

CVEN 339 – Water Resources Engineering
Summer Semester 2010
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Final Exam

Open-book, Open-notes (8 pages, front & back, not including answer sheet; 18 questions)

Questions 1 to 12 are written in the format of the F.E. Exam Morning Section and should require on average 2 minutes per question to complete. Each question is worth 4 points. **Clearly write the letter corresponding to the best answer in the blank provided on the answer sheet.**

1. A trapezoidal open channel has bottom width 2.1 m, Manning's roughness coefficient 0.012, 3.2H:1V sideslopes, and longitudinal bedslope 0.09. If the flowrate in the channel is $58.4 \text{ m}^3/\text{s}$, what will be the depth of flow (m)?

(A) 2.23
(B) 0.80
(C) 0.66
(D) 0.45

2. Two identical culverts are installed in parallel under a roadway. Each culvert has diameter 18 inches, length 158 ft, is made of concrete ($e = 0.01 \text{ ft}$), and has a mitered entrance ($K_M = 0.6$). If both ends of both culverts are fully submerged, what will be the combined flowrate (ft^3/sec) through both culverts when the difference between headwater and tailwater elevations is 4.0 ft?

(A) 28.1
(B) 12.6
(C) 25.2
(D) 37.4

3. Aquifer hydraulic head has been measured as 323.14 m and 322.10 m at points A and B, respectively, which are 800 m apart. Tracer tests have determined that aquifer flow is directly from A to B with bulk velocity 4 mm/day. The saturated hydraulic conductivity (m/day) of the aquifer is most nearly:

(A) 3.08×10^3
(B) 3.08×10^0
(C) 3.25×10^{-1}
(D) 3.25×10^{-4}

4. Which of the following watershed characteristics are included in calculation of runoff depth by the NRCS curve number method?

- I. Watershed area
- II. Soil type
- III. Land cover
- IV. Storm duration
- V. Average watershed slope

- (A) I, II, and III only
- (B) I, II, III, and IV only
- (C) II and III only
- (D) I, II, III, IV, and V

5. The rainfall for a given storm is to be estimated at Point X using the inverse distance weighting method based upon rainfall measurements from nearby rain gauges. The table below lists the rainfall at 3 nearby rain gauges and the distance of each gauge from Point X, respectively.

Rain Gauge	Rainfall for Given Storm (in)	Distance from Point X (mi)
A	2.52	15.4
B	3.84	12.6
C	1.01	21.4

The rainfall at Point X can be estimated as:

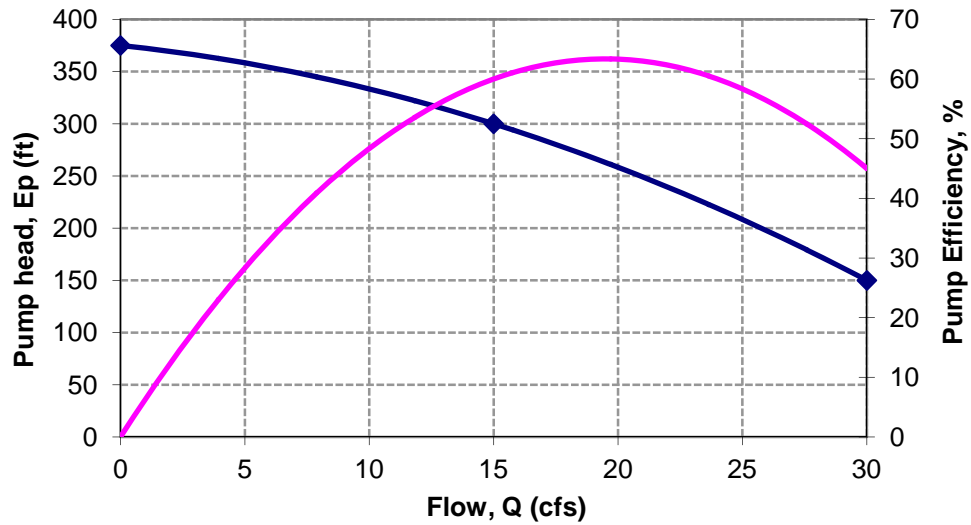
- (A) 2.70 in
- (B) 2.52 in
- (C) 2.46 in
- (D) 2.20 in

6. A river reach is 8650 ft long and has Muskingum routing parameters $X = 0.43$ and $K = 30$ minutes. Which of the following statements are true?

- I. The stream is likely meandering with low longitudinal bedslope.
- II. The mean flow velocity in the stream is approximately 2.1 ft/sec during a flood event.
- III. Muskingum routing calculations would require an inflow hydrograph time step between 10 and 30 minutes.

- (A) I, II, and III
- (B) I and III only
- (C) II and III only
- (D) III only

7. The characteristic and efficiency curves for a specific pump are given in the figure below. What will be the shaft power consumed by the pump if it operates at a flowrate of $23.0 \text{ ft}^3/\text{sec}$? (1 hp = $550 \text{ ft}\cdot\text{lb}/\text{sec}$)



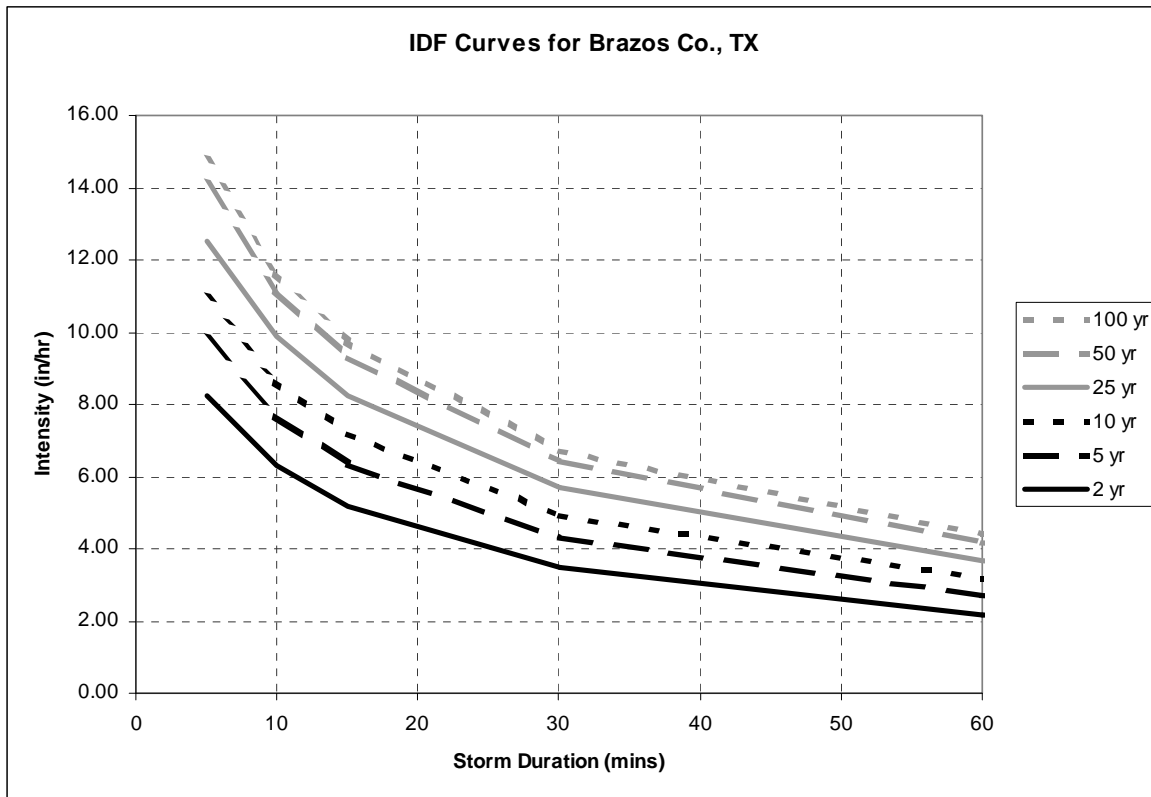
- (A) 2250 hp
- (B) 574 hp
- (C) 1435 hp
- (D) 957 hp

8. Which of the following statements regarding M-3 open channel flow profiles are true?

- I. Flow depth equals normal depth at some point on a M-3 profile.
- II. M-3 profiles typically end at hydraulic jumps.
- III. M-3 profiles can occur on steep slopes.
- IV. Flow is supercritical within a M-3 profile.

- (A) I and II only
- (B) II and IV only
- (C) I, III, and IV only
- (D) III and IV only

Use the figure below to solve problems 9 and 10.



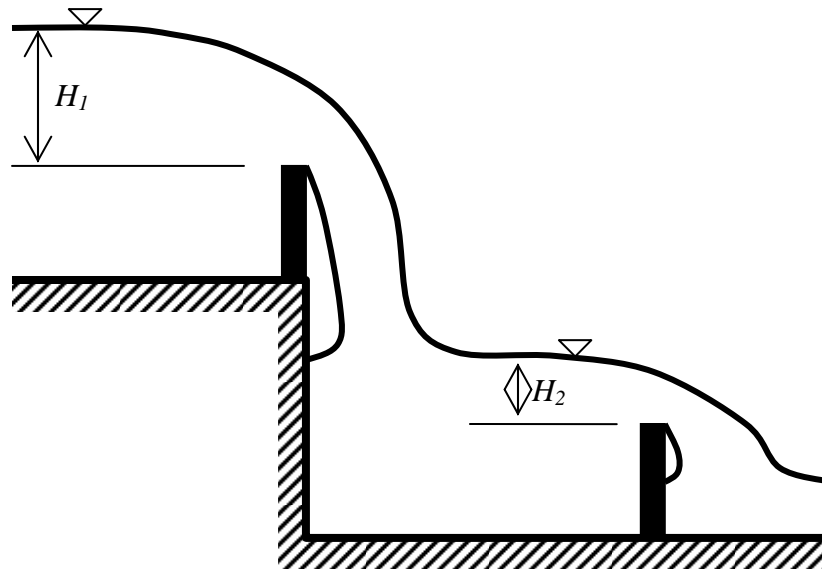
9. A culvert is located at the outlet of a 41 acre watershed and has a flow capacity of 51.7 cfs. The watershed runoff coefficient and time of concentration are 0.36 and 45 minutes, respectively. What is the annual probability that the culvert's flow capacity will be exceeded?

- (A) less than 1%
- (B) 5%
- (C) 20%
- (D) 80%

10. For the watershed and culvert in problem 9, if a second identical culvert is installed in parallel with the existing culvert, what is the annual probability that the combined culverts' flow capacity will be exceeded?

- (A) less than 1%
- (B) 5%
- (C) 20%
- (D) 80%

11. Water flows over a series of two rectangular weirs as shown in the figure below. All flows are steady state, and both weirs have the same weir discharge coefficient. If the length of the lower weir crest is 1.2 times the length of the upper weir crest, what will be the relationship of the parameters H_1 and H_2 ?



- (A) $H_2 = 0.76 \times H_1$
 (B) $H_2 = 0.89 \times H_1$
 (C) $H_2 = 1.13 \times H_1$
 (D) $H_2 = 0.83 \times H_1$

12. A rectangular open channel includes a section where longitudinal bedslope gradually increases. Before this section, flow depth is 3.2 ft and flow velocity is 1.4 ft/sec. After this section, flow velocity is 1.8 ft/sec. The specific energy (ft) of the flow after the bedslope has increased is most nearly:

- (A) 3.23
 (B) 4.16
 (C) 0.05
 (D) 2.54

Questions 13 to 18 are written in the format of the F.E. Exam Afternoon Section and should require on average 4 minutes per question to complete. Each question is worth 8.7 points. **Clearly write the letter corresponding to the best answer in the blank provided.**

13. A pipe network is shown in the drawing below. Demands are indicated for all nodes, and flow directions are indicated for all pipes. All nodes are at elevation 0 ft including the fixed-grade node, which has a free water surface at elevation 0 ft. The friction loss for each pipe is defined by the following equation:

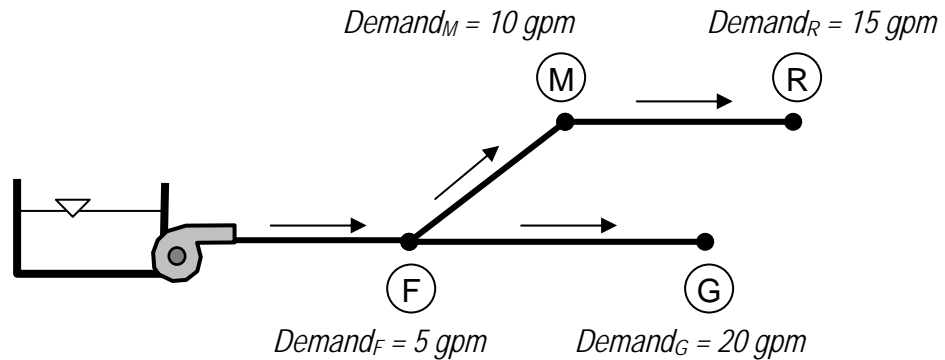
$$\text{Friction loss (ft)} = 0.014 Q^2 \text{ (gpm) for } 1 \text{ gpm} < Q < 90 \text{ gpm}$$

The pump has the pump characteristic curve defined below:

$$\text{Head (ft)} = 165 - 0.003 Q^2 - 0.05 Q \quad (Q \text{ in gpm})$$

What is the pressure (psi) at node R?

- (A) 66.8
- (B) 6750
- (C) 46.8
- (D) -20.3



14. Three monitoring wells have been drilled into an unconfined aquifer. The coordinates and piezometric head at each well are:

- Well 1: (-1200 m, 650 m), head = 343.9 m
- Well 2: (2000 m, -1250 m), head = 342.1 m
- Well 3: (1550 m, 875 m), head = 345.0 m

The aquifer's saturated hydraulic conductivity is 0.19 m/day. The average velocity and direction of flow in this aquifer is:

- (A) 2.76×10^{-4} m/day, 78.8° south of due west
- (B) 2.76×10^{-4} m/day, 78.8° north of due east
- (C) 7.85×10^{-3} m/day, 78.8° south of due west
- (D) 7.85×10^{-3} m/day, 78.8° north of due east

15. A lake has a surface area of 34,000 acres. Over a given 24 hour period, 1.25 inches of rain falls on the lake, and 0.05 inches of water evaporate. At the beginning of the same 24 hour period the stream inflow to the lake is 700 cfs and outflow is 620 cfs. At the end of the 24 hour period the stream inflow to the lake is 850 cfs and outflow is 650 cfs. The net change in lake stored water volume over the 24 hour period is most nearly: (1 acre·ft = 43,560 ft³)

- (A) +278 acre·ft
- (B) -178 acre·ft
- (C) +238 acre·ft
- (D) +119 acre·ft

16. A pump inputs water to a long pipeline. The pump has the characteristic curve defined below:

$$\text{Head (ft)} = 215 - 0.0003 Q^2 - 0.075 Q \quad (Q \text{ in gpm})$$

The pipeline has a static head of 75 ft. The friction loss in the pipeline is defined by the following equation:

$$\text{Friction loss (ft)} = 0.006 Q^2 \quad (Q \text{ in gpm})$$

If the diameter of the pipeline is increased by 25%, the flow rate (gpm) delivered by the pump in operation is most nearly:

- (A) 143
- (B) 158
- (C) 193
- (D) 233

17. A river reach has Muskingum parameters $K = 1.5$ hrs and $X = 0.30$. If outflow from the reach is 88 cfs at time $t = 0$, what will be the outflow at time $t = 2$ hrs resulting from the inflow hydrograph below?

Time (hrs)	Inflow Hydrograph (cfs)
0	88
1	125
2	134
3	130
4	115
5	95
6	88

- (A) 88 cfs
- (B) 113 cfs
- (C) 121 cfs
- (D) 134 cfs

18. A trapezoidal open channel has bottom width 4.0 ft, Manning's roughness coefficient 0.015, 2.5H:1V sideslopes, and longitudinal bedslope 0.068. If the flowrate in the channel is $81 \text{ ft}^3/\text{sec}$, which of the following statements are true?

- I. The depth of flow is 1.67 ft.
- II. The flow is supercritical.
- III. The flow's velocity head is 4.83 ft.
- IV. A decrease in longitudinal bedslope will result in an increased Froude number.

- (A) I and II only
- (B) I and IV only
- (C) II and III only
- (D) I, II, III, and IV