CVEN 311 – Fluid Dynamics
Fall Semester 2012
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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 distributed with this exam. It and a student-supplied formula sheet (8.5 x 11, 2 sides) are 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. Water flows through a 100 mm diameter galvanized iron pipe at a velocity of 2.2 m/s. The pressure drop (kPa) along each 100 m length of pipe is most nearly:

   (A) 0.39
   (B) 28
   (C) 61
   (D) 107

2. A Pitot-static tube instrument is inserted in a pipe to measure flow properties of water. If the heights of the water columns in the Pitot and static tubes, respectively, are 22.52 ft and 22.38 ft, what is the flow velocity (ft/sec)?

   (A) 38
   (B) 3.0
   (C) 0.38
   (D) 1.7

3. A rectangular plate of area 14 ft^2 is dragged across the surface of 0.08 inch thick film of lithium grease ($\nu = 3.50 \times 10^{-3}$ ft^2/sec, $SG = 0.90$). If the film of motor oil is on top of a stationary surface, what force (lb) will be required to drag the plate at a velocity of 0.40 ft/s?

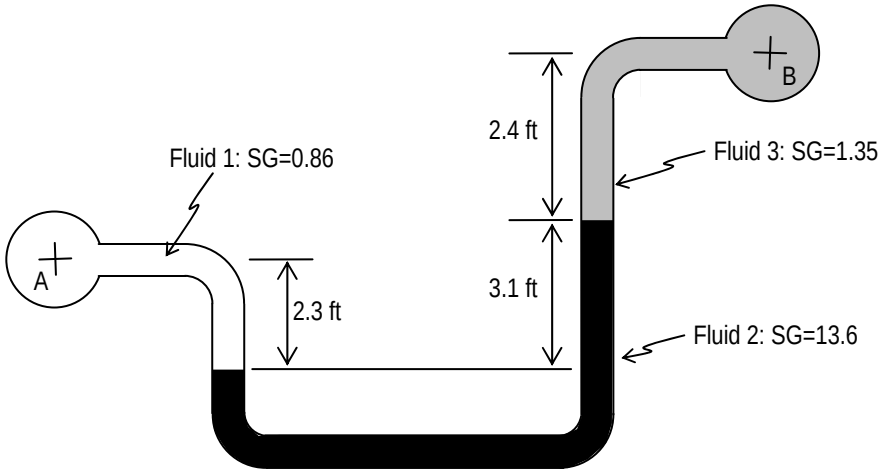
   (A) 2.9
   (B) 160
   (C) 0.36
   (D) 5.1

4. Two fluids, named "X" and "Y," flow into a reactor vessel. Inside the reactor the 2 fluids are fully consumed to produce a fluid "Z" that flows out of the reactor vessel. Densities for all 3 fluids and the volumetric flowrates for X and Y are given in the table below. Assuming that the volume of fluid contained in the reactor vessel is constant, what is the volumetric flowrate (m^3/s) of Z out of the reactor vessel?

Liquid	Density, ρ (kg/m^3)	Volumetric Flowrate, Q (m^3/s)
X	1.3	25
Y	525	0.061
Z	850	

(A) 25.061
(B) 15.4
(C) 13.2
(D) 0.076

5. A differential manometer is shown in the diagram below. If the pressure at point A is 1740 lb/ft^2, the pressure at point B (lb/ft^2) is most nearly:

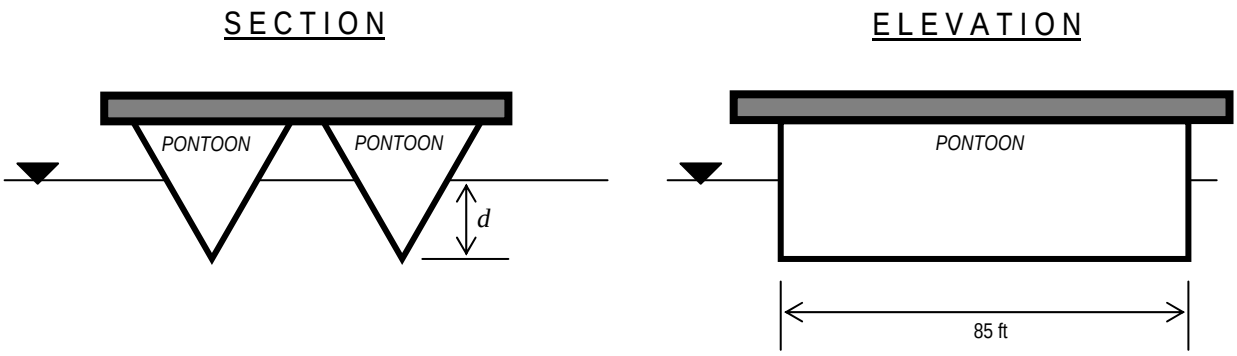


(A) – 2700
(B) – 970
(C) + 1700
(D) + 4400

6. The volumetric flowrate through a 0.13 ft diameter re-entrant (Borda) orifice is 0.12 ft^3/sec. The net head (ft) of fluid above the orifice centerline is:

(A) 3.3
(B) 16.1
(C) 0.082
(D) 4.9

7. A barge floats in freshwater on 2 pontoons built as equilateral triangular prisms as shown in the diagram below. If the total weight of the barge and pontoons is 2.2×10^6 lb, the submerged draft of the pontoons *d* (ft) is most nearly:



(A) 13.4
(B) 7.73
(C) 19.0
(D) 1.07

8. A pump has gross power consumption of 7.5 horsepower and has a flowrate (water) of 0.28 ft^3/sec. If the efficiency of the pump is 62%, the shaft head (ft) added to the flow is most nearly:

(A) 235
(B) 146
(C) 0.265
(D) 2560

9. Which of the following statements regarding the Energy Equation for Fluids is true?

I. The Energy Equation is the same as the Bernoulli Equation.
II. Minor losses are not included in the Energy Equation.
III. The Energy Equation is only valid along a streamline.
IV. The Energy Equation can be used to calculate reactive forces on control volumes.

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

10. A storage tank with vertical sides and a level bottom is 9.5 ft deep, 25 ft long, and 25 ft wide is filled with gasoline (ρ = 1.32 slugs/ft^3). The total force (lb) acting on one of the side walls is:

    (A) 1.92×10^5
    (B) 5.84×10^4
    (C) 5.05×10^5
    (D) 2.82×10^5

11. A physical model of an open channel dam spillway is to be Froude number similar to the prototype and built at a physical scaling ratio of 1:9.4. If the design spillway of the spillway prototype is 140 m^3/s, the model design flowrate (m^3/s) will be:

    (A) 0.517
    (B) 1.58
    (C) 14.9
    (D) 45.7

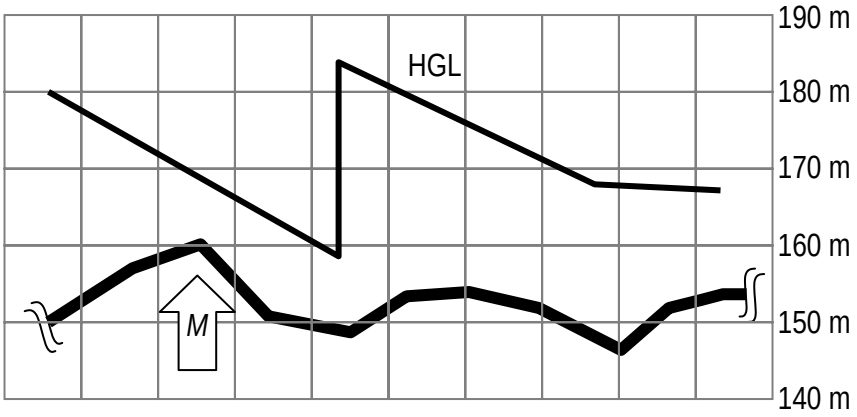
12. An unknown fluid flows through a 0.007 m diameter tube with a Reynolds number of 1250 and velocity of 0.005 m/s. What is the head loss (m) in a 25 m length of tube?

    (A) 5.1×10^{-2}
    (B) 7.0×10^{-5}
    (C) 2.3×10^{-4}
    (D) 2.9×10^{-1}

13. A fully open globe valve has a minor loss coefficient of 10. What is the pressure drop (psi) across such a valve of diameter 1 inch with flowrate 10 gal/min?

    (A) 1.12
    (B) 0.88
    (C) 50.5
    (D) 162

14. A section of water main is shown in the profile graph below with its hydraulic grade line (HGL). Based upon the figure, which of the statements below are plausible?



I. There is a significant minor loss element present in this section of pipe.
II. Flow direction is left to right.
III. Point *M* is the location of the highest pressure in this section of pipe.
IV. There is a pump present in this section of pipe.

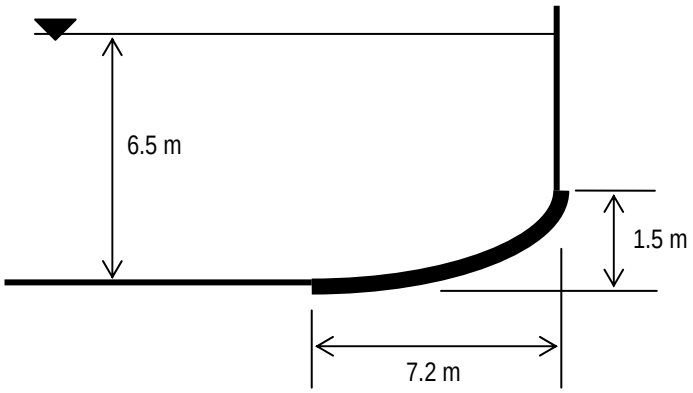
(A) II only
(B) II and IV
(C) I and III
(D) I, II, and IV

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 flows from an upper reservoir (water surface elevation 530 ft) to a lower reservoir (water surface elevation 420 ft) through a concrete pipeline (length 10,000 ft, diameter 24 inches, roughness 0.003 ft). No pumps, turbines, or significant minor loss elements are present. The volumetric flowrate (cfs) in the pipeline is most nearly:

(A) 96.5
(B) 3.14
(C) 8.21
(D) 25.8

16. The drawing below shows a tank design where the sides and bottom are joined by a half-parabola curved surface (indicated by the thick line). The fluid in the tank is water. If the dimension of the tank in/out of the page is 15 m, what will be the total force (N) exerted on the curved surface?



(A) 4.3×10^{5}
(B) 1.3×10^{6}
(C) 6.5×10^{6}
(D) 4.1×10^{4}

17. A small cart will propel itself by pumping water from an onboard tank through a nozzle to produce a jet of water in the direction opposite the intended direction of travel. If the cart has a 45 gal water tank, the pump produces a flowrate of 105 gal/min, and the nozzle diameter is 1 inch, what is the maximum impulse (lb·sec) the cart could produce starting from a full tank of water?

(A) 16100
(B) 19.5
(C) 501
(D) 25.7

18. A cylindrical bridge pier (diameter 1 ft) is immersed in a river flowing at an average velocity of 2.4 ft/sec with Froude number 0.14. What is the drag force (lb) exerted on the pier?

(A) 51.0
(B) 0.0053
(C) 1.0
(D) 21.3

19. Which of the following statements regarding pipe flows is true?

I. Radial velocity distribution is parabolic for turbulent flows.
II. The product of head loss and weight flux equals rate of entropy production.
III. Boundary layer properties strongly influence the value of the Darcy-Weisbach friction factor.
IV. Head loss can be directly correlated to drag force in an open pipe.

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

20. A nozzle is under design that will be used to create jets of fluid that will exert force to move objects remotely within a hazardous environment. The key dependent variable under consideration is reactive force *F*. Among possible other variables to consider are basic fluid properties, nozzle dimensions, and flow characteristics. Which of the following choices is a plausible dimensionless function that could be used to analyze experimental data?

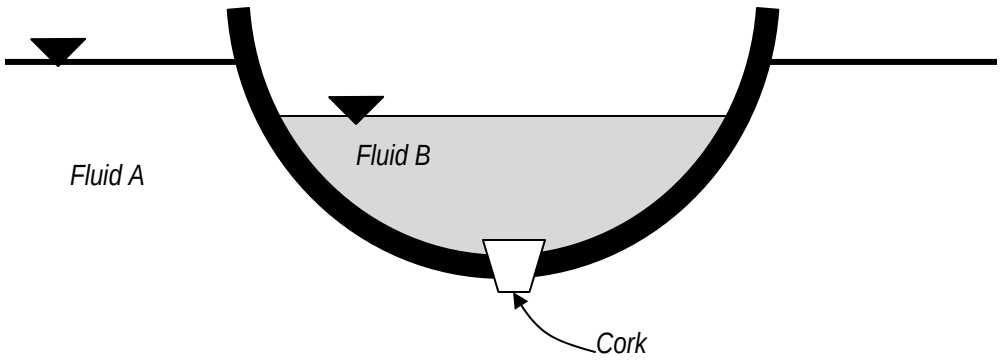
(A) $\frac{F}{V} = \phi\left(\mathrm{Re}, \frac{\frac{1}{2}\rho V^2}{p} \right)$

(B) $\frac{F}{\frac{1}{2}\rho V^2 A} = \phi\left(\frac{F}{pA}, \frac{m}{\rho Q t} \right)$

(C) $\mathrm{Re} = \phi\left(\frac{F}{pA}, \frac{\frac{1}{2}\rho V^2}{p} \right)$

(D) $\frac{F}{\frac{1}{2}\rho V^2 A} = \phi\left(\mathrm{Re}, \frac{\frac{1}{2}\rho V^2}{p} \right)$

21. The sketch below shows a hollow hemispherical shell partially filled with a fluid "B" floating in another fluid "A." A hole has been drilled in the bottom of the shell, and the hole is plugged by a cork. Initially, the system is at static equilibrium. Fluid B is denser than fluid A, and the relative levels of their free surfaces are shown. The material composing the shell is denser than either fluid. What will happen if the cork is removed?



(A) Fluid B will flow downwards out of the hole until the shell empties (rising during this process), and then fluid A will flow upwards to eventually fill and sink the shell.
(B) Fluid A will flow upwards through the hole to displace fluid B upwards. Eventually the shell will fill and sink.
(C) Fluid B will flow downwards so that the shell floats higher and higher and does not sink.
(D) Fluid A will flow upwards to float on top of fluid B inside the shell, and the shell will continuously sink downwards.