Name: _____

# CVEN 458 – Hydraulic Engineering of WDS
Spring Semester 2015
Dr. Kelly Brumbelow, Texas A&M University

## Exam #1 – Part A

***Closed-book, Closed-notes (2 pages, 2 questions in this part); Time allowed: 15 minutes***
*All work for Part A must be written on the Part A pages.*

1. Explain the function and typical applications of a pressure reducing valve. *(5 points)*

2. Your firm wins a contract to create an EPANet model of a municipal water utility WDS in the U.S. As you are reviewing as-built drawings and GIS files, you find this table describing 3 of the mains in the system:

| PIPE_ID | DIAMETER | MATERIAL | LENGTH | INSTDATE | JOB_NO |
|---|---|---|---|---|---|
| A-652-J1 | 6 | AC | 75 | 1964 | W-64-3B |
| A-320-H4 | 12 | IRON | 255 | 1970 | W-70-1C |
| C-004-B2 | 8 | PVC | 159 | 2004 | W-04-7B |

For each of the pipes listed, what information needed for formulation of the hydraulic model can you extract from this table? Is there any information presented here for which you would need further clarification from the utility – i.e., are there questions you should submit to the utility based upon what you see here? *(10 points)*

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## Exam #1 – Part B

***Open-book, Open-notes (2 pages [+ ref sheets], 2 questions); Time allowed: remainder of 60 minutes after closed-book section***
*All work for Part B must be written on separate pages with your name written on each page.*

1. A small WDS is diagrammed and relevant parameters are defined below. Attached to the exam are look-up tables and reference material that you may find helpful.

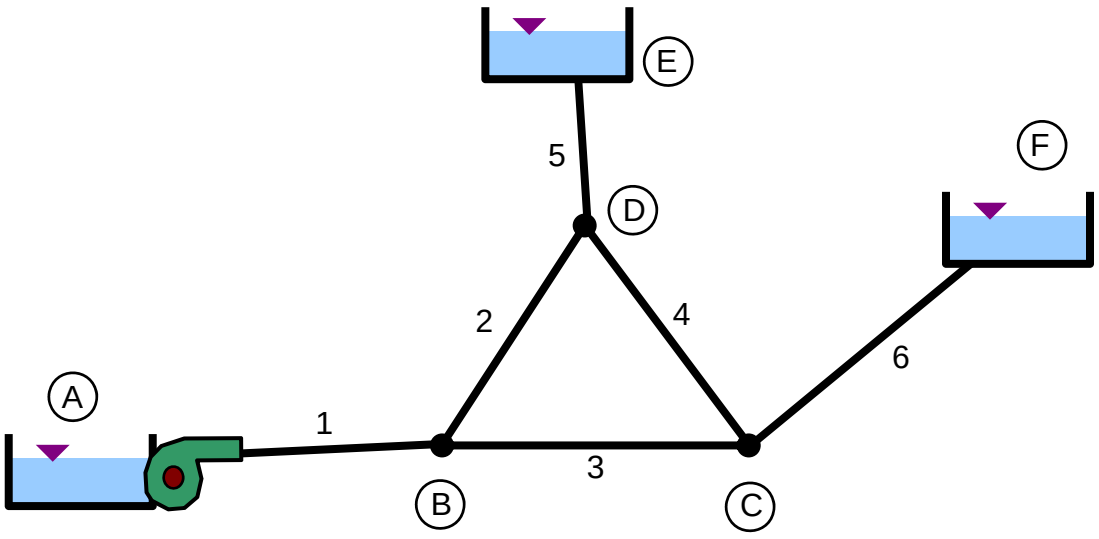
*Do all necessary work to setup the first iteration of the Gradient Method solution for flows and heads in this network using the* ***Hazen-Williams*** *equation for all pipe head losses.* Your final answer should be the matrix equation:

$$\begin{bmatrix} n\underline{A_{11}} & \underline{A_{12}} \\ \underline{A_{21}} & \underline{0} \end{bmatrix} \times \begin{bmatrix} \underline{\Delta Q} \\ \underline{\Delta H} \end{bmatrix} = \begin{bmatrix} -\underline{dE} \\ -\underline{dq} \end{bmatrix}$$

with all matrices fully written out including numerical values where possible. That is, your final answer should look something like:

$$\begin{bmatrix} 3 & 0 & 0 \\ 1 & 2 & -1 \\ 0 & 1 & 1 \end{bmatrix} \times \begin{bmatrix} \Delta Q_1 \\ \Delta Q_2 \\ \Delta H_1 \end{bmatrix} = \begin{bmatrix} 21.3 \\ -9.6 \\ -0.53 \end{bmatrix}$$

Explicitly state all assumptions made in preparing the matrices. *(50 points)*



$HGL_A$ = 840.0 ft; $HGL_E$ = 960.0 ft; $HGL_F$ = 970.0 ft

$Z_B$ = 855.0 ft; $Z_C$ = 850.0 ft; $Z_D$ = 860.0 ft

$Dem_B$ = 125 gpm; $Dem_C$ = 75 gpm; $Dem_D$ = 100 gpm

Pipe 1: $L$ = 1000 ft, $D$ = 12 in, PVC
Pipe 2: $L$ = 1500 ft, $D$ = 6 in, Cast Iron (30 years old, slight corrosion)
Pipe 3: $L$ = 1500 ft, $D$ = 6 in, Cast Iron (30 years old, slight corrosion)
Pipe 4: $L$ = 1500 ft, $D$ = 6 in, Cast Iron (30 years old, slight corrosion)
Pipe 5: $L$ = 1000 ft, $D$ = 12 in, PVC
Pipe 6: $L$ = 1000 ft, $D$ = 12 in, PVC

Pump characteristic equation: $E_p = -0.00014Q^2 - 0.00833Q + 140$, [Ep] = ft, [Q] = gpm

2. Field determination of pipe roughness values (like Hazen-Williams $C$) is done by "hydrant flow tests." In these tests, pressure gages are installed on 2 fire hydrants along the same water main, where the pipe length between the hydrants is definitely known. Then, one of the hydrants is opened with a combination valve and flow gage, so that the volumetric flowrate leaving the hydrant is measured. Assuming that flows in the main due to other demands are minimal (the tests are usually done at night when demands are low), head loss can be determined by the measured pressure drop and hydrant elevations. Then, the head loss equation can be back-solved to find the roughness value.

For a water main 8 inches in diameter and hydrants located 800 ft apart along the main (elevation difference negligible), the following data are obtained:

| **Hydrant Flow (gpm)** | **Pressure Drop (psi)** |
|---|---|
| 506 | 4.2 |
| 992 | 14.3 |
| 1210 | 21.5 |

In your engineering judgment, what is the appropriate value of Hazen-Williams $C$ for this main? *(30 points)*