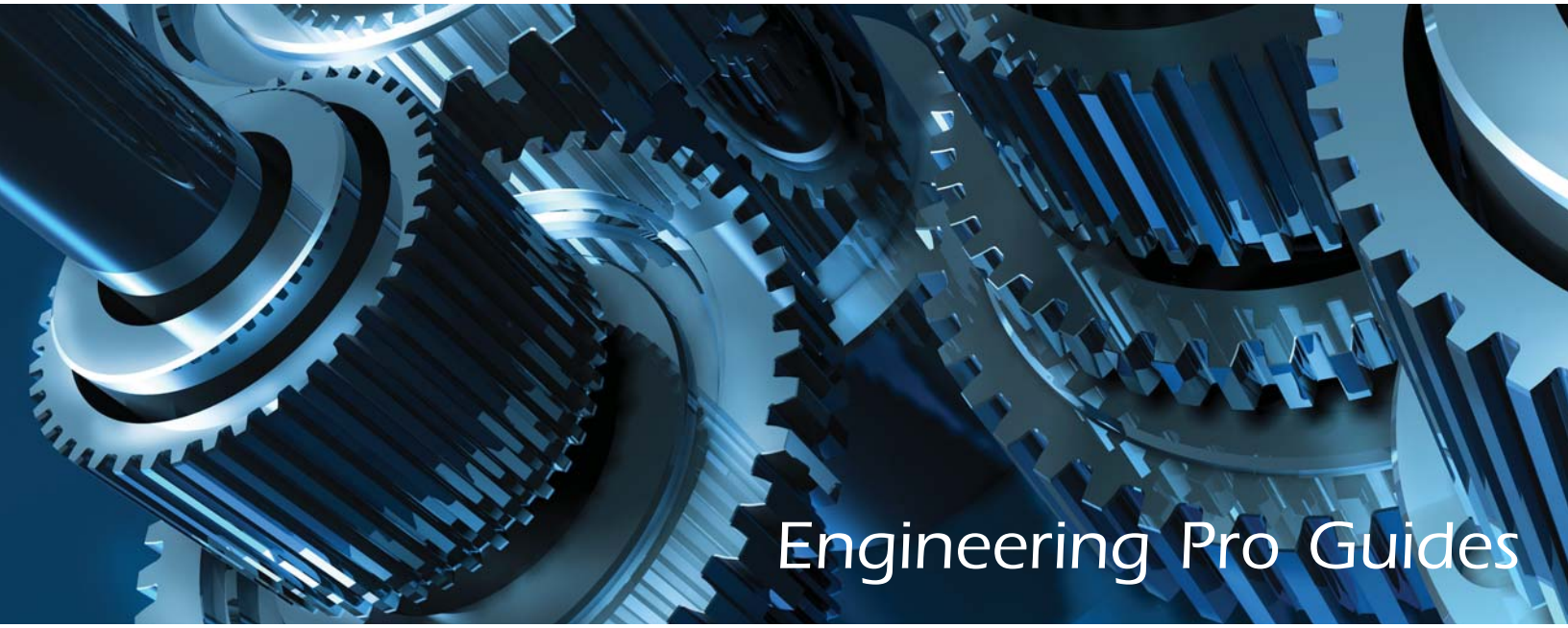
Mechanical PE Full Exam



Thermal & Fluids

- 80 exam difficulty level problems
- Covers Mechanical PE Thermal & Fluids exam topics
- Written in exam format
- Also includes detailed solutions

Justin Kauwale, P.E.

SECTION 1
INTRODUCTION

Introduction

Table of Contents

1.0 Introduction

One of the most important steps in an engineer's career is obtaining the professional engineering (P.E.) license. It allows an individual to legally practice engineering in the state of licensure. This credential can also help to obtain higher compensation and develop a credible reputation. In order to obtain a P.E. license, the engineer must first meet the qualifications as required by the state of licensure, including minimum experience, references and the passing of the National Council of Examiners for Engineering and Surveying (NCEES) exam. Engineering Pro Guides focuses on helping engineers pass the NCEES exam through the use of free content on the website, http://www.engproguides.com and through the creation of books like sample exams and guides that outline how to pass the PE exam.

The key to passing the PE exam is to learn the key concepts and skills that are tested on the exam. There are several issues that make this key very difficult. First, the key concepts and skills are unknown to most engineers studying for the exam. Second, the key concepts and skills are not contained in a single document. This exam tests the key concepts and skills required to pass the Mechanical - Thermal & Fluids Mechanical P.E. Exam.

1.1 Key Concepts and Skills

How are the key concepts and skills determined?

The key concepts and skills tested in this sample exam were first developed through an analysis of the topics and information presented by NCEES. NCEES indicates on their website that the P.E. Exam will cover an AM exam (4 hours) followed by a PM exam (4 hours) and that the exam will be 80 questions long, 40 questions in the morning and 40 questions in the afternoon. The Thermal & Fluids Mechanical PE exam will focus on the following topics as indicated by NCEES. (http://ncees.org/engineering/pe/):

I. Principles (32 questions)

A) Basic Engineering Practice *(6 questions)*
   1 Engineering terms and symbols
   2 Economic analysis
   3 Units and conversions

B) Fluid Mechanics *(6 questions)*
   1 Fluid properties (e.g., density, viscosity)
   2 Compressible flow (e.g., Mach number, nozzles, diffusers)
   3 Incompressible flow (e.g., friction factor, Reynolds number, lift, drag)

C) Heat Transfer Principles (e.g., convection, conduction, radiation) *(6 questions)*

D) Mass Balance Principles ((e.g., evaporation, dehumidification, mixing)) *(4 questions)*

E) Thermodynamics *(7 questions)*
   1 Thermodynamic properties (e.g., enthalpy, entropy)
   2 Thermodynamic cycles (e.g., Combined, Brayton, Rankine)
   3 Energy Balances (e.g., 1st and 2nd laws)

SECTION 2
AM SESSION QUESTIONS

QUESTION 1

Honey has a dynamic viscosity of 1,000 poise, a specific heat capacity of 0.6 cal/g-^{o}C, and a density of 0.05 oz/mL. The kinematic viscosity of honey, in ft^{2}/sec, is most nearly?

(A) 0.76

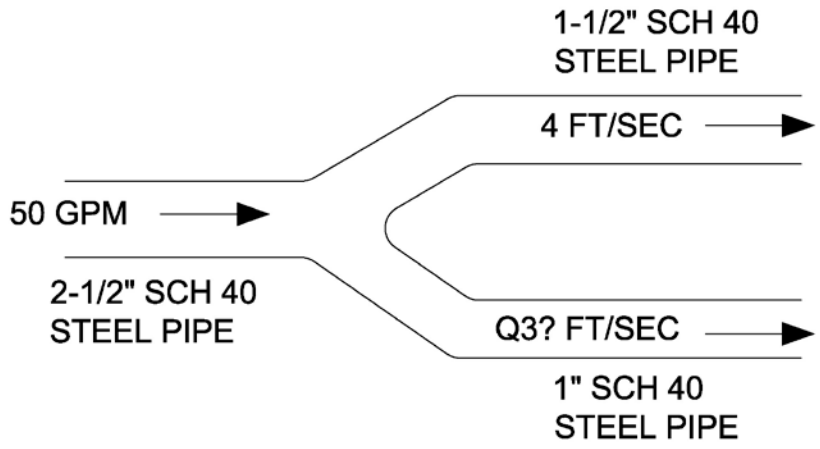
(B) 7.1

(C) 25

(D) 30

QUESTION 2

50 GPM of water flows through a 2-1/2" pipe and then branches into (2) pipes shown in the figure below. If the velocity in the 1-1/2" pipe is measured at 4 ft/sec, then what is the velocity through the 1" pipe?



(A) 3.9 ft/sec

(B) 5.6 ft/sec

(C) 7.2 ft/sec

(D) 9.1 ft/sec

QUESTION 19

What is the air to fuel ratio? Assume the equation is balanced.

$$C_4H_{10} + 6.5(O_2 + 3.76N_2) \rightarrow 4CO_2 + 5H_2O + 24.44N_2$$

(A) 10.1

(B) 12.9

(C) 14.8

(D) 15.4

QUESTION 37

A compressor has a pressure ratio of 10. Air enters the compressor at 70 F. If the air leaves at a temperature of 600 F, then what is the isentropic efficiency of the compressor?

(A) 0.97

(B) 0.93

(C) 0.86

(D) 0.81

QUESTION 38

A hydraulic pump must pump 100 GPM of a fluid with a specific gravity 1.55 to power a hydraulic system. The total pressure loss in the hydraulic system is 15 psi. Assume that the friction loss in the piping is 4 psi. What is the minimum motor horsepower required of the pump. Assume the pump has an efficiency of 55% and the motor has an efficiency of 95%.

(A) 0.5 HP

(B) 0.75 HP

(C) 1 HP

(D) 2 HP

QUESTION 39

A sensor is placed in a 2-inch, steel, schedule 40 pipe to measure the velocity pressure of the cooling water passing through the pipe. The velocity pressure is measured as 0.5 psi. What is the velocity of the cooling water?

(A) 2.1 ft/sec

(B) 5.7 ft/sec

(C) 8.6 ft/sec

(D) 12.1ft/sec

QUESTION 40

Which of the following is not a benefit of installing an intercooler and compressing air in two stages as opposed to compressing air in a single stage?

(A) There is an increase in efficiency in the multi-stage compression process with intercooler as compared to the single stage compression.

(B) There is an increase in volume in the multi-stage compression process with intercooler as compared to the single stage compression.

(C) There is a reduced amount of work done by compression in a multi-stage compression process with inter cooler as compared to the single stage compression.

(D) There is a decrease in the exiting temperature in the multi-stage compression process with intercooler as compared to the single stage compression.

SECTION 3
PM SESSION QUESTIONS

QUESTION 41

A manufacturer provides the viscosity for a fluid as 0.41 centipoise. The density of the fluid is 60 lbs/ft^3. A pump is used to pump 100 GPM of this fluid through a cooling system that has a total pressure drop of 100 ft of head. What is the mechanical horsepower required to pump this fluid?

(A) 0.2 horsepower

(B) 2.5 horsepower

(C) 3.6 horsepower

(D) 4.5 horsepower

QUESTION 42

A compressor is used to compress air from 14.7 psi to 225 psi. The air enters the compressor at a temperature of 100 F. What is the resulting enthalpy of the air?

The answer is most nearly,

(A) 134 Btu/lbm

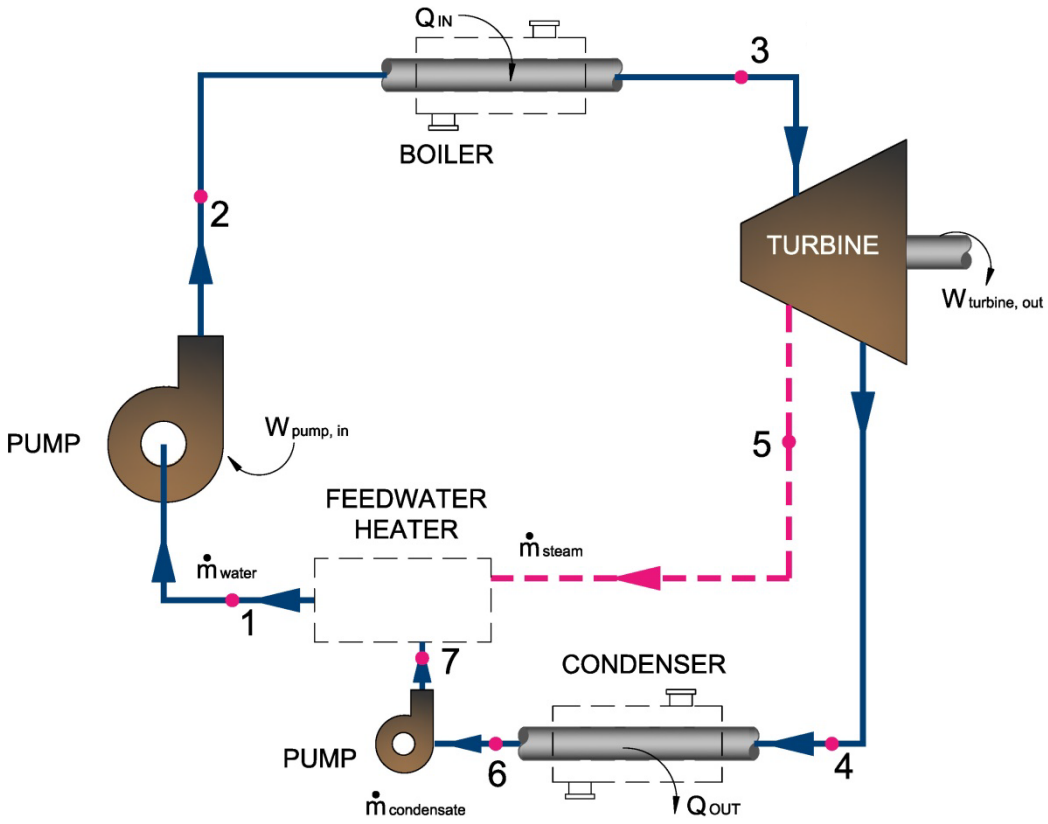
(B) 176 Btu.lbm

(C) 263 Btu/lbm

(D) 293 Btu/lbm

QUESTION 78

A steam power plant operates at a maximum pressure of 500 psia and a low pressure value of 14.7 psia. 50 lbm/hr of the steam is extracted from the turbine at 50 psia and is directed to the open feedwater heater. The maximum temperature is 1000 F. 510 lbm/hr is directed to the condenser. The temperature of the condensate at point 7 is 130 F. What is the resulting temperature at point 1?



(A) 200 F

(B) 210 F

(C) 220 F

(D) 230 F

SECTION 4
AM SESSION SOLUTIONS

SOLUTION 1

Honey has a dynamic viscosity of 1,000 poise, a specific heat capacity of 0.6 cal/g-^{o}C, and a density of 0.05 oz/mL. The kinematic viscosity of honey, in ft^2/sec, is most nearly?

Kinematic viscosity is defined as:

$$\nu = \frac{\mu}{\rho}$$

The specific heat capacity is irrelevant.

The dynamic (or absolute) viscosity is irrelevant:

$$\mu = (1000\ poise) * \frac{1\ \text{Pa} \cdot \text{s}}{10\ \text{poise}} * \frac{0.020885 \frac{\text{lbf}}{\text{ft}^2}}{Pa} = 2.09 \frac{lbf \cdot s}{ft^2}$$

The density is:

$$\rho = 0.05 \frac{oz}{mL} * \frac{0.0625\ lbm}{1\ oz} * \frac{28317\ mL}{1\ ft^3} = 88.4 \frac{lbm}{ft^3}$$

Therefore the kinematic viscosity is:

$$\nu = 2.09 \frac{lbf \cdot s}{ft^2} * \frac{ft^3}{88.4\ lbm} * 32.2 \frac{lbm * \frac{ft}{s^2}}{lbf} = 0.76 \frac{ft^2}{s}$$

The correct answer is **(A) 0.76**

SOLUTION 20

An open feedwater heater is supplied with 200 lbm/hr of water at 70 F and steam from the turbine at 100 lbm/hr at 300 F. Assume the pressure of the water and steam is 14.7 psia. What is the resulting enthalpy and mass flow rate of the mixture?

The first step is to find the enthalpy of the entering conditions.

200 lbm/hr of water at 70 F (14.7 psia):

$$Saturated\ steam\ table, subcooled\ liquid, 70\ F\text{:}\ h_{liquid} = 38.08 \frac{Btu}{lbm}$$

Steam from the turbine at 100 lbm/hr at 300 F (14.7 psia):

$$Superheated\ steam\ table, 300\ F, 14.7\ psia\text{:}\ h_{steam} = 1{,}192.7 \frac{Btu}{lbm}$$

Now you should mix the two incoming streams via the lever rule.

$$\dot{m}_{liquid} * h_{liquid} + \dot{m}_{steam} * h_{steam} = \dot{m}_{mix} * h_{mix}$$

$$Mass\ Balance \rightarrow \dot{m}_{mix} = \dot{m}_{liquid} + \dot{m}_{steam} = 300 \frac{lbm}{hr}$$

$$200 \frac{lbm}{hr} * 38.08 \frac{Btu}{lbm} + 100 \frac{lbm}{hr} * 1{,}192.7 \frac{Btu}{lbm} = 300 \frac{lbm}{hr} * h_{mix}$$

$$h_{mix} = 423\ Btu/lbm$$

The correct answer is most nearly**, (C) 300 lbm/hr at h =420 Btu/lbm**.

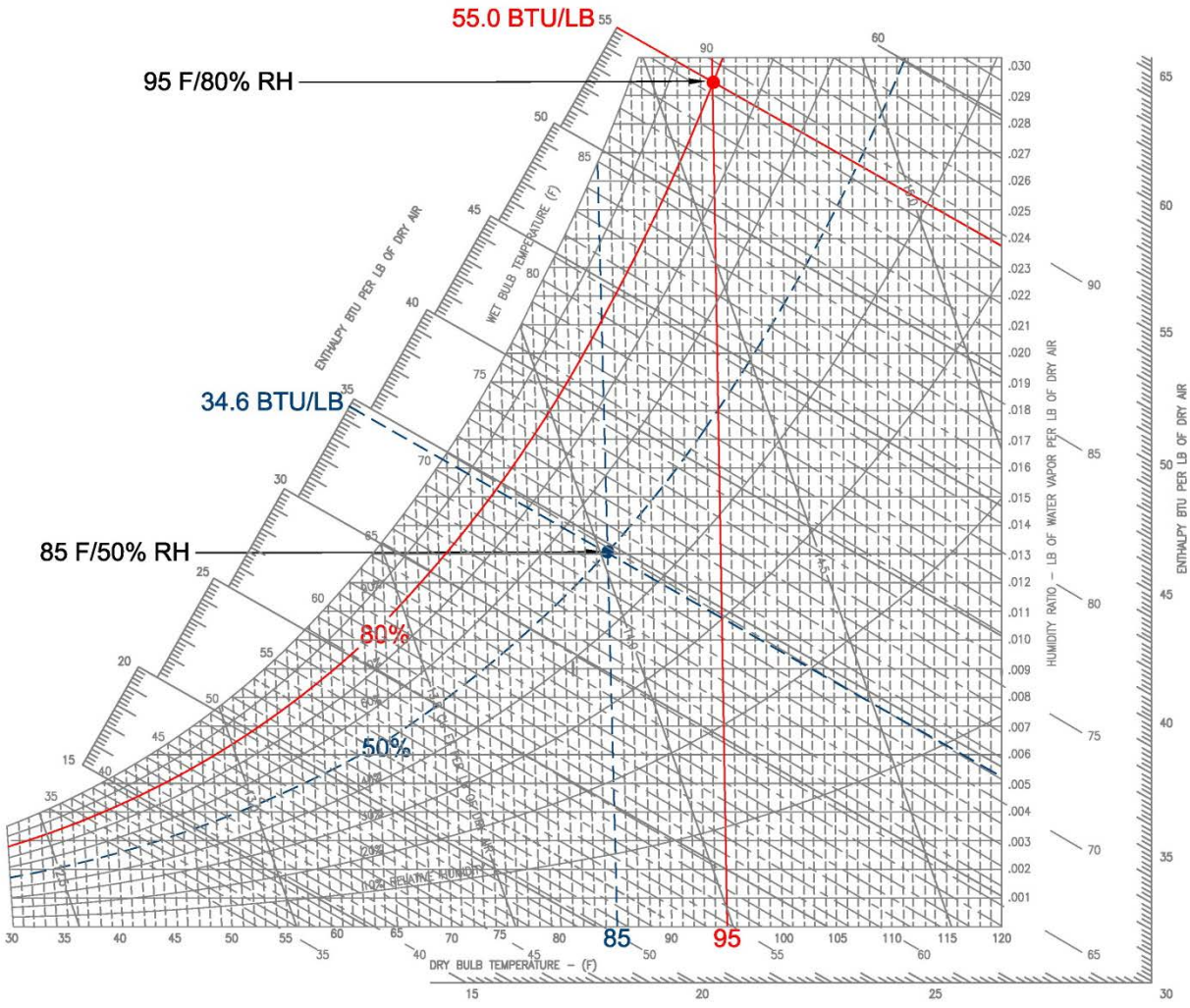
SOLUTION 31

A cooling tower is used to cool 10,000 lbs/hr of condenser water from 105 F to 80 F. If the air is designed to enter at ambient air conditions of 85 F/50% relative humidty and leave at 95 F/80% relative humidity, then what is the mass flow rate of air required?

The energy from the condenser water is transferred to the air.

$$\dot{m}_{water} * c_{p,water} * \left(T_{enter,water} - T_{leaving,water}\right) = \dot{m}_{air} * (h_{leaving,air} - h_{enter,air})$$

$$h_{leaving,air} \; and \; h_{enter,air} \; are \; found \; using \; the \; psychrometric \; chart$$



$$10{,}000\frac{lbs}{hr} * 1.0\frac{BTU}{lbm\ °\mathrm{F}} * (105 - 80\ F) = \dot{m}_{air} * (55.0 - 34.6\frac{BTU}{lbm})$$

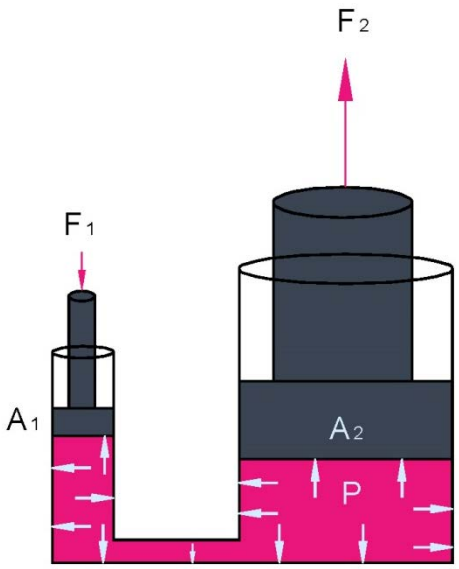
$$12{,}255\frac{lbs}{hr} = \dot{m}_{air}$$

The correct answer is most nearly, **(D) 12,255 lbs/hr**

SECTION 5
PM SESSION SOLUTIONS

QUESTION 47

A master cylinder compresses the hydraulic fluid to a pressure of 80 psi. Cylinder 2 in the diagram below has a diameter of 6" and Cylinder 1 has a diameter of 1". What is the ratio of Force 2 to Force 1.



A pressure of 80 psi is exerted on both area 1 and area 2, where pressure is equal to force divided by area.

$$80\ psia = \frac{F_1}{A_1} = \frac{F_2}{A_2};$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2} \rightarrow \frac{F_2}{F_1} = \frac{A_2}{A_1}$$

$$\frac{F_2}{F_1} = \frac{\pi * \frac{D^2}{4}}{\pi * \frac{D^2}{4}}$$

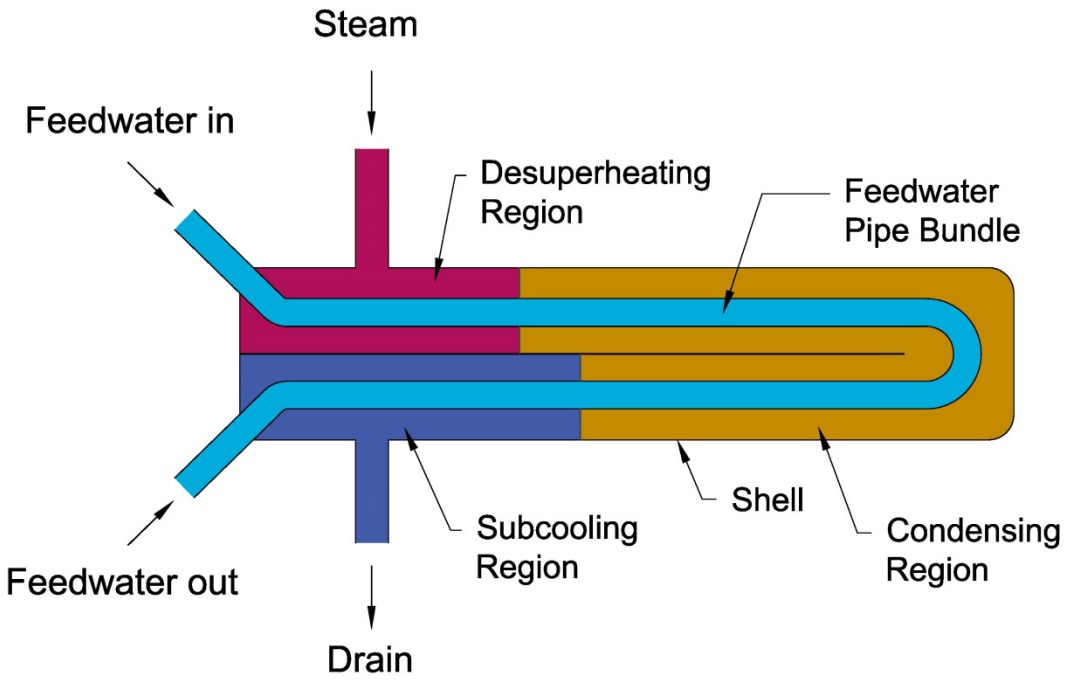
$$\frac{F_2}{F_1} = \frac{\pi * \frac{6^2}{4}}{\pi * \frac{1^2}{4}}$$

$$\frac{F_2}{F_1} = 36$$

The correct answer is most nearly, **(A) 36**.

QUESTION 73

Steam enters a closed feedwater heater and normally leaves as a condensate (sub-cooled liquid). However, you notice that vapor is leaving the feedwater heater through the drain in lieu of condensate. Which of the following is most likely true? Assume there have been no changes to the feedwater or steam conditions and flow rates.



Since, there have been no changes to the feedwater or steam conditions or flow rate, then something must have occurred within the feedwater heater. A feedwater heater is in its basic form a type of heat exchanger. Overtime, the surfaces where heat transfer occurs will build up deposits, which will block heat transfer from one fluid to the other fluid. This buildup is called fouling. This buildup decreases the heat transfer coefficient. Once the buildup is cleaned, the heat transfer coefficient should be increased.

The correct answer is most nearly, **(D).**

SECTION 6
CONCLUSION

5.0 CONCLUSION

If you have any questions on this sample exam or any other Engineering Pro Guides product, then please contact:

Justin Kauwale at contact@engproguides.com

Hi. My name is Justin Kauwale, the creator of Engineering Pro Guides. I will be happy to answer any questions you may have about the PE exam. Good luck on your studying! I hope you pass the exam and I wish you the best in your career. Thank you for your purchase!

SECTION 7
DIAGNOSTICS OUTLINE

Mechanical PE Exam – Thermal & Fluids
AM Session -Sample Exam Diagnostics

#	Major Category	Correct?
1	Principles – Basic Engineering Practice	
2	Principles – Basic Engineering Practice	
3	Principles – Basic Engineering Practice	
4	Principles – Basic Engineering Practice	
5	Principles – Basic Engineering Practice	
6	Principles – Basic Engineering Practice	
7	Principles – Fluid Mechanics	
8	Principles – Fluid Mechanics	
9	Principles – Fluid Mechanics	
10	Principles – Fluid Mechanics	
11	Principles – Fluid Mechanics	
12	Principles – Fluid Mechanics	
13	Principles – Heat Transfer	
14	Principles – Heat Transfer	
15	Principles – Heat Transfer	
16	Principles – Heat Transfer	
17	Principles – Heat Transfer	
18	Principles – Heat Transfer	
19	Principles – Mass Balance	
20	Principles – Mass Balance	
21	Principles – Mass Balance	
22	Principles – Mass Balance	
23	Principles - Thermodynamics	
24	Principles - Thermodynamics	
25	Principles - Thermodynamics	
26	Principles - Thermodynamics	
27	Principles - Thermodynamics	
28	Principles - Thermodynamics	
29	Principles – Supportive Knowledge	
30	Principles – Supportive Knowledge	
31	Principles – Supportive Knowledge	
32	Principles – Supportive Knowledge	
33	Application – Hydraulic & Fluid Equip.	
34	Application – Hydraulic & Fluid Equip.	
35	Application – Hydraulic & Fluid Equip.	
36	Application – Hydraulic & Fluid Equip.	
37	Application – Hydraulic & Fluid Equip.	
38	Application – Hydraulic & Fluid Equip.	
39	Application – Hydraulic & Fluid Equip.	
40	Application – Hydraulic & Fluid Equip.	

Mechanical PE Exam – HVAC & Refrigeration
PM Session -Sample Exam Diagnostics

#	Major Category	Correct?
41	Application – Hydraulic & Fluid Equip.	
42	Application – Hydraulic & Fluid Equip.	
43	Application – Hydraulic & Fluid Equip.	
44	Application – Hydraulic & Fluid Equip.	
45	Application – Hydraulic & Fluid Equip.	
46	Application – Hydraulic & Fluid Equip.	
47	Application – Hydraulic & Fluid Equip.	
48	Application – Hydraulic & Fluid Distr.	
49	Application – Hydraulic & Fluid Distr.	
50	Application – Hydraulic & Fluid Distr.	
51	Application – Hydraulic & Fluid Distr.	
52	Application – Hydraulic & Fluid Distr.	
53	Application – Hydraulic & Fluid Distr.	
54	Application – Hydraulic & Fluid Distr.	
55	Application – Hydraulic & Fluid Distr.	
56	Application – Hydraulic & Fluid Distr.	
57	Application – Energy/Power Equip.	
58	Application – Energy/Power Equip.	
59	Application – Energy/Power Equip.	
60	Application – Energy/Power Equip.	
61	Application – Energy/Power Equip.	
62	Application – Energy/Power Equip.	
63	Application – Energy/Power Equip.	
64	Application – Energy/Power Equip.	
65	Application – Cooling/Heating	
66	Application – Cooling/Heating	
67	Application – Cooling/Heating	
68	Application – Cooling/Heating	
69	Application – Cooling/Heating	
70	Application – Cooling/Heating	
71	Application – Energy Recovery	
72	Application – Energy Recovery	
73	Application – Energy Recovery	
74	Application – Energy Recovery	
75	Application – Energy Recovery	
76	Application – Combined Cycles	
77	Application – Combined Cycles	
78	Application – Combined Cycles	
79	Application – Combined Cycles	
80	Application – Combined Cycles	