

CVEN 311 – Fluid Dynamics
Fall Semester 2011
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Final Exam

8 pages, front & back, not including reference sheets; 21 questions

An excerpt from the NCEES *Fundamentals of Engineering Supplied-Reference Handbook* is attached to this exam. It is the only reference material allowed during this exam.

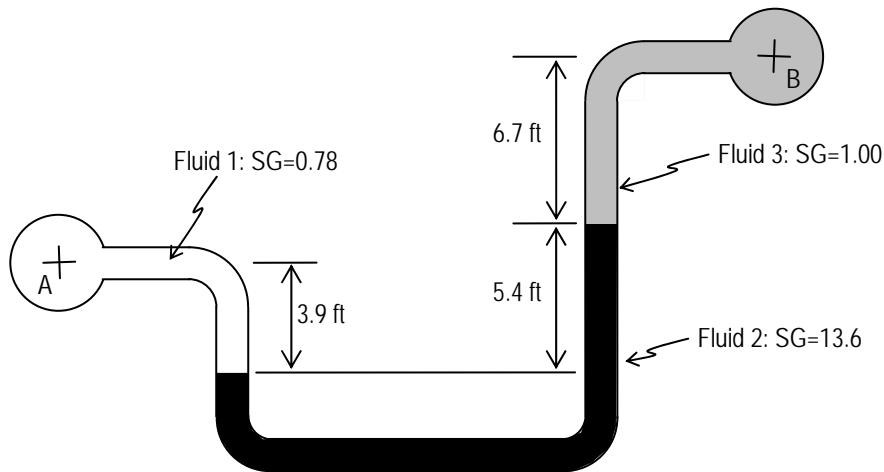
Questions 1 to 14 are written in the format of the F.E. Exam Morning Section and should require on average 2 minutes per question to complete. Each question is worth 3.5 points. **Clearly write the letter corresponding to the best answer in the blank provided on the answer sheet.**

1. The static pressure (Pa) at the bottom of a 7.3 m deep tank of gasoline ($\rho = 720 \text{ kg/m}^3$) is most nearly:
 - (A) 5 300
 - (B) 52 000
 - (C) 72 000
 - (D) 170 000

2. An experiment is designed to determine the behavior of transient pressure waves in crude oil pipelines using a model pipeline that is Cauchy number-similar to the prototype pipeline. In the prototype, fluid density is 1.69 slugs/ft^3 ; flow velocity is 13.2 ft/sec ; and bulk modulus is $1.96 \times 10^5 \text{ psi}$. If the model uses 70°F water ($E_v = 3.12 \times 10^5 \text{ psi}$) as its pipeline fluid, what will be the necessary model flow velocity?
 - (A) 15.5 ft/sec
 - (B) 4.28 ft/sec
 - (C) 18.3 ft/sec
 - (D) 11.2 ft/sec

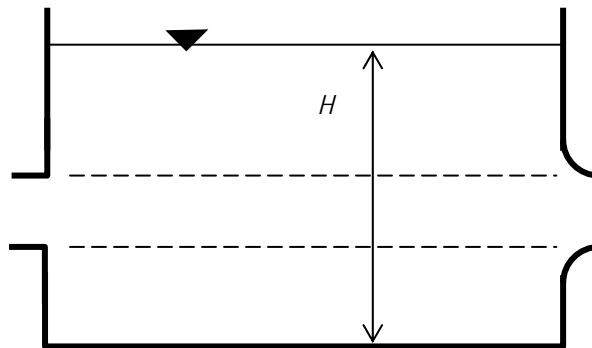
3. Water flows at a rate of 10 gal/min through a 1 inch diameter pipe. The pipe includes a partially closed valve along its length. If the static pressure immediately before the valve is 72 psi and immediately after the valve is 64 psi, the minor loss coefficient for the valve is most nearly:
 - (A) 0.048
 - (B) 3.6
 - (C) 6.9
 - (D) 220

4. A differential manometer is shown in the diagram below. The difference in pressure between point A and point B ($p_A - p_B$) (lb/ft^2) is most nearly:



- (A) -4800
 (B) +4800
 (C) -130
 (D) +130

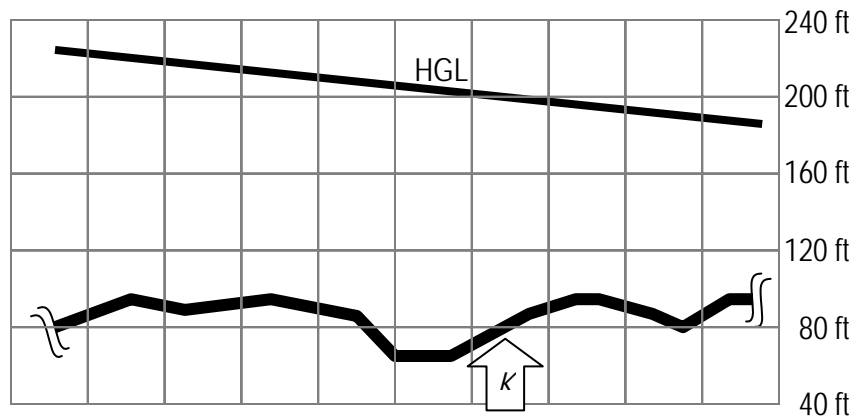
5. The tank drawn below has 2 circular orifices in its sidewalls and is filled with liquid to a depth H as shown. The orifices have upper and lower edges at equal elevations as indicated. Which of the following statements regarding the tank drawn below are true?



- I. Volumetric flowrate through the 2 orifices will be equal.
 II. Velocity out of the orifices will increase if the tank is filled with a denser liquid.
 III. Flowrate through the orifices is proportional to $H^{1/2}$.
 IV. Closing one of the orifices will increase the flowrate in the other.

- (A) II and IV
 (B) I, III, and IV
 (C) II and III
 (D) None of the statements is true

6. A section of water main is shown in the profile graph below with its hydraulic grade line (HGL). The pressure (psi) at point *K* is most nearly:



- (A) 7500
 (B) 87
 (C) 35
 (D) 52
7. Glycerin ($\rho = 1260 \text{ kg/m}^3$, $\mu = 1.50 \text{ N}\cdot\text{s/m}^2$) flows in a smooth 25 mm diameter pipe at a velocity of 7 mm/s. The head loss (mm) in each 5 m length of pipe is most nearly:
- (A) 66
 (B) 217
 (C) 32
 (D) 147
8. A 1 m diameter sphere is fabricated so that exactly one-half of the sphere is solid steel ($SG = 7.8$) and one-half is filled with air. The outer skin of the sphere is of negligible mass. If the sphere is then dropped into a tank of water, which of the following statements would be true?
- I. The sphere will sink to the bottom of the tank.
 II. There will be no buoyancy force acting on the sphere.
 III. The centers of gravity and buoyancy will arrange themselves in positions of stable equilibrium.
 IV. It is not possible to predict the behavior of the sphere with the information given.
- (A) III only
 (B) IV only
 (C) I and III
 (D) I and II

9. Carbon tetrachloride ($\rho = 1590 \text{ kg/m}^3$) flows in a conduit at a velocity of 2.5 m/s. A Pitot-static tube is used for velocity measurements and records a static pressure of 78 kPa. What is the value of stagnation pressure (kPa) measured by the Pitot tube?

- (A) 5
- (B) 78
- (C) 83
- (D) 73

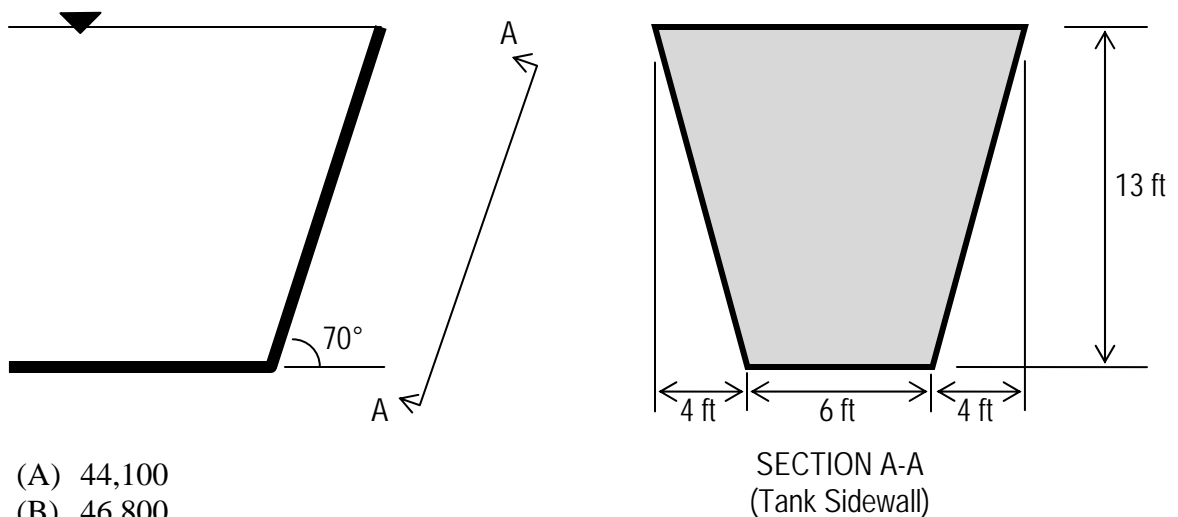
10. A fluid has specific gravity equal to 0.68 and absolute viscosity equal to $6.5 \times 10^{-6} \text{ lb}\cdot\text{sec}/\text{ft}^2$. Its kinematic viscosity (ft^2/sec) is:

- (A) 1.5×10^{-7}
- (B) 2.0×10^5
- (C) 9.6×10^{-6}
- (D) 4.9×10^{-6}

11. Water at 200°F flows in a 2 inch diameter pipe at a flowrate of $0.091 \text{ ft}^3/\text{sec}$. The Reynolds number of the flow is most nearly:

- (A) 2.0×10^5
- (B) 1.4×10^3
- (C) 6.6×10^4
- (D) 3.8×10^5

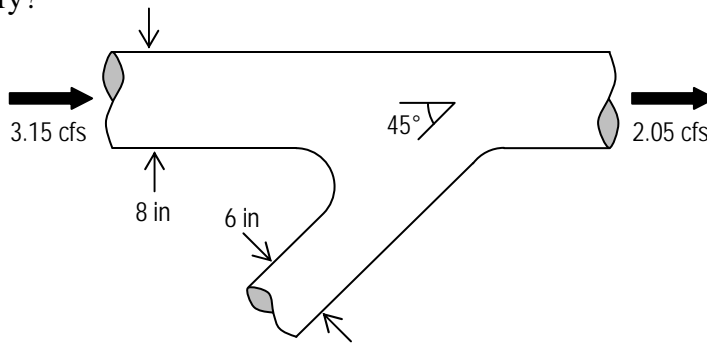
12. A tank filled with seawater ($\gamma = 64.0 \text{ lb}/\text{ft}^3$) has one side that is trapezoidal in shape and inclined at a 70° angle as shown in the drawing below. The total force (lb) acting on the side wall is:



- (A) 44,100
- (B) 46,800
- (C) 57,600
- (D) 71,100

13. A 0.6 m diameter cylindrical bridge pier is installed in a river that is 5.7 m deep. If the mean flow velocity of the river approaching the pier is 1.2 m/s, what is the drag force exerted on the pier?
- (A) 616 N
 (B) 1480 N
 (C) 2460 N
 (D) 739 N

14. A three-branch pipe fitting is shown in the drawing below. Static pressure is 12 psi at each branch. Given the flows and pressures present, what is the force that must be exerted to hold the fitting stationary?



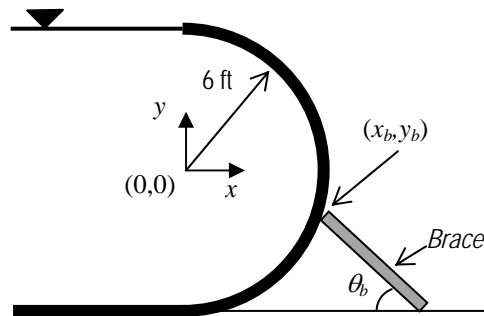
- (A) 380 lb
 (B) 520 lb
 (C) 43 lb
 (D) 300 lb

Questions 15 to 21 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 7 points. **Clearly write the letter corresponding to the best answer in the blank provided on the answer sheet.**

15. Water is pumped from a lower reservoir (water surface elevation 110 m) to an upper reservoir (water surface elevation 180 m) through a concrete pipeline (length 3000 m, diameter 500 mm, roughness 2.5 mm). The flowrate in the pipeline is $0.52 \text{ m}^3/\text{s}$, and minor losses are negligible. If the gross efficiency of the pump is 45%, what will be the gross power consumption (W) of the pump?

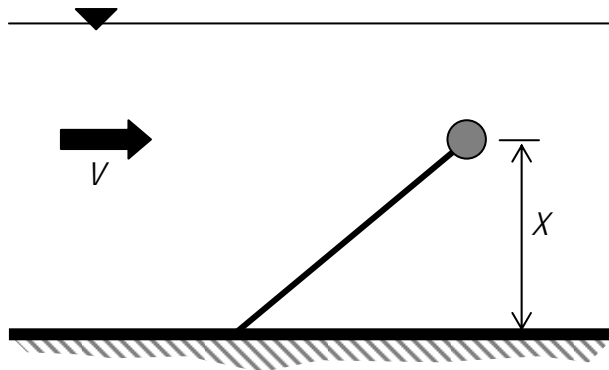
- (A) 6.84×10^5
 (B) 6.35×10^4
 (C) 1.52×10^6
 (D) 1.55×10^5

16. A tank with a semi-circular side will require this side to be braced. If the liquid contained in the tank is fresh water, what will be the brace position (x_b, y_b) and bracing angle θ_b to support the tank side in direct opposition to the fluid static force?



- (A) (2.55, -2.00) and 57.5°
 (B) (2.55, -2.00) and 32.5°
 (C) (3.22, -5.06) and 57.5°
 (D) (4.08, -4.40) and 57.5°

17. A 0.1 m diameter rubber sphere ($\rho = 700 \text{ kg/m}^3$) is tethered to a river bottom and submerged as shown in the figure below. The length of the tether is 7.5 m, and its mass is negligible. If the average velocity of the river current approaching the sphere is 1.74 m/s, the distance X between the sphere and the river bottom is most nearly:



- (A) 0 m
 (B) 1.9 m
 (C) 4.9 m
 (D) 6.8 m

18. The production facility in a paint manufacturing plant includes a set of mixing and packaging containers. Each container has a volume of 1 liter and begins a packaging cycle completely empty. Two liquid components, "A" and "B," flow into each container from separate tubes, and an outflow tube allows some of the mixture of A and B to begin flowing out immediately. Liquid "A" has density 760 kg/m^3 and absolute viscosity $1.3 \times 10^{-2} \text{ N}\cdot\text{s/m}^2$ and flows into the container through a 5 mm diameter tube. Liquid "B" has density 1150 kg/m^3 and absolute viscosity $7.2 \times 10^{-3} \text{ N}\cdot\text{s/m}^2$ and flows into the container through a 2 mm diameter tube. The outflow tube is 2 mm in diameter. If the centerline velocities of the flows in the A inflow, B inflow, and mixture outflow tubes are, respectively, 1.2 m/sec, 0.9 m/sec, and 0.8 m/sec, how long is required to fill a 1 liter packaging container?

- (A) 1 min 9 sec
- (B) 0 min 42 sec
- (C) 1 min 24 sec
- (D) 1 min 16 sec

19. Water flows from an upper reservoir (elevation 750 ft) to a lower reservoir (elevation 700 ft) through a pipe that changes diameter and material along its path. The first section of the pipe is cast iron, 12 inch diameter, and 500 ft long. The second section of the pipe is galvanized iron, 8 inch diameter, and 950 ft long. The flowrate (ft^3/sec) through the pipe is most nearly:

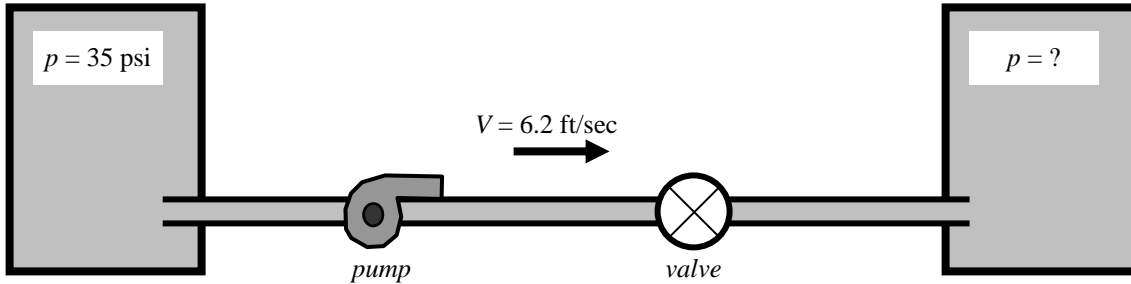
- (A) 18
- (B) 3.7
- (C) 11
- (D) 6.1

20. Which of the following statements regarding minor losses are true?

- I. Minor losses are a direct consequence of the Bernoulli equation.
- II. It is possible for minor losses to be greater than major losses along a pipe.
- III. Minor loss is proportional to pressure head in the minor loss element.
- IV. The shape of a hydraulic exit affects the minor loss coefficient for the exit.

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

21. A 100 ft long smooth plastic pipe of 2.5 inch diameter connects two pressurized tanks of water as shown in the drawing below. The pump has a power input of 450 ft·lb/sec with perfect efficiency. The tanks are at the same elevation. The minor loss coefficient of the valve is 5.3. What is the pressure (psi) in the right tank?



- (A) 64
- (B) 1900
- (C) 230
- (D) 48