CVEN 311 – Fluid Dynamics
Fall Semester 2010
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Final Exam

8 pages, front & back, not including reference sheets; 22 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 points*. ***Clearly* write the letter corresponding to the best answer in the blank provided on the answer sheet.**

1. Water (temperature 20° C) flows through a tube of diameter 10 mm with velocity 100 mm/s. What is the value of the Darcy-Weisbach friction factor *f* for this flow?

   (A) 0.064
   (B) 33.1
   (C) 0.663
   (D) 6.54×10^{-8}

2. A Pitot-static tube is used to measure velocity of diesel fuel (ρ = 1.617 slugs/ft^3) flowing in a pipe. If pressure on the pitot gage is 66.2 psi and pressure on the static gage is 45.0 psi, the velocity of the flow (ft/sec) is most nearly:

   (A) 1.11
   (B) 1.22
   (C) 4.16
   (D) 14.6

3. A turbine is used to extract energy from water (temperature 50° F) flowing through a large pipe. The pipe is 60 inches in diameter, and the velocity of the flow is 9.7 ft/sec. If the shaft head extracted from the flow is 36.9 ft, the turbine's power output (hp) will be:

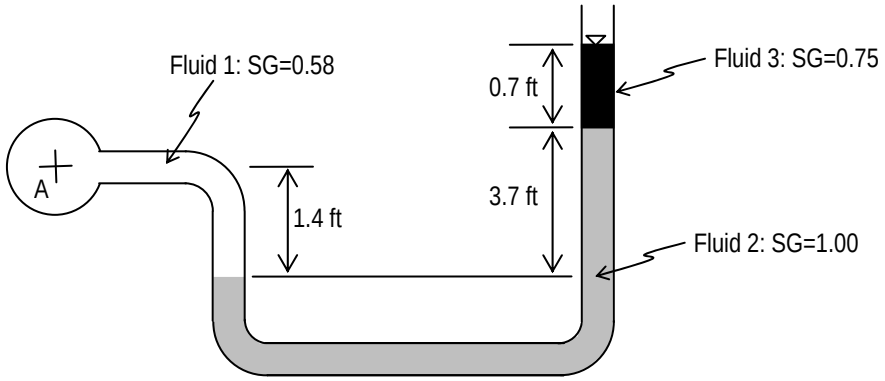
   (A) 24.8
   (B) 159
   (C) 797
   (D) 3190

4. Which of the following statements regarding hydraulic and energy grade lines for flows in pipes are true?

   I. It is impossible for the hydraulic grade line to be above the energy grade line.
   II. It is impossible for the hydraulic grade line to be at the same elevation as the energy grade line.
   III. It is impossible for the hydraulic grade line to be below the elevation of the pipe centerline.
   IV. The difference between the hydraulic grade line and energy grade line elevations is always the pressure head.

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

5. A three fluid manometer is shown in the diagram below. The pressure at point A (lb/ft^2) is most nearly:

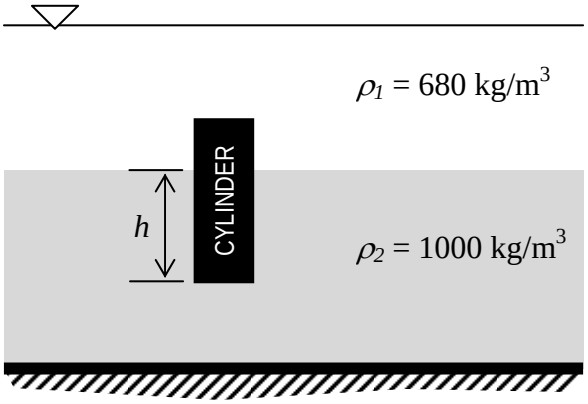


   (A) 249
   (B) 191
   (C) 213
   (D) 314

6. A water storage tank is a cylinder 75 ft in diameter and 32 ft high. Inflow to the tank is constant at 1200 gal/min, and the tank is empty at 12:00 Midnight. If outflow from the tank is 275 gal/min from 12:00 Midnight to 4:15 AM and zero after 4:15 AM, at what time will the tank be full of water?

   (A) 11:25 AM
   (B) 3:40 PM
   (C) 2:41 PM
   (D) 7:15 AM

7. A solid cylinder of diameter 0.2 m and height 1.0 m is immersed in two immiscible liquids as shown in the diagram below. The density of the cylinder material is 885 kg/m^3. The value of the dimension *h* is most nearly:



(A) 0.89 m
(B) 1.0 m
(C) 0.52 m
(D) 0.64 m

8. Water (temperature 5° C) flows at a velocity of 4.2 m/s in a 150 mm diameter pipe. The flow passes through a 90° bend with static pressure 83.0 kPa at both the entrance and exit of the bend. The force required to hold the bend in place is:

(A) 441 N
(B) 1640 N
(C) 2120 N
(D) 2520 N

9. Ethanol (ρ = 789 kg/m^3, μ = 0.00119 N·s/m^2) flows in a smooth 75 mm diameter pipe at a flowrate of 2.4 L/s. The head loss (m) per 100 m of pipe is most nearly:

(A) 0.867
(B) 0.471
(C) 0.0235
(D) 0.291

10. Which of the following statements regarding the Bernoulli equation are true?

I. The Bernoulli equation can be used for analysis of inviscid flows.
II. The Bernoulli equation can be used to calculate the difference in pressure between parallel streamlines in a circular flow.
III. The Bernoulli equation is a manifestation of the principle of conservation of energy.
IV. The Bernoulli equation describes the behavior of low Reynolds number flows better than it describes the behavior of high Reynolds number flows.

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

11. Motor oil ($\gamma = 8.95$ kN/m^3) flows through a partially closed valve. Static pressure immediately upstream and downstream of the valve are 552 kPa and 539 kPa, respectively. The flow velocity in the tubing upstream and downstream of the valve is 1.80 m/s. The minor loss coefficient of the valve is:

(A) 15.8
(B) 4.40
(C) 8.80
(D) 28.9

12. A desalination filter has an inflow of seawater ($\gamma = 64.0$ lb/ft^3) at a volumetric flowrate of 5000 gal/day. Two outflows leave the filter: pure water ($\gamma = 62.4$ lb/ft^3) at 3500 gal/day and waste brine. Assuming that the volume of dissolved salt is negligible, what is the specific weight γ of the waste brine?

(A) 88.8 lb/ft^3
(B) 63.2 lb/ft^3
(C) 64.7 lb/ft^3
(D) 67.7 lb/ft^3

13. A swimming pool with vertical sides and a level bottom is 12 ft deep, 30 ft long, and 30 ft wide is filled with seawater ($\gamma = 64.0$ lb/ft^3). The total force (lb) acting on one of the side walls is:

(A) 4,300
(B) 138,000
(C) 276,000
(D) 345,000

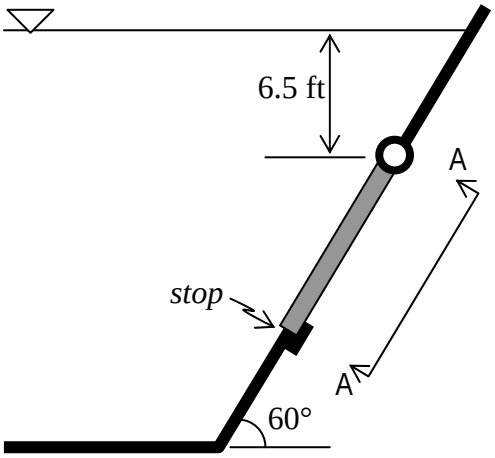
14. Water at 40° F flows through a smooth pipe with Re = 1800. If the flow velocity remains constant and the water temperature rises to 200° F, which of the following statements will be true?

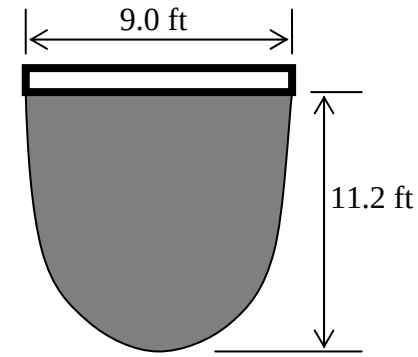
I. The flow will no longer be laminar.
II. The Darcy-Weisbach friction factor *f* will increase.
III. Head loss per unit length of pipe will increase.

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

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 *6 points*. ***Clearly* write the letter corresponding to the best answer in the blank provided on the answer sheet.**

15. A hinged parabolic shaped gate is built into the inclined side of a tank as shown in the drawings below. The fluid in the tank is seawater ($\gamma = 64.0$ lb/ft^3). The force (lb) exerted by the gate on the stop at its bottom edge is most nearly:





SECTION A-A
(Parabolic Gate and Hinge)

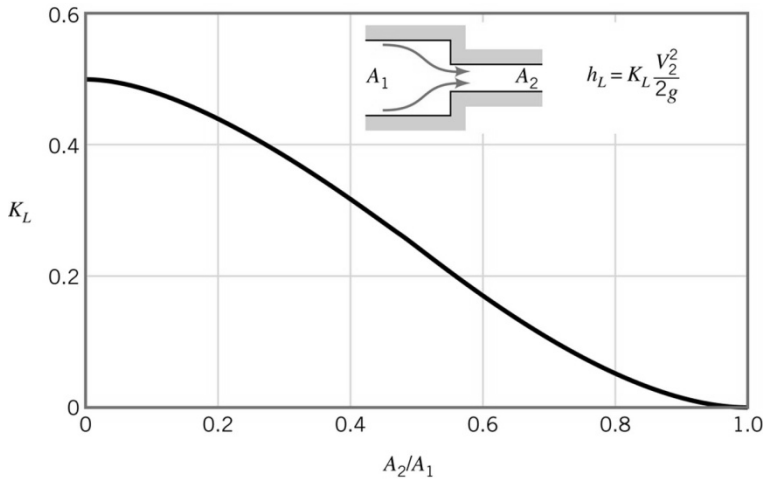
(A) 44,600
(B) 29,700
(C) 20,700
(D) 17,900

16. Which of the following statements regarding model similitude are true?

I. As long as the same fluid is used in the model and prototype, it is possible to have a model that is simultaneously Reynolds and Froude number similar.
II. It is possible to build a pipe flow model with the same Darcy-Weisbach friction factor *f* as its prototype even if the Reynolds numbers of the model and prototype are not the same.
III. If surface tension effects are important in the prototype, the model should be built with a high Weber number to account for those effects.
IV. Model similitude requires that the same fluid always be used in the prototype and the model.

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

17. Water flows from a 4 inch diameter pipe through a reducer coupling to continue in a 2 inch diameter pipe. Minor loss through the reducer is expected to follow the behavior described in the figure below. Which of the following statements is true?



(A) Static pressure in the flow will be higher after the coupling than before it.
(B) Momentum flux will be higher after the coupling than before it.
(C) Minor loss through the reducer will be less than the velocity head before the reducer.
(D) None of the above.

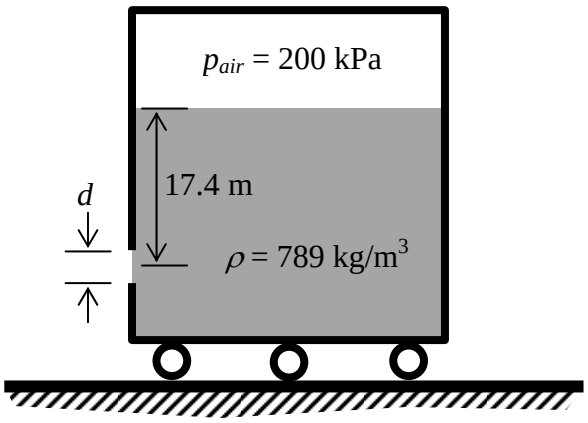
18. An open channel physical model will be used to assess behavior of oil slicks on river surfaces and will be Weber number similar. Water will be the principal fluid used in both the prototype and the model. The model will have a physical scaling ratio of 8.4:1 (prototype:model). If the volumetric flowrate in the prototype is 17.4 ft^3/sec, what should be the volumetric flowrate in the model?

(A) 0.715 ft^3/sec
(B) 0.247 ft^3/sec
(C) 2.07 ft^3/sec
(D) 6.00 ft^3/sec

19. A fluid flows in a long pipe (diameter 10 mm) in a laminar flow with no change in elevation. Two manometers installed 2 m apart record a loss of pressure head of 0.72 m. If the dynamic viscosity and density of the fluid are 1.50 N·s/m^2 and 1260 kg/m^3, what is the velocity of the flow?

(A) 31 mm/s
(B) 0.58 mm/s
(C) 9.3 mm/s
(D) 72 mm/s

20. A partially filled tank of ethanol includes a pocket of pressurized air and rests on rollers as shown in the diagram below. A circular sharp-edged orifice is located in the side of the tank with centerline 17.4 m below the liquid surface. What is the diameter *d* of the orifice if the propulsive force produced by the exiting jet is 2910 N?



(A) 0.07 m
(B) 0.19 m
(C) 0.03 m
(D) 0.12 m

21. A pump has a 6 inch diameter inflow pipe and an 8 inch diameter outflow pipe and is used to pump 50° F water. The gross energy input to the pump is 48 hp. Static pressure in the inflow and outflow pipes is 35 psi and 87 psi, respectively. If the velocity in the outflow pipe is 3.4 ft/sec, what is the efficiency of the pump?

(A) 0.13%
(B) 34%
(C) 69%
(D) 1.0%

Question 22 is a "work-out" problem for which partial credit may be given. You should answer the question on the answer sheet *exactly as asked* to receive credit as indicated.

22. A 100 ft long pipe of diameter 4 inches connects two reservoirs. The pipe material is cast iron. The pipe protrudes into both the upper and lower reservoirs. The elevations of the two reservoirs are 135 ft and 128 ft, respectively. Water at 50° F is the fluid present.

(i) Note the entrance and exit locations for an appropriate control volume, and write the full energy equation across that control volume. (3 pts)
(ii) Remove terms in the energy equation that may be neglected. (2 pts)
(iii) Expand all remaining terms to the expressions from which you will determine their values. (3 pts)
(iv) Re-arrange the equation from (iii) to one where velocity is isolated on one side. Circle any Reynolds number-dependent terms on the other side of the equation. (3 pts)
(v) Carry out an appropriate iterative solution to determine flow velocity through the pipe. In each iteration explicitly state: beginning value of velocity, Reynolds number, friction factor, calculated velocity. (5 pts)
(vi) State your final solution for flow velocity through the pipe. (2 pts)