Plan for Lesson # 2:
Hydraulics of Water Distribution Systems

CE174 – Design of Water Distribution and Wastewater Collection Systems
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Lesson # 2: Hydraulics of Water Distribution Systems

Timeframe: 2 hours for pre-class individual space activities;
2 hours and 45 minutes for in-class group space activities; and
3 hours for post-class homework assignment.

Materials needed:

- Flip charts and markers;
- copies of the worksheets;
- extra pencils for the students;
- projection system for presenting PowerPoint slides; and
- system for answering quiz questions (iClickers).

Learning Objectives (LOs):

Basic:

1. Write the Conservation of Mass Principle and explain its applications

2. Write the Conservation of Energy Principle and explain its applications

3. Write the definition of Reynolds Number

4. Explain the difference between friction loss and minor losses

5. Write Darcy-Weisbach friction loss equation and use Moody Diagram correctly

6. Explain the difference between EGL and HGL and plot them on a diagram

7. Write the steps to analyze a water distribution network using the Hardy Cross Method

8. Explain the water hammer (hydraulic transients) problem and how to avoid it

Advanced:

1. Apply the Conservation of Mass Principle to a falling-head tank problem

2. Apply the Conservation of Energy Principle to a design problem

3. Apply the Conservation of Energy Principle to an analysis problem (iteratively using Moody Diagram)

4. Solve for the flows in a water distribution network using the Hardy Cross Method

Background: The course consists of senior and graduate students in Civil and Environmental Engineering. In this part of the class, they are learning the hydraulics of pressurized pipe systems, including tanks, pumps and valves. They need to be able to analyze and design such systems.

Introduction to Lesson # 2: During the two weeks leading to Lesson # 2, the students will watch tutorial videos that explain the governing principles of hydraulics of pressurized pipe flow. The videos also cover techniques to tackle problems involving pipeline design as well as analysis. The lesson culminates with the students learning how to iteratively solve for the flows or velocities in a looping water distribution network.

During the in-class group activities, the students will apply what they havee learned to solve design and analysis problems for pressurized pipes. Finally, as a post-class homework exercise, they will fully-solve the four main problems started in class.

Procedure:

Pre-Class Individual Space Activities and Resources [2 hours]:

Steps	**Purpose**	**Estimated Time**	**Learning Objective**
Step 1: Watch part of the webinar given by the instructor, titled "An Overview of Hydraulics of Water Distribution Networks," **from the time 3:10 to 46:55,** available through this link: http://baywork.org/resource/baywork-an-overview-of-hydraulics-of-water-distribution-networks-webinar/ The PowerPoint for the webinar is provided on Canvas. Following the video, take a short quiz on Canvas.	Introduce students to the principles of hydraulics and basic equations for pressurized flow in pipe networks.	50 minutes	Basic LOs #1 to #6
Step 2: Watch video on energy equation: https://youtu.be/5BH4iSTv16Y Following the video, take a quiz on Canvas.	Write/setup the energy equation.	30 minutes	Basic LOs #2, # 4 & #5
Step 3: Watch video on iterative procedure to solve the energy equation: https://youtu.be/98k72JJgkkI Following the video, take a quiz on Canvas.	Solve the energy equation for unknown flow (Q) using an iterative procedure.	40 minutes	Advanced LO #3

In-Class Group Space Activities and Resources [2 hr 45 min]:

Steps	**Purpose**	**Estimated Time**	**Learning Objective**
Step 1: Use iClicker to answer short questions on the material in the videos covered in the pre-class activities.	Clear up any general confusion or misconceptions.	15 minutes	All Basic LOs
Step 2: Solve problem of the falling-head tank, conducted in the "Write/Pair/Share" format.	Apply the Conservation of Mass Principle to a problem requiring the solution of a first-order differential equation.	30 minutes	Advanced LO #1
Step 3: Solve the straightforward problem of designing a pipe between two tanks, conducted in the "Corners" format.	Apply the Conservation of Energy Principle to a design problem.	30 minutes *Step 3 is followed by a 10-min break.*	Advanced LO #2
Step 4: Solve the iterative problem of analyzing the flow in a pipe using Moody Diagram, conducted in the "Write/Pair/Share" format.	Apply the Conservation of Energy Principle to an analysis problem (iteratively using Moody Diagram).	40 minutes	Advanced LO #3
Step 5: Analyze a pipe network using Hardy Cross Method. Conduct this exercise in the "Corners" format.	Solve for the flows in a water distribution network using the Hardy Cross Method.	35 minutes	Advanced LO #4

Closure/Evaluation [5 minutes]:
Describe the upcoming homework assignment and discuss how it relates to the group space activities that were completed in class.

Analysis:
Students in this class are senior and graduate students in Civil and Environmental Engineering. The in-class group space activity is designed to allow students to apply the general concepts they learn in the pre-class individual space activities in a way that they are comfortable with, namely, solving problems and crunching numbers. Iterative methods are complex and confusing. Having the students first practice the concepts and apply the methods in class should make it easier for them to later apply the methods in the post-class individual space activities.

Post-Class Individual Space Activities:
As a post-class homework assignment, they will each fully-solve the four main problems started in class.

Connections to Future Lesson Plan(s):
Lesson # 2 is the foundation for pressurized pipe flow problems. It will help them in tackling the topic of pumps in Lesson # 3.