Advanced Problems: Start by simplifying as many terms as possible, using the order of operations.

1. **Get the unknown by itself on one side of the equal sign (must be in the numerator). To get the unknown by itself, do the opposite process.**
2. **Anything done to one side of the equation must be done to the other side.**

Example 1: What is the length of a trench with a width of 7m and an area of 42 m²

We use the formula for area of a rectangle: $A = L \times W$

Rearrange the formula to solve for Length by getting the unknown by itself (get rid of W). To do this, do the opposite. Since Length and Width are being multiplied, do the opposite

which is divide: $A = \frac{L \times W}{\mathbf{W}}$

What you do to one side, you must do to the other: $\frac{A}{\mathbf{W}} = \frac{L \times W}{W}$

On the right side of the equation, when you multiply by W and divide by W, they cancel each other out: $\frac{A}{W} = \frac{L \times \cancel{W}}{\cancel{W}}$

You can write it either way, it doesn't matter!

You are left with the equation: $\frac{\mathbf{A}}{\mathbf{W}} = \mathbf{L}$ **or flip it to** $\mathbf{L} = \frac{\mathbf{A}}{\mathbf{W}}$

Plug in your numbers: $L = \frac{42\ m^2}{7\ m}$

Solve the equation: **L = 6 m**

Example 2: What is the Time (s) if the Pump Power (W) is 5 watts, the Force is 10 N and the Height is 5m?

$$\text{Pump Power (W)} = \frac{F \times h}{T}$$

When the unknown is on the bottom (denominator) you need to move it into the numerator.

To do this, first multiply both sides by the unknown (T): $W \times T = \frac{F \times h}{T} \times T$

The T's on the right side of the equation cancel out: $W \times T = \frac{F \times h}{\cancel{T}} \times \cancel{T}$

You're left with: $W \times T = F \times h$

Now you can get the T by itself by doing the opposite: $\frac{W \times T}{W} = F \times h$

What you do to one side you do to the other: $\frac{W \times T}{W} = \frac{F \times h}{W}$

You're left with: $T = \frac{F \times h}{W}$

Now plug in the numbers $T = \frac{10\ N \times 5\ m}{5\ watts}$

$T = \frac{50}{5}$

T = 10 s

You can also plug the numbers into the equation first, and then rearrange it:

Example 3: The circumference of a water tank is 254 feet. What is the diameter of the tank?

$C = \pi D$

254 feet = (3.14) (D)

$\frac{254\ feet}{3.14} = \frac{(3.14)(D)}{3.14}$

$\frac{254\ feet}{3.14} = D$

80.89 feet = D

Example 4: What is the Width of a wet well that has an Area of 20 ft² and a Length of 5 ft?

$A = L \times W$

$20\ ft^2 = 5\ ft \times W$

$$\frac{20\ ft^2}{5\ ft} = \frac{5\ ft \times W}{5\ ft}$$

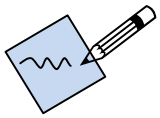
$$\frac{20\ ft^2}{5\ ft} = \frac{\cancel{5\ ft} \times W}{\cancel{5\ ft}}$$

$$\frac{20\ ft^2}{5\ ft} = W$$

4 ft = W

The opposite of multiply is divide and the opposite of divide is multiply
The opposite of add is subtract and the opposite of subtract is add
The opposite of squared (x^2) is the square root ($\sqrt{\ }$)

Exercise 1:



Rearrange the following equations to solve for the unknown.

1. $C = 2\pi R$
   Solve for Radius

2. Use your formula sheet and rearrange the velocity formula to solve for Flow Rate.

3. Use your formula sheet and rearrange the Total Chlorine Dosage formula to solve for Chlorine Demand.

4. Rearrange the power (watts) equation to solve for Current.

5. Rearrange the first Chemical Dosage formula (under the Chemical Requirements heading) to solve for C.

6. A wet well can hold 14000 L of water. The wet well is 6 m long and 2 m wide. What is the depth of the wastewater?

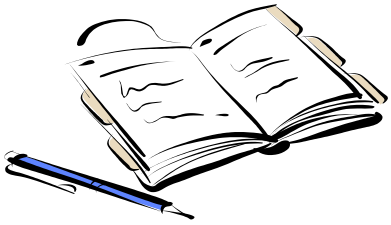
PROBLEM SOLVING STEPS

Knowing how to solve the math problems on the licensing exams is very important. Knowledge of and experience with basic water system concepts can help operators understand the problems but knowing how to approach each problem will increase the chance of success on the exams.

The first approach that should be used in solving any problem is to visualize the conditions presented in the problem. Use experience to see if a straightforward solution is available. A problem may not require the use of formulas but may be solvable instinctively.

Be aware that test makers may provide "extra" information in a problem that is not needed to solve it. The multiple choice exam will give you possible answers. You can usually cross out at least one or two of these answers right away, because they are obviously wrong. To find the correct answer, you may need to do the following steps:

Step 1 – Read the Problem

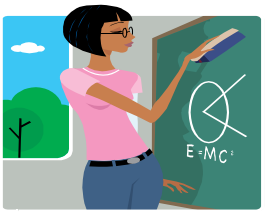


- Read to understand and to get a mental picture.
- Reread the problem.

Step 2 – Identify the Unknown

- Identify what it is that you are trying to find.
- Identify the units of the unknown (highlight or circle the unknown).
- The benefit of multiple choice tests is that the 4 possible answers given in the question will help you identify what the question is asking for!
- Questions often give you **extra information** that you will not need to solve the problem. Don't let this throw you off! Cross it out and don't worry about it.

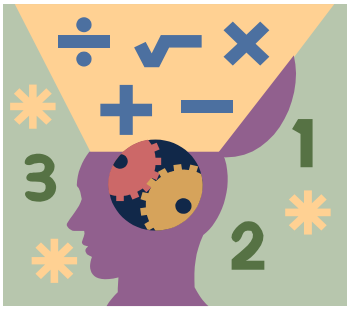
Step 3 – Make a Drawing



- Some of us are visual learners so if you think it will help you understand the problem, make a drawing.
- Place all the known values on the drawing.
- Identify the unknown on the drawing with a question mark.

Step 4 – Convert the Units

- The equations on the formula sheet will show you which units are needed in order to use the formula.
- If necessary, examine the units for the given information and convert units so that they can be used in the formula.
- Change fractions and percents to decimals so they can be entered into a calculator.



Step 5 – Find the Equation(s)

- If you cannot directly determine the equation required, search the formula sheet provided. Look at the units on the formula sheet and that may help you find the correct equation that will give you the units you need for your answer.
- Look at the 4 answers given and their units then try to find a formula with the same units!

Step 6 – Rearrange the Equation and Plug in the Known Values

- If necessary, rearrange the equation so the unknown is by itself on one side of the equation.
- Insert the known values from the question (or drawing) into the equation. Make sure the units are correct!

Step 7 – Use a Calculator to Solve for the Unknown

- Solve the equation.
- Check your answer.
- Ask yourself: “Does this answer make sense?”
- Find that answer in the 4 choices given and circle it!

Step 8 – Select the Closest Answer

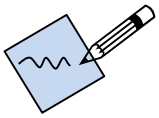
- Your answer may not match exactly to the list of possible answers. If several calculations are required, the rounding of numbers at different stages of the calculation can create different answers. Try not to round numbers until the final answer.

Important to Remember:

If you don't know the answer to a question, circle it or place a mark beside it so you can come back to it later. Often information in another question will help you solve the one you didn't know. It also helps to build your confidence when you focus on the questions you do know how to solve first, and then move on to ones that may be more difficult.

Pace yourself. Know how much time you have and how much time you can spend on each question. For example, if you have 60 minutes to do 60 questions you know you have 1 minute for each question. So if you spend 5 minutes on the first question, you know you will have to rush through others in order to finish on time.

Exercise 2:



Solve the following word problems.

1. What is the radius of a circular tank (in metres) with a flow of 1000 m^3/s and a diameter of 80 feet?

$$\frac{40 \text{ feet}}{1 \text{ foot}} = \frac{? \text{ m}}{0.305 \text{ m}}$$

2. What is the diameter of a circular water storage tank with a radius of 7.4 m and a height of 15 m?

3. What is the length of a trench with a width of 3 feet and a floor area of 18 square feet that was dug on the north side of a 200 foot tall office building?

4. What is the radius of the cone portion of a water storage tank that has a height of 11.23 m and a volume of 96.3 m^3?

5. What is the height of a cylindrical water tank with a volume of 22,796.4 cubic metres and a radius of 11 metres and it sits on a platform that is 4 feet off the ground?

6. What is the height (in metres) of a cylinder if the radius is 78.74 inches and the volume is 753.6 cubic metres?

7. Detention Time = 78.25 s

   Flow Rate = 8 m/s

   Volume = _____

Preparing for Technical Training:

Essential Skills for Water/Wastewater Operators

MODULE 6

Chemical Measurements

MODULE 6: CHEMICAL MEASUREMENTS

Objectives:

When you have completed this section, you will be able to:

- Explain what chemical dosage means
- Use two different formulas to solve for chemical dosage
- Rearrange the chemical dosage formula to solve for mass of chemical added
- Explain how the purity of the chemical affects the dosage
- Calculate the chemical required if it is not 100% pure
- Use the Chlorination formula to solve for chlorine dosage
- Rearrange the chlorination formula to solve for chlorine demand
- Solve chlorine demand problems

Contents:

MODULE 6

PRE-TEST

Answer all of the following pre-test questions below:

1. The required chlorine dosage is 250 mg/L. A tank 18 m in diameter is filled with water to a depth of 6 m. How much chlorine (in kg) is needed to treat the water in the tank?

2. How many kg of 84% available chlorine are necessary to provide 1.5 kg of chlorine?

3. How many kilograms of a chemical applied at the rate of 3 mg/L are required to disinfect 200,000 litres of wastewater?

4. Calcium hypochlorite (71.5% available chlorine) is used to treat 25 MLD. If 80 kg/day of calcium hypochlorite is used, what is the chlorine dosage in milligrams per litre?

5. The chlorine demand is 1.7 mg/L. If the desired chlorine residual is 0.3 mg/L, what is the desired chlorine dose, in mg/L?

In water treatment and distribution systems, chemicals are added to the water. These chemicals include chlorine, alum, lime and fluoride. The units of measurement for chemicals may be in weight such as grams or in volume such as gallons or litres. There are also different strengths and purities. When performing chemical calculations, both the weight and the percentage purity of the chemical are very important factors.

CHEMICAL DOSAGES

Dosage refers to the amount of chemical that is being added to the water. This is usually expressed as ppm (parts per million) or mg/L (milligrams per litre). Both ppm and mg/L are used interchangeably because they are equal units. The following equation is used to calculate chemical dosage:

Important Conversion

$$\text{Chemical Dosage (mg/L)} = \frac{\text{C (chem. added in kg)} \times 1000}{\text{Volume (m}^3\text{)}}$$

Example: What is the dosage at a wastewater treatment plant if 250 kg of chlorine was added to 1000 m³ of wastewater?

$$\text{CD (mg/L)} = \frac{\text{C (kg)} \times 1000}{\text{Volume (m}^3\text{)}}$$

Plug the numbers into the formula:

$$\text{CD} = \frac{250 \text{ kg} \times 1000}{1000 \text{ m}^3}$$

CD = 250 mg/L

For most of the questions, we will be solving for "C" which is the amount of chemical we need to add to the water. This equation is not given; therefore, we have to rearrange the Chemical Dosage formula:

$$\textbf{CD} = \frac{\textbf{C x 1000}}{\textbf{Volume}}$$

Get C by itself on one side of the equal sign:

Remember, when you are dividing by a number and then you multiply by that number, they cancel out.
Ex. 5 x 4 ÷ 4 = **5**

First get rid of the Volume by doing the opposite (x) on each side of the equal sign:

$$\text{CD x Volume} = \frac{\text{C x 1000 x } \cancel{\text{Volume}}}{\cancel{\text{Volume}}}$$

So you're left with: CD x Volume = C x 1000

Now get rid of the 1000 by doing the opposite (÷) on each side of the equal sign:

$$\frac{\text{CD x Volume}}{1000} = \frac{\text{C x } \cancel{1000}}{\cancel{1000}}$$

So you're left with: $\frac{\text{CD x Volume}}{1000} = \text{C}$

$$\textbf{C (mass of chemical in kg)} = \frac{\textbf{CD (dosage in mg/L) x Volume (m}^3\textbf{)}}{\textbf{1000}}$$

Example 1: How much chlorine is needed to treat a 1,000 m³ tank if the required chlorine dosage is 250 mg/L?

$$\text{C} = \frac{\text{CD x V}}{1000}$$

$$\text{C} = \frac{250 \text{ mg/L} \times 1000 \text{ m}^3}{1000}$$

C = 250 kg

Example 2: How many kg of chlorine (100% available) are required to disinfect a 10,000 L tank if it must be disinfected with 25 mg/L of chlorine?

$$C = \frac{CD \times V}{1000}$$

Convert 10,000 L to m^3 before using the formula:

$$\frac{10{,}000\ L}{1000\ L} = \frac{?\ m^3}{1\ m^3}$$

$$= 10\ m^3$$

Now plug the numbers into the formula:

$$C = \frac{25\ mg/L \times 10\ m^3}{1000}$$

C = **0.25 kg**

There are **two formulas** for chemical requirements on your formula sheet. The second formula uses the mass of chemical added in kilograms per day and the flow rate of the water. The formula is stated as follows:

Important Conversion

$$\textbf{Chemical Dosage (mg/L)} = \frac{\textbf{C (chem. added in kg/day) x 1000}}{\textbf{Flow Rate } (\textbf{m}^3\textbf{/day})}$$

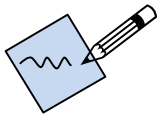
Example: Determine the dosage (mg/L) if the chlorinator feed rate is 100 kg/day and the water flow rate is 1000 m^3/day.

$$CD = \frac{C \times 1000}{\text{Flow Rate}}$$

$$CD = \frac{100\ kg/day \times 1000}{1000\ m^3/day}$$

CD = **100 mg/L**

MODULE 6



Exercise 1:

Solve all of the following chemical dosage problems.

1. A 3 foot diameter pipe that is 200 m long was disinfected with chlorine gas. If 50 kg of chlorine were used, what was the chlorine dosage in mg/L?

2. How many grams of chlorine need to be added to 50 L of water to give 10 mg/L of added chlorine?

3. The required chlorine dosage is 250 mg/L. A tank 18 m in diameter is filled with water to a depth of 6 m. How much chlorine (in kg) is needed to disenfect the water in the tank?

4. Determine the dosage if the chlorinator feed rate is 80 kg/day and the water flow rate is 1,400,000 litres/day.

5. Determine the dosage (mg/L) if the chlorinator feed rate is 50 kg/day and the water flow rate is 1500 m^3/day.

6. A water plant has a flow of 1900 m^3/day. Chlorine gas at a rate of 163.27 kg/day is added for disinfection. What is the chlorine dosage in milligrams per litre?

PURITY OF CHEMICAL REQUIRED

All of the above problems assume that the chemical used is 100% pure. If the chemical required is not 100% pure, we must divide the amount of chemical added (C) by its purity (expressed as a decimal). The equation is:

Important Conversion

$$\text{Chemical Required (kg)} = \frac{\text{Pure Chemical (kg)}}{\text{\% Purity (as a decimal)}}$$

Example 1: How many kg of 67% available chlorine would be necessary to provide 3 kg of chlorine?

$$\text{Chemical Required (kg)} = \frac{\text{Pure Chemical (kg)}}{\text{\% Purity}}$$

$$\text{Chemical Required} = \frac{3 \text{ kg}}{0.67}$$

Chemical Required = **4.48 kg**

Example 2: The chlorine dosage is 100 mg/L. A water tank is 1000 m³ in volume. How much 60% available chlorine is necessary to treat the full tank of water?

$$C = \frac{CD \times V}{1000}$$

$$C = \frac{100 \text{ mg/L} \times 1000 \text{ m}^3}{1000}$$

C = 100 kg

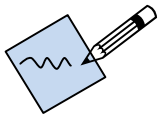
But, the chlorine is only 60% strength:

$$\text{Chemical Required} = \frac{\text{Pure Chemical}}{\text{\% Purity}}$$

$$\text{Chemical Required} = \frac{100 \text{ kg}}{0.60}$$

Chemical Required = **166.7 kg**

MODULE 6



Exercise 2:

Answer all of the following chemical dosage questions where the purity of the chemical is not 100%.

1. How many kg of 84% available chlorine are necessary to provide 1.5 kg of chlorine?

2. How many kilograms of 70% available chlorine are necessary to provide 40 kg of chlorine?

3. A water main that is 14 m^3 in volume must be disinfected with calcium hypochlorite (60 % chlorine concentration). The required dosage is 50 mg/L. What is the applied calcium hypochlorite dosage in kilograms?

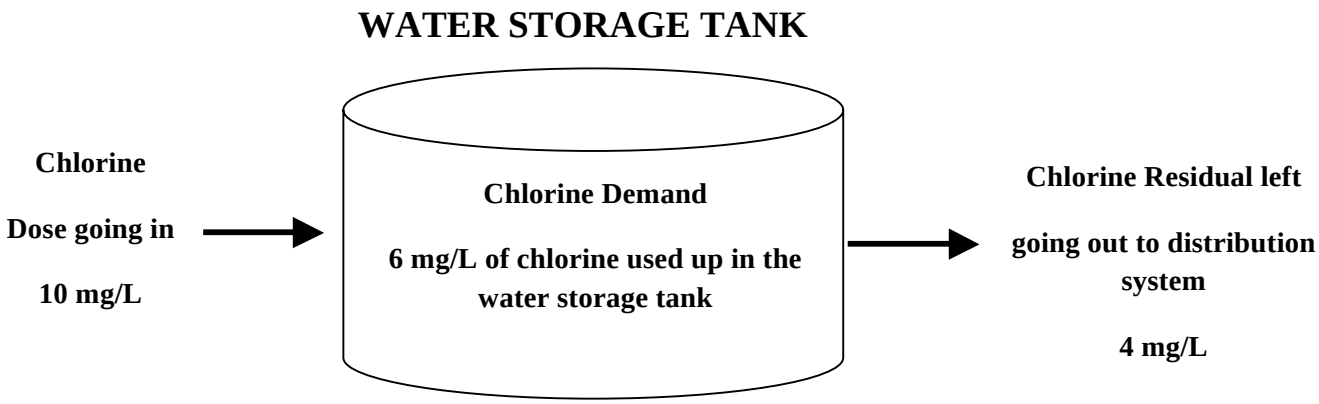
4. The chlorine dosage is 100 mg/L. How much 60% available chlorine is necessary to treat the water in a cylindrical water tank with diameter equal to 5 m and 6 m deep?

5. How many grams of 61% calcium hypochlorite are needed to disinfect a water storage tank at a dosage of 50 mg/L. The tank is 110 m in diameter and has a maximum water level of 20 m?

CHLORINE DEMAND

Chlorine demand is the difference between the amount of chlorine that is added to the water (called Chlorine Dosage) and the amount of Chlorine remaining (called the Chlorine Residual). It is typically measured in mg/L.

It can be explained using the following diagram:



The formula on the formula sheet solves for Chlorine Dosage and is stated as:

Important Conversion

Total Chlorine Dosage =

Chlorine Demand + Chlorine Residual

Often, you will need to solve not only Chlorine Dosage problems but Chlorine Demand problems. In order to do this we must rearrange this equation to solve for Chlorine Demand:

Chlorine Dosage = Chlorine Demand + Chlorine Residual

Get chlorine demand by itself on one side of the equal sign:

To do this, get rid of "Chlorine Residual" by doing the opposite (-) on both sides of the equal sign:

Dosage – Chlorine Residual = Chlorine Demand + ~~**Chlorine Residual**~~ – ~~**Chlorine Residual**~~

The Chlorine Residual's both cross out, so you're left with:

Chlorine Dosage – Chlorine Residual = Chlorine Demand

Chlorine Demand = Chlorine Dosage - Chlorine Residual

Example: A chlorine dose of 2.5 mg/L is added to the water supply prior to entering the distribution system.

The chlorine residual at a point in the distribution system is measured at 0.4 mg/L. What is the chlorine demand in the distribution system?

Chlorine Demand = 2.5 mg/L - 0.4 mg/L

Chlorine Demand = **2.1 mg/L**

MODULE 6

Exercise 3:

Solve all of the following chlorine demand problems.

1. The chlorine demand is 1.7 mg/L. If the desired chlorine residual is 0.3 mg/L, what is the desired chlorine dose, in mg/L?

2. What is the chlorine demand if the chlorine residual is 3.2 mg/L and 6.7 mg/L of chlorine has been added?

3. a) How many mg/L of Chlorine must be added to a tank to achieve a chlorine residual of 2 mg/L when the Chlorine Demand is 0.3 mg/L

   b) How many kilograms of Chlorine must be added if the tank is 400,000 L?

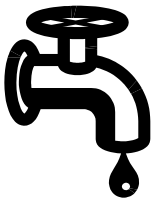
Preparing for Technical Training:

Essential Skills for Water/Wastewater Operators

MODULE 7

Hydraulics

MODULE 7: HYDRAULICS



Objectives:

When you have completed this section, you will be able to:

- Define pressure, force and head and perform calculations for all three using formulas
- Define velocity and flow rate and perform flow rate calculations using the formula
- Define detention time and perform calculations using the formula
- Define horsepower and perform calculations using formulas
- Define efficiency and perform calculations using the formula

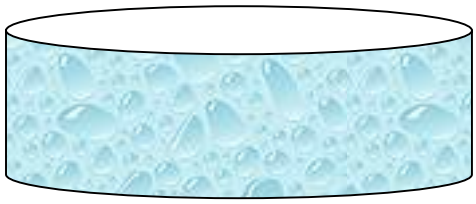
Contents:

MODULE 7

PRE-TEST

Complete all the pre-test questions below:

1. a. The tank below is filled completely with water. What is the pressure at the bottom of the tank?



   b. Some of the water is drained from the tank and it now only has water in it to a height of 9 metres. What is the new pressure at the bottom of the tank in psi?

2. If a pump discharges 10,350 L in 3 hours and 45 minutes, how many litres per minute is the pump discharging?

3. What is the detention time in an aerobic digester with a volume of 500 m^3 and a flow of 25 m^3/s?

4. What is the horsepower, in kilowatts of a pump that has a 220 volt motor running it using 90 amps?

HYDRAULICS

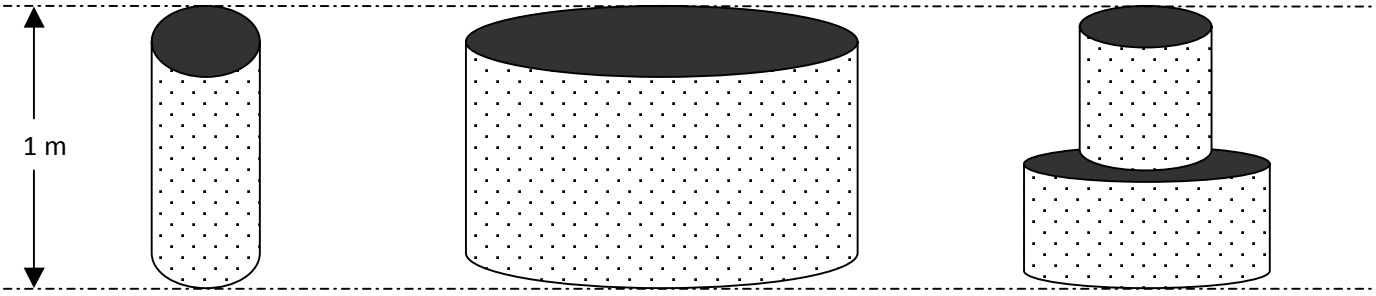
Hydraulics is the science that deals with the behaviour and movement of fluids. Water treatment plant operators must know and understand the concepts within hydraulics in order to perform their jobs correctly.

Force	The push exerted by water on any surface containing it; Measured in Newtons (N)
Uplift Force	The force of water pressure pushing upward
Pressure	The amount of force acting on a unit area; Measured in Kilo Pascals (kPa)
Head (H)	The vertical distance measured from the water surface to a point below the water surface; measured in metres (m)

1 metre of hydraulic head = 9.81 kPa

(this conversion is found under "Pressure and Head Equivalents"
on the Imperial-Metric Conversion Factors page of the formula sheets)

Pressures are usually expressed in terms of height of water, or head. It is the height of water that determines the pressure over the area and not the shape or diameter of the container. Example:



All three containers are 1 m tall but their diameters are all different. Pressure is not influenced by the diameter of the tank therefore the pressure is the same at the bottom of all three tanks. The pressure in each tank is 9.81 kPa (because 1 m head = 9.81 kPa).

The pressure at the bottom of a tank is usually measured with a pressure gauge and is called gauge pressure. We can use the formula:

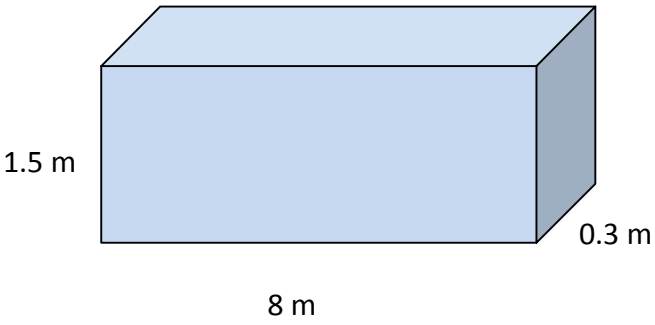
Gauge Pressure (kPa) = Head (m) x 9.81

MODULE 7

Exercise 1:

Calculate the gauge pressure for the following tanks.

1. The sedimentation tank below is full of water. Find the pressure at the bottom of the tank.



2. The pressure of a fire hydrant reads 300 kPa on the gauge. What is the pressure head in meters at the fire hydrant?

3. a) There is a 40 metre high water tank filled with water. Calculate the pressure in kilopascals at a point 15 metres below the water surface.

   b) Convert the answer above from kPa to psi.

4. A standpipe has a water level of 400 feet. What is the pressure in psi at the bottom?

5. A water storage tank is 45 feet tall and 155 feet in diameter. It currently has a depth of 32 feet of water. What is the pressure at the bottom of the tank is kPa?

MOVEMENT OF WATER

Velocity and flow rate are used to measure the movement of water in pipes and channels.

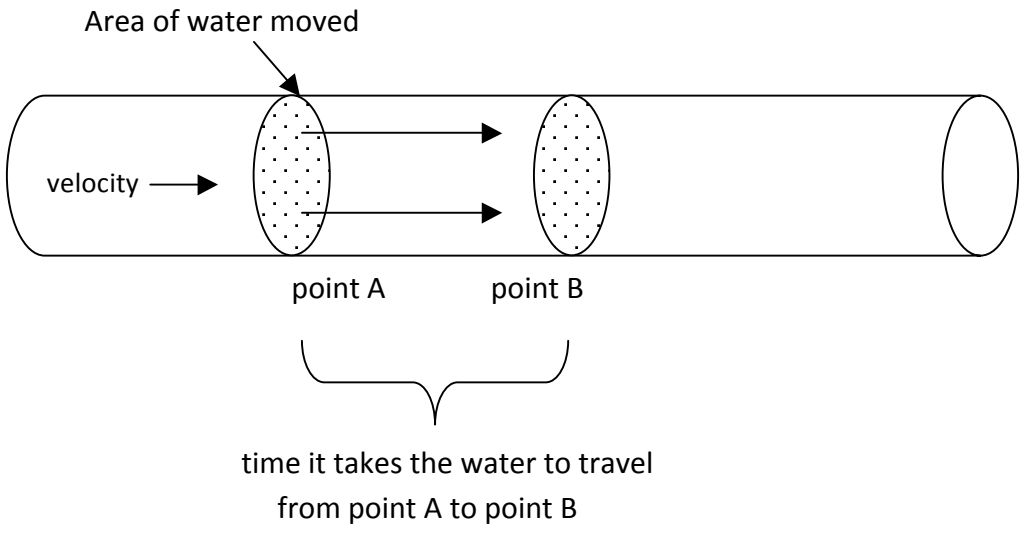
Velocity (v)	The speed of a moving object or material that travels a specific distance within a specific time; Measured in metres per second (m/s).
Flow Rate (Q)	The volume of a fluid which passes a specific point within a set time period; Measured in cubic metres per second (m^3/s). The flow rate depends on the cross-sectional area of the pipe and the velocity of the water moving through it.

Water travels through a pipe at a certain velocity from point A to point B. While travelling this distance, it takes a certain amount of time. During that time a specific volume of water moves through from point A to point B. The formula we use to calculate flow rate is:

Important Conversion

Flow Rate (m^3/s) =

Area (m^2) x Velocity (m/s)



Example: What is the water flow rate in a 0.6 m diameter pipe when the flow velocity is 11 metres per second?

Use the diameter to calculate the area of the pipe:

Area of a circle = $\frac{3.14\ (0.6m)^2}{4}$

Area = $0.2826\ m^2$

Now plug the numbers into the flow rate formula:

Flow Rate = $0.2826\ m^2$ x 11 m/s

Flow Rate = **$3.1085\ m^3/s$**

DETENTION TIME

The amount of time that a volume of water will remain in a space (such as a pipe, clearwell, water storage tank); Measured in seconds.

We calculate detention time with the following formula:

Important Conversion

$$\text{Detention Time(s)} = \frac{\text{Volume } (m^3)}{\text{Flow Rate } (m^3/s)} = \frac{V}{Q}$$

Careful, velocity and volume can both be abbreviated with a "v"

Example: What is the detention time of a 45.4 m^3 tank having a flow of 0.0378333 m^3/s?

Detention Time (s) = $\frac{45.4\ m^3}{0.0378333\ m^3/s}$

= 1200 s

MODULE 7

Exercise 2:

Perform the following calculations.

1. Calculate the water velocity in a pipe in m/s if the cross-sectional area is 0.186 m^2 and the accompanying flow rate is 3785 l/min

2. a. Water is flowing through a 100 mm diameter pipe at 2 m/s. What is the flow rate?

   b. What is the flow rate in m^3/d?

3. A grit channel has a velocity of 2 metres per second, a channel flow depth of 0.25 metres and the channel is 1 m wide. What is the flow rate in cubic metres per second?

   Note: area of a channel is width x depth (look on the formula sheet)

4. A channel is 12 m x 12 m. If a pump feeds into the reservoir for 3 hours at 20 l/s, how much will the water level rise (assuming that none is being withdrawn)?

Change 3 hrs to seconds (or you could change 20 L/s to L/hr.)

Set up a ratio:

$$\frac{20\ \text{L}}{?\ \text{L}} = \frac{1\ \text{sec}}{10{,}800\ \text{sec}}$$

If 20 L flows into the reservoir in 1 sec
then how much would flow in 10,800 sec?

= _____

We know the volume in the tank; we know the tank's length and width, so we can find the height of water in the tank, using the volume formula:

Volume = L x W x H

First change the volume of 216,000 L into m^3

Plug numbers into the volume formula and rearrange it to solve for Height:

5. If the discharge rate of a pump is 500 litres per minute, how long will it take to fill a water tank with a 100,000 litre capacity?

6. If the discharge rate of a pump is 400 litres per minute, how long will it take to fill a rectangular water tank with dimensions 2 m wide x 4 m long x 6 m deep?

7. A wastewater treatment pond with a surface area of 5500 square metres (m^2) and a depth of 3.7 m receives 23 million litres per day. Calculate the detention time in hours.

$$\textbf{Detention Time (s)} = \frac{\textbf{Volume } (m^3)}{\textbf{Flow Rate } (m^3/s)}$$

Calculate the volume: Volume = area x depth

= _____

Convert flow rate from L/day to m^3/s

$$\frac{23{,}000{,}000 \text{ L}}{1 \text{ day}} \quad x$$

Put volume and flow rate into the Detention Time formula:

Detention Time (s) =

Convert to hours:

8. What is the detention time of a 227 m^3 aerobic digester having a sludge flow of 0.227 m^3/minute?

9. The maximum flow rate of a chemical feed pump is 234 mL/min. If this pump ran continuously at this maximum rate, how many gallons would be pumped in one day?

10. A sedimentation tank has a capacity of 60,000 litres. In one hour, 20,800 litres of water flow to the clarifier. What is the detention time?

    a) 2.1 hours
    b) 2.88 hours
    c) 5.06 hours
    d) 0.88 hours

POWER AND HORSEPOWER

Power is defined as the rate at which work is done. It is measured in watts or kilowatts (1 kW = 1000 watts). The formula we use to calculate power is:

Important Conversion

Power (kW) =
Current (amps) x Voltage (volts)

P = I x E

P = Power
I = Current (amps)
E = Voltage (volts)

Motors are rated in terms of kilowatts or **horsepower**. 0.7457 kW is equal to 1 Hp. Power must be supplied to the motor by the electrical system. But no motor is 100% efficient. Motors lose energy due to heat loss, friction, etc.

Work (W)	The energy needed to lift a weight a specific vertical distance; Measured in joules (J)
Pump Power (P)	The rate of doing work over time; Measured in kilowatts. Pumps must be able to work at the rate needed to deliver water.
Horsepower (Hp)	The motor power needed to pump water.
Water Power (measured in kW) or Water Horsepower (measured in Hp)	The power needed to do work. This assumes 100% motor and pump efficiency.
Brake Power	The power needed to do work and it takes into account the efficiency of the pump (Ep). If the pump is inefficient, it would require more power to do the same amount of work; Measured in kilowatts (kW).
Motor Power	The power needed to do work and it takes into account the efficiency of the motor (Em); Measured in kilowatts.
Weight of Water	1 L of water weighs 1 kg

Be aware of the proper units needed for all power calculations. You may have to convert your units given in the question to the proper units before putting the numbers into the equation.

Note: The **Brake Power** Equation provides two different equations for solving problems. They are both the same, just shown in a different way. Which you use depends on the information given in the question.

$$\text{Brake Power} = \frac{Q \times H}{6125\ Ep}$$

Change efficiency which will be given as a percent into a decimal (move decimal 2 spaces to the left)

Multiply 6125 and Ep (even though there is no multiplication sign)

Example: What brake power is needed to pump a flow of 4540 L/min against a head of 21.34 m, if the pump has an efficiency of 85%?

$$\text{Brake Power} = \frac{Q \times H}{6125 \times Ep}$$

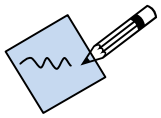
$$= \frac{4540\ \text{L/min} \times 21.34\ \text{m}}{6125 \times 0.85}$$

$$= \frac{96883.6\ \text{L/min}\ \text{m}}{5206.25}$$

= 18.61 kW

Brake power is expressed in kW.

Exercise 3:



Complete the following power calculations.

1. What is the horsepower, in kilowatts of a pump that has a 200 volt motor running it using 90 amps?

2. What is the brake power if the flow is 1090 lpm with a head of 200 metres and a pump efficiency of 90%?

3. A pump with an efficiency of 92% pumps a flow of 1400 lpm from the treatment plant to the clearwell. The total head of the pumping system is 655 feet. What is the Brake Power (in kW) and Horsepower (in Hp)?

4. a) What brake power would be needed to pump a flow of 900 gallons/minute against a head of 70 feet, if the pump has an efficiency of 85%?

   b) What is the above answer stated in Horsepower?

5. What is the motor horsepower for a pump with the following parameters?

Motor efficiency	87%
Total head	107 ft
Pump efficiency	79%
Flow Rate	6741.82 L/minute

6. A motor has an efficiency of 85% and a horsepower of 10. What is the brake horsepower?

7. The amount of power needed to pump water to a certain point is:

   a) Brake Horsepower
   b) Motor Horsepower
   c) Wire Horsepower
   d) Water power

8. Wire to water efficiency is defined as:

   a) The overall efficiency of the pump and motor
   b) The overall efficiency of the pump horsepower
   c) The efficiency of the pump
   d) The efficiency of the motor

9. What would the waterpower of a pump be if it had a flow of 5648 Lpm against a head pressure of 75 meters?

   a) 17 KW
   b) 69 KW
   c) 65 KW
   d) 170 KW

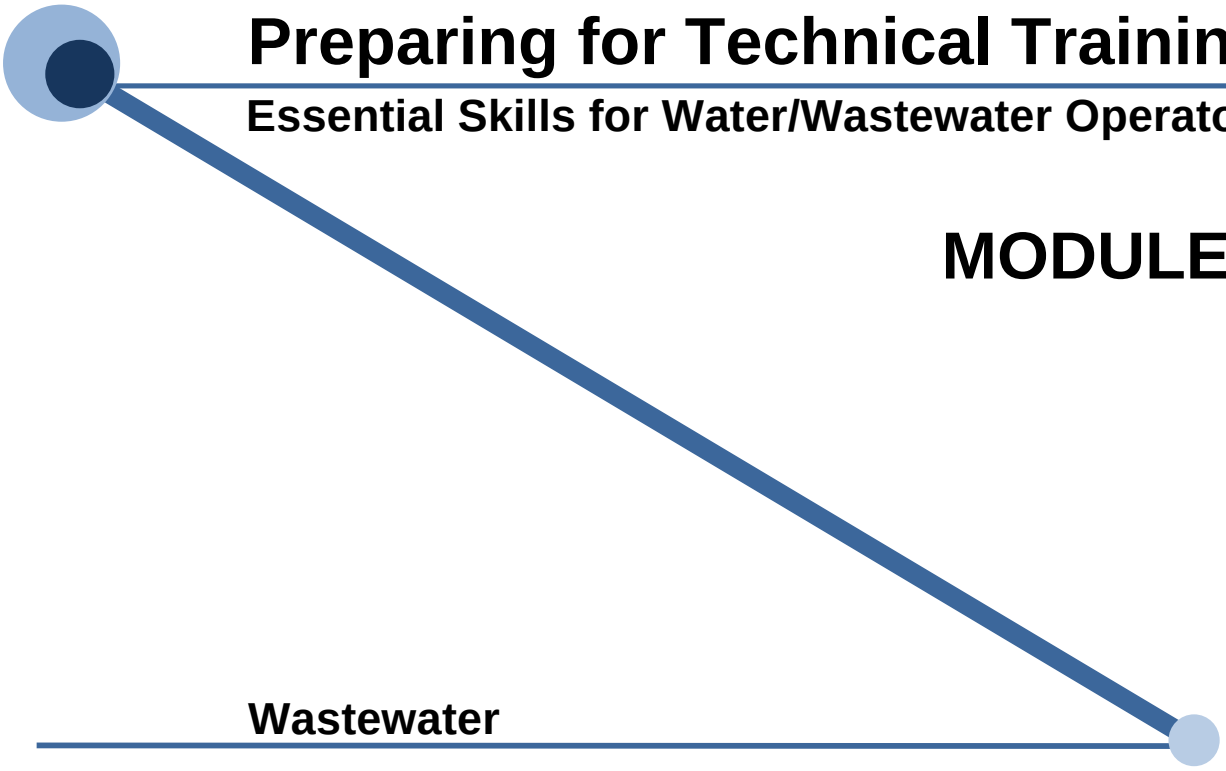
10. Determine the head pressure of a pump that has a flow rate of 2616 Lpm, is 83% efficient, and has a brake horsepower of 46 KW.

    a) 35440 m
    b) 746 m
    c) 89 m
    d) 73 m

Preparing for Technical Training:

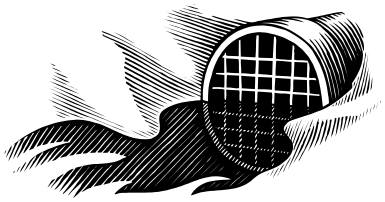
Essential Skills for Water/Wastewater Operators

MODULE 8



Wastewater

MODULE 8: WASTEWATER



Objectives:

When you have completed this section, you will be able to:

- Define weir overflow rate and calculate it using the formula
- Calculate the treatment efficiency
- Define filter loading rate and calculate it using the formula
- Define solids loading rate and calculate it using the formula
- Define BOD and SS
- Define influent and effluent

Contents:

MODULE 8

PRE-TEST

Complete all the pre-test questions below:

1. Calculate the weir overflow of a circular tank (weir is all along the circumference of the tank) with a diameter of 9 m and a flow of 5000 cubic metres per day.

2. Determine the removal efficiency for total solids where the influent is 800 mg/L and the effluent is 620 mg/L.

3. Determine the filter loading rate of a filter with an area of 75 square metres and a flow passing through it of 22,000 cubic metres each day.

WASTEWATER TREATMENT

Wastewater treatment is the process of removing contaminants from wastewater and household sewage. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce a waste stream (or treated effluent) and a solid waste or sludge suitable for discharge or reuse back into the environment. (Adapted from *Wikipedia* "Sewage treatment")

WEIR OVERFLOW RATE

this calculation is used to detect high velocities near the weir, which affect the efficiency of the sedimentation process. If the velocities are too high, the settling solids get pulled over the weirs and into the effluent trough. The formula for Weir overflow rate is:

Important Conversion

$$\text{Weir Overflow Rate } (m^3/d \times m) = \frac{\text{Flow } (m^3/d)}{\text{Weir Length } (m)}$$

Example: The water in a sedimentation tank flows over a 25 m weir at a rate of 1700 m³/day. What is the weir overflow rate?

$$\text{Weir Overflow Rate} = \frac{1700\ m^3/d}{25\ m}$$

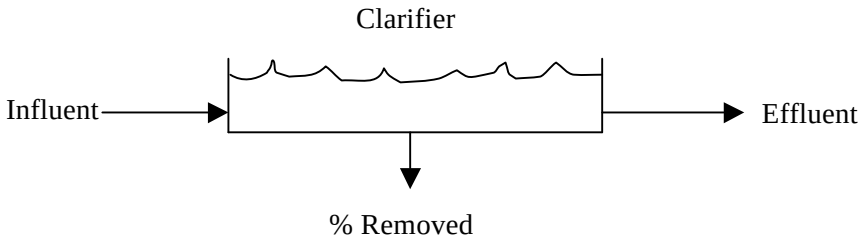
Weir Overflow Rate = **68 m³/d x m**

SOLIDS REMOVAL EFFICIENCY

The Biochemical Oxygen Demand (BOD) and Suspended Solids (SS) removal efficiency gives the operator an indicator of the clarifier's effectiveness. The removal may be affected by several factors such as flow, type of waste or temperature of water. To perform these calculations we must know the concentration of the influent (flowing in) and the concentration of the effluent (flowing out).

$$\text{Treatment Efficiency} = \frac{\text{In} - \text{Out}}{\text{In}} \times 100\%$$

Example: The suspended solids in the influent are 223 mg/L and from the clarifier effluent are 107 mg/L. What is the percent removal efficiency of the suspended solids from the clarifier?



$$\text{Treatment Efficiency} = \frac{223 \text{ mg/L} - 107 \text{ mg/L}}{223 \text{ mg/L}} \times 100\%$$

$$= \frac{116 \text{ mg/L}}{223 \text{ mg/L}} \times 100\%$$

$$= \mathbf{52\%}$$

MODULE 8

Exercise 1:

Solve the following problems involving Weir Overflow and Treatment Efficiency.

1. The influent of a clarifier contains 250 mg/L of BOD and the plant's final effluent contains 10 mg/L of BOD. What is the treatment plant's BOD percent removal efficiency?

2. What is the overflow rate of a weir with a flow of 190 m^3/d and a length of 400 feet?

3. What is the percent removal efficiency of the suspended solids with an influent of 237 mg/L and an effluent of 108 mg/L?

4. A clarifier has a continuous weir around the perimeter and a diameter of 18.3 m. What is the weir over flow rate if the flow is 1,000,000 m^3/day?

FILTER LOADING

The filter load rate measures the amount of water flowing down through each square metre of filter area. The equation we use to calculate this is:

Important Conversion

$$\text{Filter Loading Rate } (L/m^2/ \text{ x s}) = \frac{Q\ (m^3/d) \text{ x } 0.0116}{A\ (m^2)}$$

Example: A sand filter with an area of 100 m² receives a flow of 30,000 m³/d. What is the filter loading rate?

$$\text{Filter Loading Rate} = \frac{30{,}000\ m^3/d \text{ x } 0.0116}{100\ m^2}$$

Filter Loading Rate **= 3.48 L/m² x s**

SOLIDS LOADING

This refers to the daily mass of suspended solids entering the clarifier or sedimentation basin. The equation we use to calculate this is:

Important Conversion

$$\text{Solids Loading (kg/d)} = \frac{Q\ (m^3/d) \times C\ (mg/L)}{1000}$$

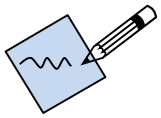
Example: A clarifier experiences a flow of 4200 cubic metres per day and a suspended solids concentration of 2900 mg/L. The clarifier is circular with a diameter of 10 metres and is 2.5 metres deep. Find the solids loading in kilograms per day.

$$\text{Solids Loading} = \frac{4200\ m^3/d \times 2900\ mg/L}{1000}$$

Solids Loading = **12,180 kg/d**

MODULE 8

Exercise 2:



Perform the following loading calculations.

1. A sand filter is 12 m wide and 15 m long. If the flow through the filter is 47,000 m^3/day, what is the filter loading rate?

2. A filter has surface dimensions of 40 ft by 30 ft. If the flow to the filter is 7000 m^3/day, what is the filtration rate in L/m^2 x s?

3. a. There is a flow of 6200 cubic metres per day for a secondary clarifier with a concentration of SS of 2500 mg/L. Determine the solids loading rate in kg/day.

b. Find the above rate in kg/hour.

4. A 50 ft secondary clarifier receives a flow of 4,211 m^3/day. It was reported that the suspended solids concentration in the aeration tank is 2,700 mg/L. What is the solids loading rate in kg per day?

Preparing for Technical Training:

Essential Skills for Water/Wastewater Operators

MODULE 9

Electricity

MODULE 9: ELECTRICITY

Objectives:

When you have completed this section, you will be able to:

- Compare hydraulics to electricity
- Use Ohm's law and rearrange the equation to solve for voltage, current and resistance
- Use the power formula to solve for power, current and voltage
- Define key electrical terms.

Contents:

MODULE 9

PRE-TEST

Complete all of the following pre-test questions:

1. What is the term for the flow of electrons through a conductor?

2. What is the term for a material that does not conduct electricity?

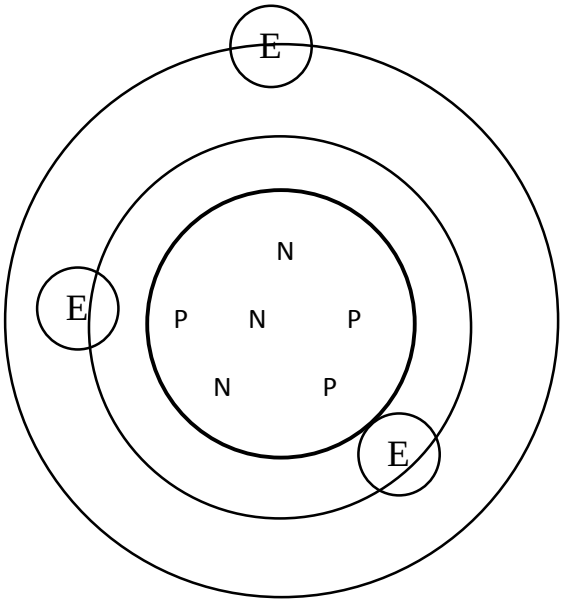
3. What is the electrical pressure that is produced by a battery called?

4. Rearrange Ohm's law (E = IR) to solve for resistance.

5. Power = 2000 kW
   Voltage = 220
   Amperage = ?

ELECTRICITY

All matter is made of microscopic particles called **atoms.** Electricity can be explained by understanding the structure and behaviour of atoms. An atom is like a tiny solar system, with a **nucleus** at the center. The nucleus contains the **neutrons (neutral)** and **protons (positive charge)**. Swirling around the nucleus are smaller, lighter particles called **electrons (negative charge)**.



There is only one electron swirling in the outer orbit of this atom. It is loosely attracted to the nucleus and is easily taken away from the atom. A battery can force an electron to leave the atom, allowing an electron from an adjacent atom to rush in and take its place. Such a flow of electrons along a conductor is an electric current. The flow of electrons (current) continues along a conductor from a current-making device to a current-consuming device.

MODULE 9

COMPARING ELECTRICITY TO HYDRAULICS

Operators at water treatment plants must understand the basic principles of electricity and electric concepts because of the variety of electrical equipment in most plants. Electricity can be difficult for most people to understand. You can't properly see it, you can't properly feel it and you can't taste it or smell it, so what is it? It travels quite well through metals and generally poorly through non-metals. It doesn't behave quite like anything else.

Fluid flowing through a system of pipes can behave in many respects like electricity flowing in a circuit. If you pierce a pipe full of water, the water comes out. With an electrical wire, try piercing the insulation and touching the conductor: you will soon find the electricity coming out! The main difference is that water will fill any space whereas electricity will 'fill' only a conductor.

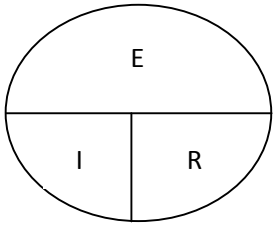
Voltage (E) 	The electrical pressure that causes current to flow through wires. Could be produced by a battery, for example; Measured in volts. Voltage between two points is similar to the **pressure required to move water,** usually created by a pump.
Current (I) 	The flow of electrons through a conductor; Measured in amperes (amps). Amperage – another word for Current, which is measured in amps. Current is similar to the flow of water in a pipe, called **flow rate (Q)**; Measured in Litres per minute (lpm)
Resistance (R) 	Slows or opposes the flow of electricity; Measured in ohms. All pipes have some resistance to flow just like all wires have some resistance to current; comparable to static or friction head losses in a pump system.
Conductor 	A substance that readily conducts electricity, such as a metal wire. A wire is like a piece of **pipe** that allows water to flow through.
Non-conductor	Does not conduct electricity, also called insulators. Examples include rubber, plastic, glass.
Work (W)	The energy needed to lift a weight a specific vertical distance; Measured in joules (J)
Power (P)	The rate of work (of using or supplying energy); Measured in watts. Wattage – another word for Power.

Important Conversion

Power (watts) = Current)"I" in amps) x Voltage ("E" in volts)

P = I x E

Ohm's Law:



E = IR E = Voltage (volts), I = Current (amps), R = Resistance (ohms)

Use the Ohm's Law Circle to help rearrange the formula: E = I x R

Or $I = \frac{E}{R}$ Or $R = \frac{E}{I}$

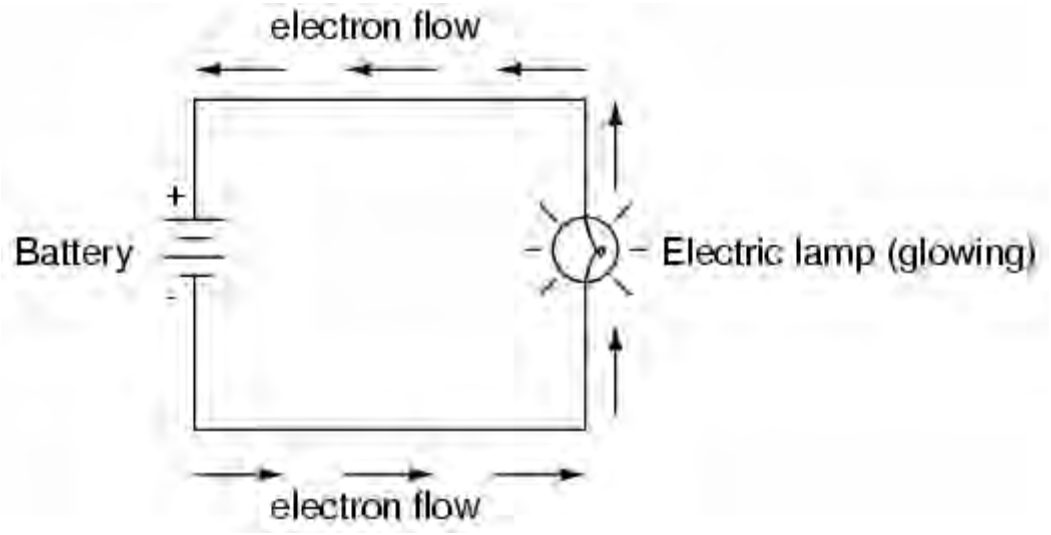
MODULE 9

Exercise 1:

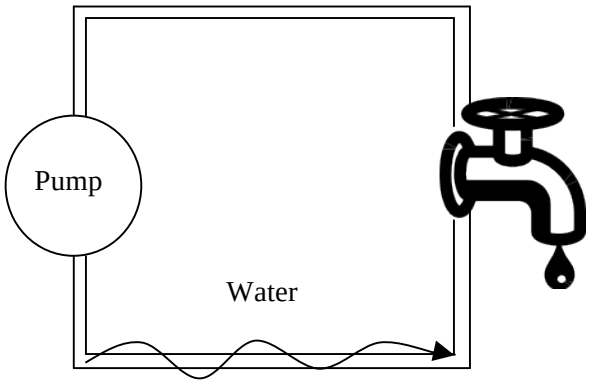
Complete the chart comparing Electrical terms to Water terms:

Electricity	Water Hydraulics
Voltage	
Current	
Resistance	
Wire	
	Q
	Water pump

Example:
In the electrical diagram below, **current** flows through the electrical wire. There is one source of **voltage**, the battery, and one source of **resistance** to current, the lamp, which uses up energy (some energy is useful to make light, and some is wasted as heat from the bulb).



This makes it very easy to apply Ohm's Law. If we know the values of any two of the three quantities (voltage, current, and resistance) in this circuit, we can use Ohm's Law to determine the third.



In the diagram above, the **current** is the water that flows through pipes. Instead of a battery, our source of **voltage** is a pump, which drives the water. Energy is used up at the lamp the same way as water is used up at the tap (or toilet, or shower, or dishwasher, etc).

MODULE 9

Exercise 2:

Perform the following calculations.

1. P = 22000 watts
   I = 100 amps
   E = ?

2. P = 26400 watts
   E = 240 volts
   I = ?

3. Power = 162 kW
   Voltage = 180
   Amperage = ?

4. Wattage is another name for _____.

5. _____ is measured in amperes.

6. What would the motor horsepower of a pump be if it had a 220 volt motor running it using 110 amps?

   a) 24200 kW
   b) 2.4 kW
   c) 24 kW
   d) 32300 kW

7. What is the term used for the electrical pressure that causes current to flow through wires?

   a) Amperage
   b) Wattage
   c) Voltage
   d) Ohms

8. What is the term used for how hard the electricity is working?

   a) Amperage
   b) Wattage
   c) Voltage
   d) Ohms

9. What is the correct formula for determining watts?

   a) Watts = volts/amps
   b) Watts = (horsepower) (ohms)
   c) Watts = resistance/volts
   d) Watts = (amps) (volts)