Module 25:
Introduction to Flowmeters
Answer Key

Calculation

1. If you have a channel that is 1 foot wide, the flow is 6 inches deep, and the velocity is 2.5 feet per second (fps), what is the volume in cubic feet per second and gallons per minute?

Ans: (1 foot x 2.5 feet x 0.5 foot) = 1.25 cfs

(1.25 cfs x 7.48 gals/cu ft x 60 second/minute) = 561 gpm

2. If you have an 8 inch diameter pipe and the velocity is 2.5 fps, what is the volume? (Hint: $A = \pi r^2$)

Ans: The area of a circle is expressed as $A = \pi r^2$, where π is the Greek letter pi (pronounced pie) and r is the radius. Pi is a constant that is used in many computations involving circles and is commonly approximated by the number 3.14

Remember to keep units the same, therefore, convert 8 inches to feet.
8 inches/12 inches = 0.667 ft

The radius is equal to half the diameter.
0.667 ft/2 = 0.333 ft

Determine the area.
$A = (3.14)\ (0.333\ \text{ft})^2 = 0.348$ sq ft

Now determine the volume.
Q = AV = 0.348 sq ft x 2.5 fps = 0.87 cubic feet per second

If we want to convert this to gallons, we multiply by 7.48 gallons per cubic feet.
Q = 0.87 cfs x 7.48 gallons = 6.5 gallons per second

3. Given a flow of 0.87 cfs conveyed in a 12 inch diameter sewer line, what would be the velocity?

Ans: Remember to keep units the same, therefore, convert 12 inches to feet.
12 inches/12 inches = 1 ft

The radius is equal to half the diameter.
1 ft/2 = 0.5 ft

Determine the area.
$A = (3.14)\ (0.5\ \text{ft})^2 = 0.78$ sq ft

Now determine the velocity.
V = Q/A = 0.87 cfs/ 0.78 sq ft = 1.11 fps

Exercise/Activity

We have an effluent flow that ranges from 10 gpm to 1,500 gpm from a well-operated WWTP. We do not anticipate an unacceptable amount of solids. What are possible V-notch weir options? Use Appendix D - ISCO Table 5-3A.

Ans: Either a 30 or 45 degree V-notch weir as shown in ISCO Table 5-3A.

Exercise/Activity

If we have a 2 ft rectangular weir without end contractions and the depth is 0.33 feet, what is the flow? Use Appendix D - ISCO Table 11-3.

Ans From ISCO Table 11-3, the flow is 567 gallons per minute.

Calculation

If we have a pipe of 4 inch diameter, using the separation distance guidelines, what is the absolute minimum distance of straight pipe that is needed (excluding the width of the meter)?

Ans 10 D = (10) (4 inches) = 40 inches upstream

5 D = (5) (4 inches) = 20 inches downstream

40 + 20 = 60 inches. We will need at least a 60 inch section or 5 feet of straight unobstructed pipe, excluding the width of the meter.

Calculation

Look at Appendix D and use Table 9-5 (90 degree V-notch weir). Compare how ½ inch makes a difference in flow reading. Compare 6 inch (0.50 feet) with 6.5 inch (0.54 feet).

Ans: The flow at 0.50 feet is shown as 198 gpm, but at a depth of 0.54 feet the depth is 240 gpm. For a day, the difference between 240 gpm and 198 gpm would result in a difference of 42 gpm or 60,480 gallons.

☑ Exercise/Activity

1. We want to meter the effluent flow from a small wastewater treatment system that serves the community of King Village of approximately 200 homes. It is assumed that each home uses approximately 250 gpd, for a total daily flow of approximately 50,000 gpd. The discharge is temporary stored within the system and discharged with a pump during a 12 hour period instead of continuously over a 24 hour period. Use Appendix D and look at tables 9-1 through 9-5 to select a V-notch weir which would be appropriate and state why. Do not allow more than a maximum of 1 foot of head over weir.

Ans: If the 50,000 gallons is going to discharge during 12 hours, the flow rate would be (50,000 gallons) divided by 12 hours divided by 60 min/hour; or about 69 gpm, if the rate would be constant.

Table	V-Notch size	Min flow @ head, ft	Depth of head at 69 gpm	Flow at 1 ft depth
9-1	22 ½ degree	3.99 gpm at 0.20 ft	0.63 ft	223 gpm
9-2	30 degree	5.43 gpm at 0.20 ft	0.56 ft	303 gpm
9-3	45 degree	8.31 gpm at 0.20 ft	0.47 ft	465 gpm
9-4	60 degree	11.58 gpm at 0.20 ft.	0.41 ft	648 gpm
9-5	90 degree	20.07 gpm at 0.20 ft.	0.33 ft	1,122 gpm

Discussion Items:

- The minimum flow rate for the larger V-notch is close to the anticipated flow rate and should not be used. As an example, the 90 degree V-notch minimum rate is 20 gpm and the probable flow is 69 gpm.
- The 22 ½ or 30 degree V-notch weirs provide much better coverage of the range.
- To make a decision, you would need to compare the accuracy of the 22 ½ degree V-notch weir and its associated higher maintenance requirements to the 30 degree V-notch weir and its lower maintenance requirements.
- If the 22 ½ degree weir is selected, it should be shielded from the sun to reduce growth of algae. It should also be easily accessible for cleaning.

2. Having taken this course, a WWTP operator measured the following depths at the proper location upstream of a 1 foot rectangular weir without end contractions. What are the flows? Use Appendix D - ISCO Table 11-1.

Ans:

Measured Depth (inches)	Calculated Depth (feet)	Reading (gpm)	Reading (mgd)
2.40	0.200	133.7	0.19
2.52	0.210	143.9	0.21
2.76	0.230	164.9	0.24
3.00	0.250	186.9	0.27
3.60	0.300	245.7	0.35
4.32	0.360	322.9	0.46
4.92	0.410	392.5	0.56

Note: The readings in the mgd column have been rounded to the appropriate significant figure. Avoid creating false accuracy.

☑ Exercise/Activity

The WWTP staff was able to measure the depth of the flow in a 6 inch Parshall flume at Ha with good accuracy and they determined the following depths. What are the flows? Should an instrumentation person be contacted to inspect the flume?

Ans:

Measured Depth (inches)	Calculated Depth (feet)	Reading (gpm) Table 13-4
1.2	0.10	24
3.0	0.25	103
4.5	0.38	200
6.0	0.50	309
7.5	0.62	434

Note: that the depth of flow through the meter was able to be measured with good accuracy and all readings were within the ranges listed in the Table. Unless there are other concerns with the meter (e.g., the meter is due for its annual calibration), it does not appear an instrumentation person needs to be contacted.

☑ Exercise/Activity

Display Slide 20—Potential Problem?
What potential problem exists in this picture? Which types of sensors would this problem affect?

Ans: There is a foaming problem.

An ultrasonic sensor is the sensor most affected by foam.

☑ Exercise/Activity

Assume a 120 degree v-notch weir, with an average flow of 500 gpm. After initial operation, it was recognized that the flow could range from 20 gpm to 900 gpm. Is there a better v-notch weir for this application? Use Appendix D - ISCO Tables 9-3, 9-5, and 9-6.

Ans Using ISCO Table 9-5, a 90 degree v-notch weir has a range from 20 gpm to 1,122 gpm. This is a better v-notch weir for this application.
