1. One acre is a square with sides of length of 208.71 feet. How many square feet in an acre?

2. 1 inch is ≈ 25.4 millimeters. What is the diameter of a six-inch pipe, in millimeters?

3. 1 meter is ≈ 3.28 feet. There are 5280 feet in a mile. How many meters in one mile?

4. One hectare is a square with sides of length 100 meters. How many acres in one hectare?

Figure 1: Photograph of ancient storm drain

5. Figure 1 is a photograph of a
   (a) Wässerbürger system
   (b) Water use system
   (c) Water control system
   (d) Environmental restoration system

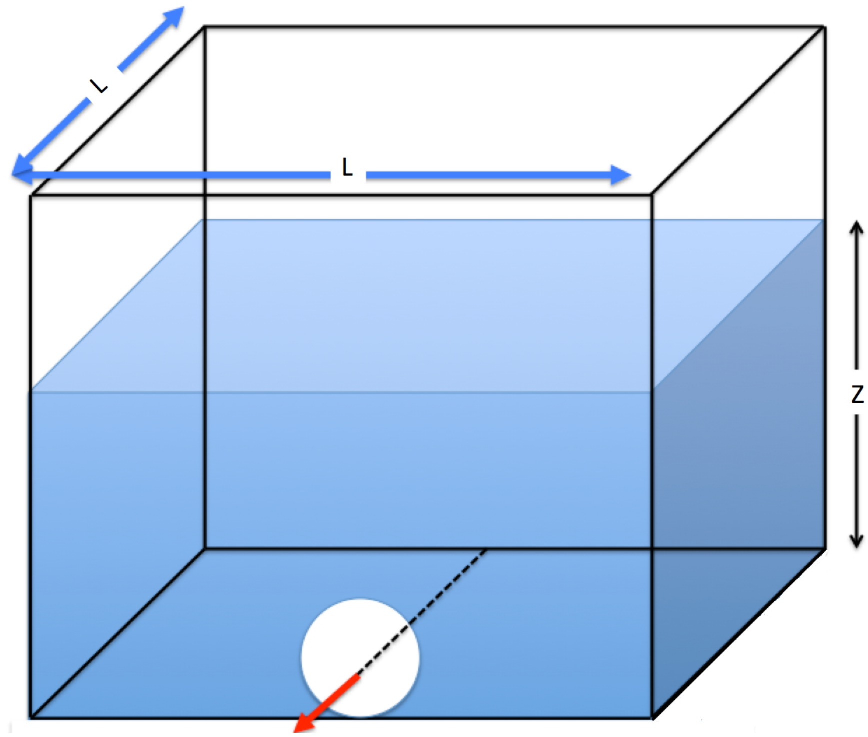

Figure 2: Square detention pond

6. Figure 2 is a square (plan view) detention pond. The initial depth in the 1 hectare (plan view) ($L = 100.0$ meters) is $Z = 3$ meters. What is the average outflow rate in cubic-meters-per-second, if the pond drains through the hole in the side in 24 hours?

7. Figure 3 is a portion of an engineering drawing of a gravity-flow wastewater conduit.

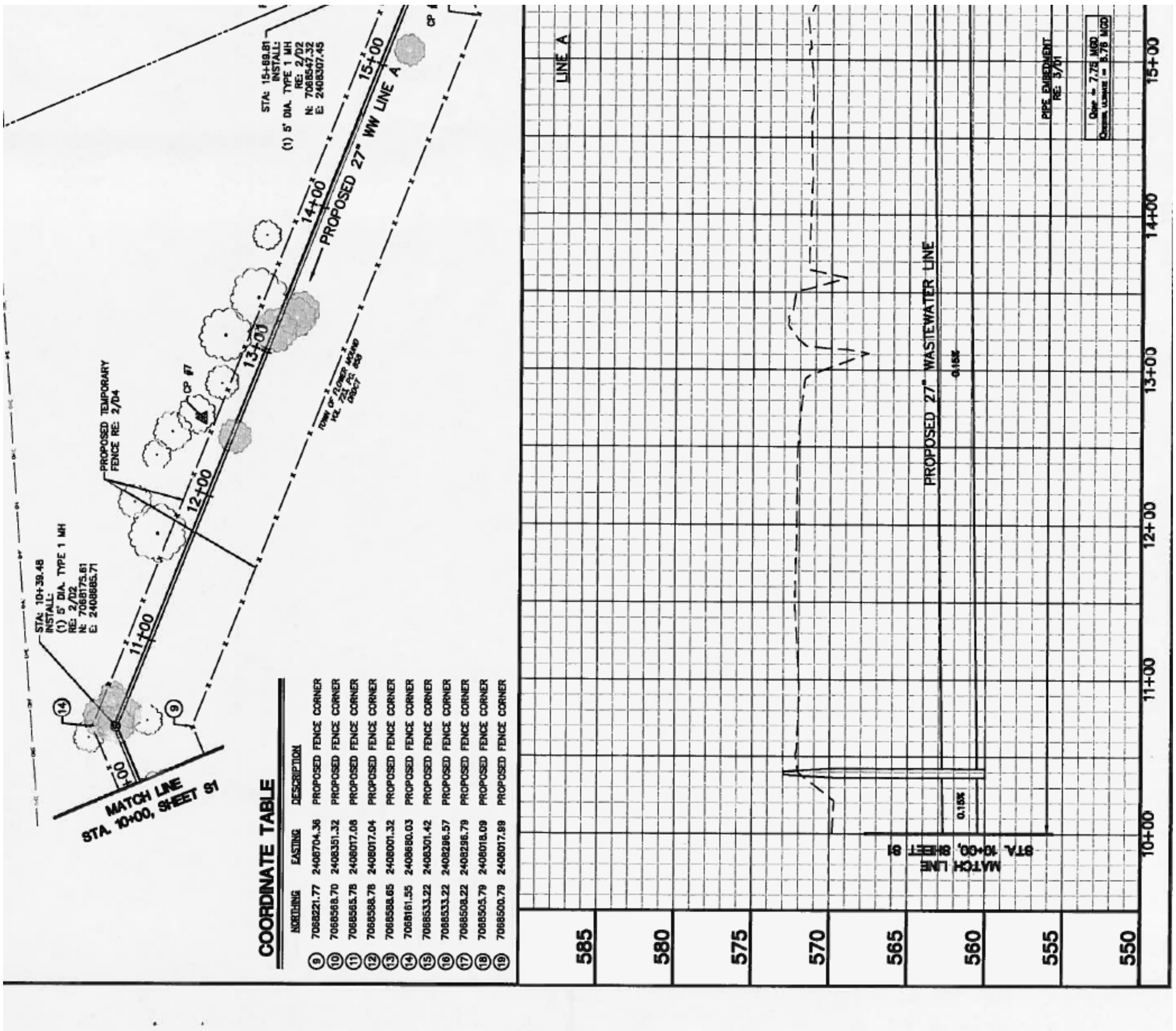

Figure 3: Engineering drawing of sanitary sewer system (display is rotated)

(a) What object is located at station 10+38.48?

(b) What is the invert elevation of the pipe at station 13+00?

(c) What is the diameter of the pipe in inches?

(d) What direction is sewage intended to flow?

8. Equation 1 is the Hazen-Williams discharge model for S.I. units.

$$Q = 0.849\ A\ C_h\ R^{0.63}\ S^{0.54} \tag{1}$$

where;

> Q is the discharge in m^3/sec;
> A is the cross section area of pipe in m^2 ($A = \frac{\pi D^2}{4}$; D is the pipe diameter.);
> C_h is the Hazen-Williams friction coefficient (depends on pipe material);
> R is the hydraulic radius in m; ($R = \frac{A}{P_W}$)
> P_W is the wetted perimeter;
> S is the slope of the energy grade line ($\frac{h_f}{L}$); and
> L is the length of pipe.

For a 3660 meter long, 1.83-meter diameter steel pipe, determine:

(a) The wetted perimeter, P_W, in meters.

(b) The cross sectional area of flow, A, in square meters.

(c) The hydraulic radius, R, in meters.

(d) The head loss in the pipe, if $C_h = 150$, and the discharge is $Q = 8.36$ cubic meters per second

9. Equation 2 is an explicit formula (based on the Darcy-Weisbach head loss model and the Colebrook-White frictional loss equation)for estimating discharge from head loss and material properties.

$$Q = -2.22D^{5/2} \times \sqrt{gh_f/L} \times [log_{10}(\frac{k_s}{3.7D} + \frac{1.78\nu}{D^{3/2}\sqrt{gh_f/L}})] \quad (2)$$

where;

Q is the discharge in L^3/T;
D is the pipe diameter;
h_f is the head loss in the pipe;
g is the gravitational acceleration constant;
L is the length of pipe;
k_s is the pipe roughness height;
ν is the kinematic viscosity of liquid in the pipe;

Estimate the discharge in cubic-feet-per-second for the 3.2 mile long, 24-inch diameter, ductile iron pipe connecting points A and B as depicted Figure 4. The sand roughness height of ductile iron is $8.5 \times 10^{-4}\ ft$. The 50^{o}F water has kinematic viscosity of $1.45 \times 10^{-5}\ ft^2/s$. Point A is 28 feet higher in elevation than point B. The pressure at point B is 21 pounds per square-inch (psi) greater than the pressure at point A. (Show your work on the next page)

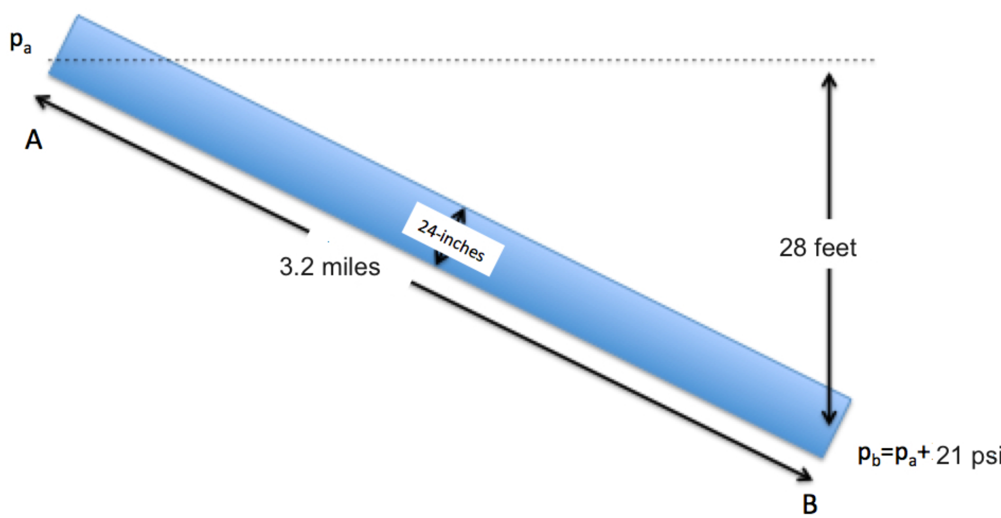

Figure 4: Pipeline Schematic

Problem 9 (Continued)

10. Figure 5 is an aerial image of a parallel pipeline system in California.

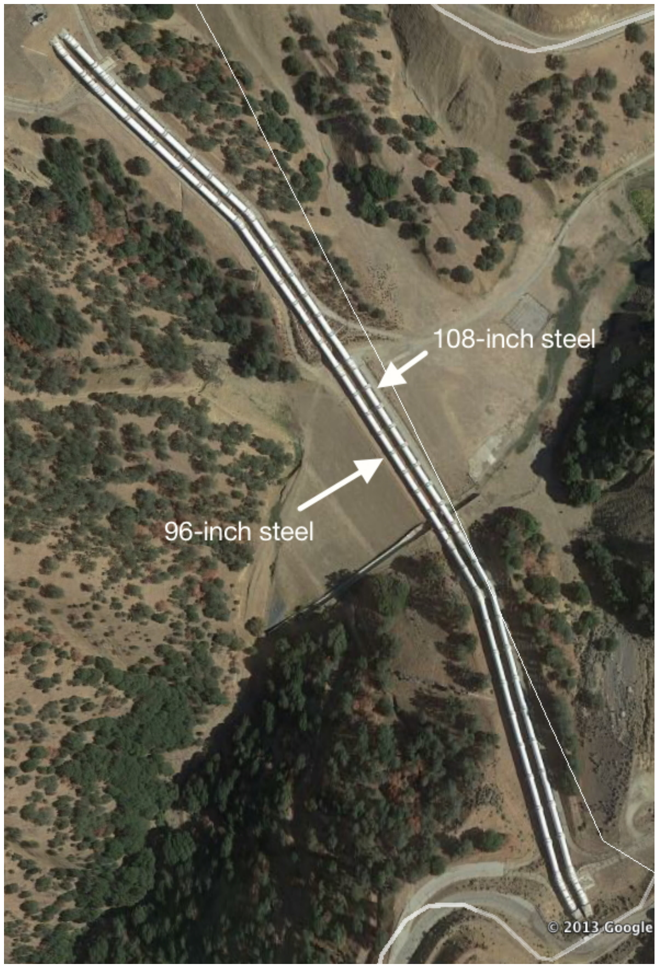

Figure 5: Parallel Pipeline System

The left pipeline is a 96-inch diameter steel pipe, whereas the right pipeline is a 108-inch diameter steel pipe. Water at 50^{o}F has kinematic viscosity of 1.45×10^{-5} ft^2/s. The sand roughness of ductile iron is 1.64×10^{-4} ft. If the head difference for the one-mile long pipelines between the thrust blocks is 90 feet, determine the discharge in each pipe in cubic-feet-per-second. (Show your work on the next page)

Problem 10 (continued)

Figure 6 is a pipe network with the following properties:

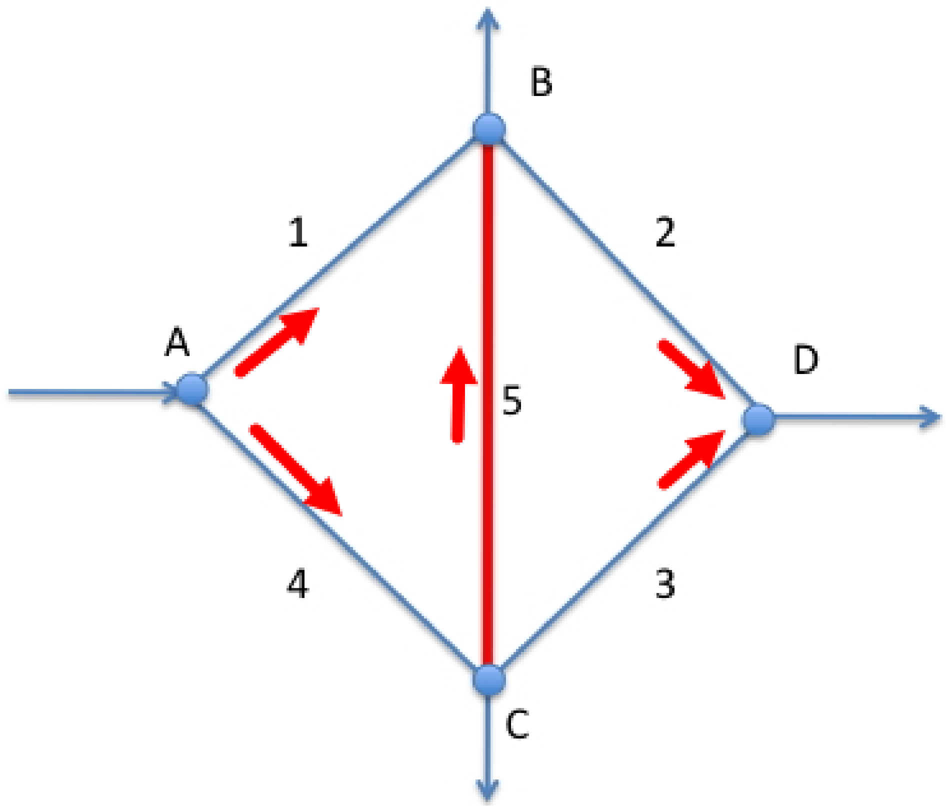

Figure 6: Pipe network

Table 1: Network properties for Figure 6

Node	Demand (lps)	Elevation(m)
A	-0.60	0.00
B	0.15	0.00
C	0.15	0.00
D	0.30	0.00
Pipe	**Length (m)**	**Diameter (mm)**
1	10,000	77.0
2	10,000	77.0
3	10,000	77.0
4	10,000	77.0
5	14,000	77.0

11. Referring to Figure 6, and Table 1 the flow distribution is:
    (A) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,0.15,0.15,0.30,0.00] LPS
    (B) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,0.15,0.15,0.30,0.30] LPS
    (C) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,0.15,0.15,0.00,0.50] LPS
    (D) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,-0.15,-0.15,0.30,-0.60] LPS
12. Referring to Figure 6, assuming the average friction factor is 0.033, the head loss, in feet, from Node A to Node C is closest to
    (A) 1.25 meters
    (B) 2.50 meters
    (C) 5.00 meters
    (D) 10.0 meters
13. Referring to Figure 6, if the demands at all nodes are those in Table 1, and pipe 2 is decreased to a diameter of 50.8 mm, the discharge in pipe 5 is closest to
    (A) 0.00 lps, from Node C to Node B
    (B) 0.15 lps, from Node B to Node C
    (C) 0.30 lps, from Node C to Node B
    (D) 0.60 lps, from Node B to Node C

14. Water is to be pumped at a rate of 70 liters per second in a 1-kilometer meter long, 200 millimeter diameter pipeline between two reservoirs with an elevation difference of 30 meters. The roughness height of the steel pipe is 0.045 millimeters.

    The Reynolds number for water is computed from

    $$Re = \frac{VD}{\nu} \tag{3}$$

    The kinematic viscosity of water in the system is

    $$\nu = 1 \times \ 10^{-6} \mathrm{m}^2/\mathrm{s} \tag{4}$$

    The Jain equation (Jain, 1976) that directly computes friction factor from Reynolds number, diameter, and roughness is

    $$f = \frac{0.25}{[log(\frac{k_s}{3.7D} + \frac{5.74}{Re^{0.9}})]^2} \tag{5}$$

    The Darcy-Weisbach head loss equation (for pipe losses) is

    $$h_{loss} = f\frac{L}{D}\frac{V^2}{2g} \tag{6}$$

    Using the description and these equations

    a) Sketch the system – show the two reservoirs and the pump on the sketch.

    b) Convert the pipe diameter into meters (you will need this value below).

    c) Convert the flow rate into cubic-meters-per-second (you will need this value below).

d) Determine the pipeline velocity (in meters per second).

e) Compute the Reynolds number for the system.

f) Compute the friction factor from the Jain equation.

g) What is the pipe head loss in the system at 70 liters per second?

h) What is the static lift (in meters of head)?

i) What is the sum of the frictional loss and the static lift (in meters of head)?

Select a pump from one of the four on Figure 7 below. Indicate the operating point on the pump you select.

j) Which pump and operating impeller speed did you choose?

k) Estimate the required NPSH for the pump you choose.

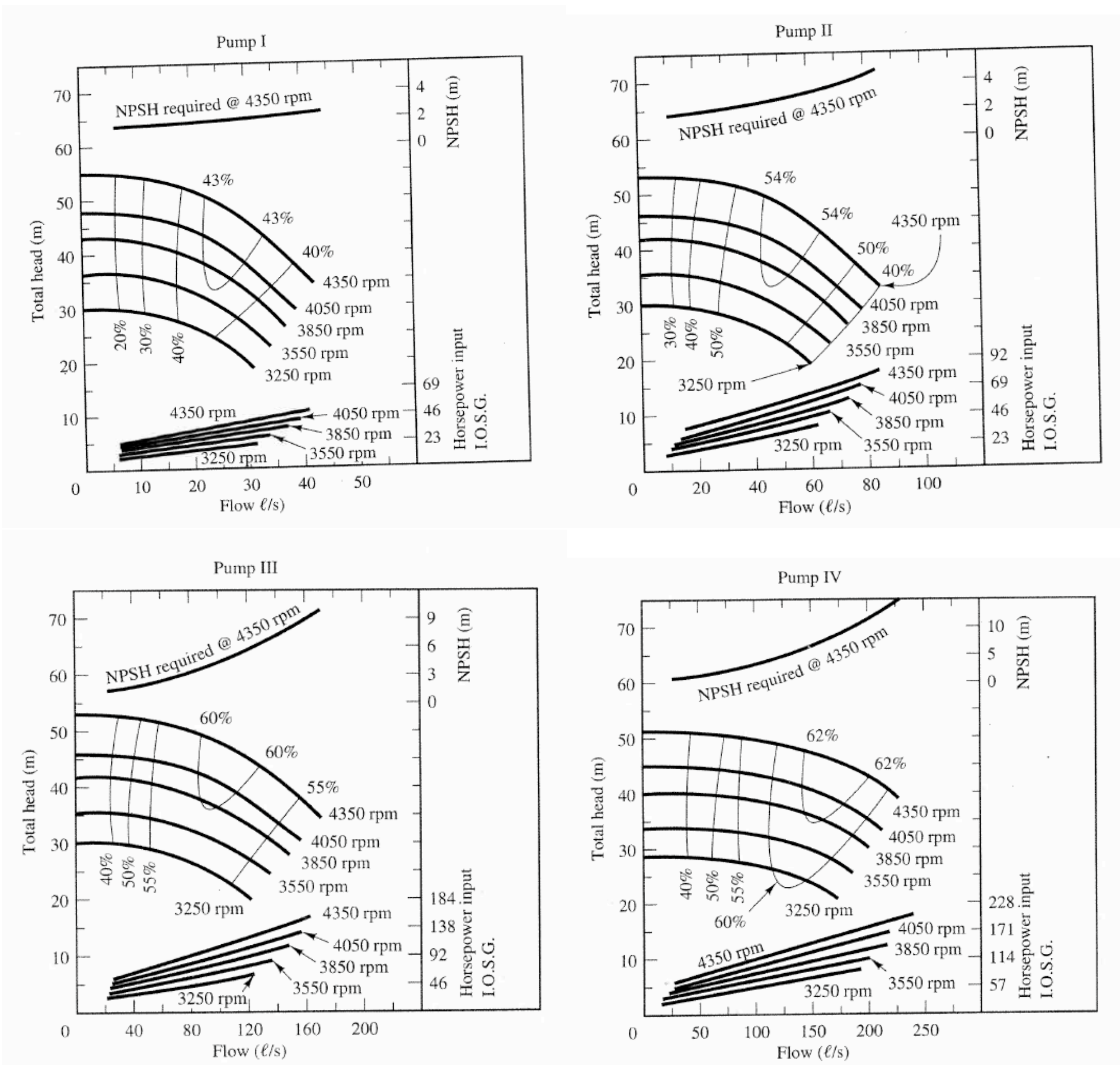

Figure 7: Pump curves for four different pumps. Each pump has five different impeller speeds for 20 possible different combinations.

15. Critique the memorandum in Figure 8. Mark directly on the figure – you are to identify the grammar, spelling, punctuation and format errors and state the required corrections.

NAME:___________________.

MEMORANDUM

TO: DR. THEODORE CLEAVELAND, P.E.
FROM: ALASKA TANGLEWILDE

DATE: FEBRUARY 16, 2016
RE: ENGINEERING CALCULATIONS AND PUMPS

Purpose: Answer questions from ES-4

Discussion: The first question in the ES asks about the required unit conversions needed to make the Swamee-Jain Equation work. I first convert the inches into feet. Then I work the excel spread sheet found on the class server (http://rtfmps.com/university-courses/ce-3372/2-Homework/ES-5/ES-5-Solution/).

Discharge in a Pressure Pipe (US Units)

INPUTS	VALUE	UNITS
Diameter	2	feet
Gravity	32.2	feet/second^2
Head Loss	26.154	feet
Length	10560	feet
Roughness	1.23E-05	feet
Viscosity	1.41E-05	feet^2/second

RESULT	VALUE	UNITS
Discharge	**15.90389**	feets^3/second

Concluding Remarks: From the online calculator, the result of the discharge for the pipe is 15.9 ft^3/s. IT was found that this is a normal flow rate for the □ pipe is with in the acceptable range.

□

Alaska Tanglewilde

All values and work is shown on the attached solution.
□

Figure 8: Pipe network