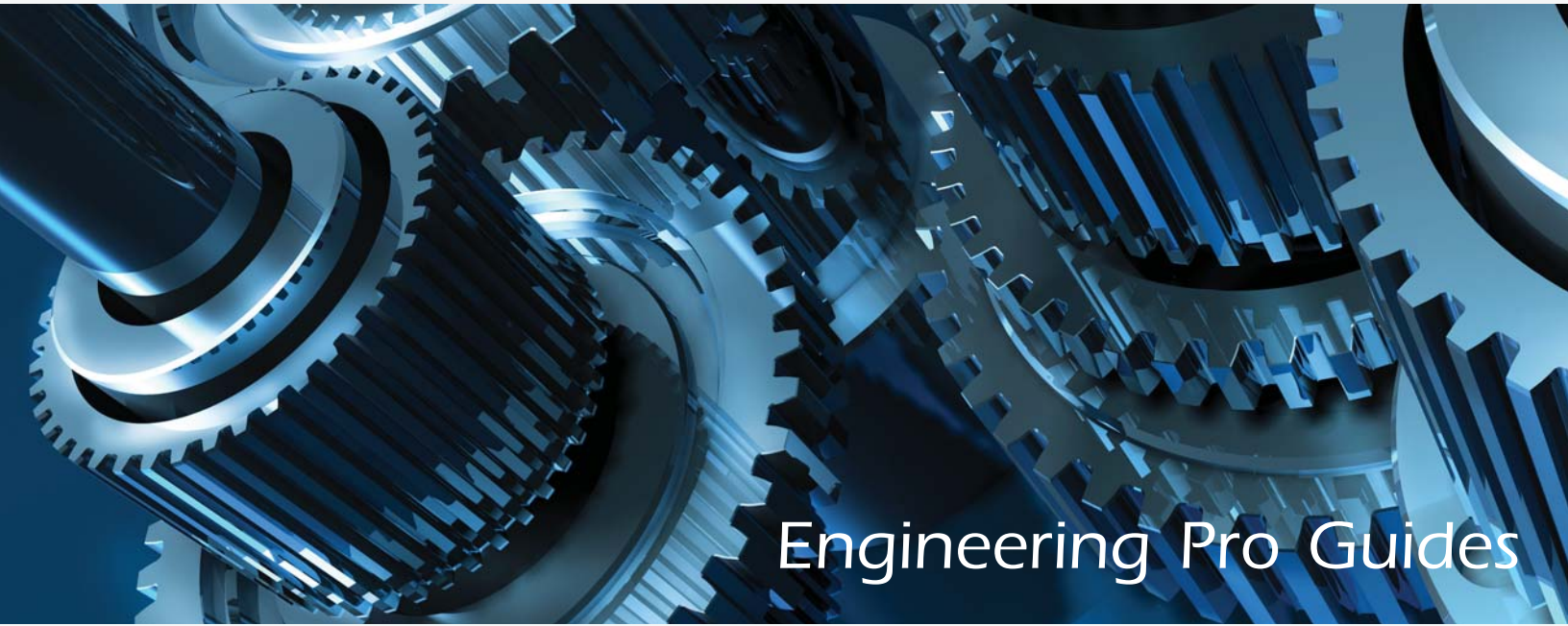


# Mechanical PE

## HVAC References Exam



Engineering Pro Guides

# HVAC & Refrigeration

## Supplemental Reference Lookup Practice Problems

- 40 reference specific exam problems
- Tests ASHRAE Handbook lookup for the HVAC PE Exam
- Practice your familiarity and speed with HVAC References
- Written in exam format with exam difficulty level
- Also includes detailed solutions

Justin Kauwale, P.E.

# SECTION 1

## INTRODUCTION

# 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 this sample exam and technical study guides.

This sample exam is intended to be a sample test on ONLY your knowledge of the references required for the HVAC & Refrigeration Mechanical P.E. Exam. A portion of the exam will require you to use your references to find solutions to problems. The remainder of the exam will test your skills and knowledge on the key concepts and skills in the HVAC & Refrigeration field.

## 1.1 KEY CONCEPTS AND SKILLS

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 the PM exam (4 hours). Within the Mechanical Engineering field, there are three specialties to choose from for the depth exam: HVAC & Refrigeration, Thermal & Fluids and Mechanical Systems & Materials.

This sample exam focuses on the HVAC and Refrigeration topic. NCEES indicates on their website that the HVAC and Refrigeration exam will focus on the following topics:

(<http://ncees.org/engineering/pe/>):

- Topic 1.0 - Introduction (0 of 80 problems)
- Topic 2.0 - Basic Engineering Practice (4 of 80 problems)
- Topic 3.0 - Thermodynamics (4 of 80 problems)
- Topic 4.0 - Psychrometrics (8 of 80 problems)
- Topic 5.0 - Heat Transfer (7 of 80 problems)
- Topic 6.0 - Fluid Mechanics (4 of 80 problems)
- Topic 7.0 - Energy/Mass Balance (5 of 80 problems)
- Topic 8.0 - Heating/Cooling Loads (8 of 80 problems)
- Topic 9.0 - Equipment & Components (18 of 80 problems)
- Topic 10.0 - Systems & Components (18 of 80 problems)
- Topic 11.0 - Supportive Knowledge (4 of 80 problems)

Each of these topics were investigated and filtered by Engineering Pro Guides for concepts and skills that meet the following criteria:

(1) First, the concept and skill must be commonly used in the HVAC & Refrigeration field of Mechanical Engineering. For example, pump sizing, fan sizing, determining friction losses and calculating net positive suction head are regular occurrences in the HVAC & Refrigeration field. The breakdown of question topics is shown in the list above.

(2) Second, the skill and concept must be testable in roughly 6 minutes per problem. There are (40) questions on the afternoon exam and you will be provided with 4 hours to complete the test. This results in an average of 6 minutes per problem. This criterion limits the complexity of the exam problems and the resulting solutions. For example, pressure drop calculations are common in the HVAC & Refrigeration field, but the calculation is often very lengthy because of the number of steps involved, especially if a unique fluid and flow condition is used. Thus, common fluids like water/air and common pipe/duct materials are used.

(3) Third, the key concepts and skills must be used or be known by practicing HVAC & Refrigeration Mechanical Engineers. This criterion is similar to the first criterion. However, this criterion filters the concepts and skills further by limiting the field to material encountered and used by practicing engineers. The HVAC & Refrigeration, Thermal & Fluids and Mechanical Systems & Materials fields are vast and there are many different avenues an engineer can take. Two diverging paths are those engineers involved in research and those who practice. Research engineers are pushing the boundaries of the field and are highly focused in their specific area of the field. The Professional Engineering exam does not cover emerging technologies or highly focused material.

(4) The P.E. Exam must test the principle or application of the skill and concept and not the derivations or the background knowledge of the topic or concept. The exam also does not cover background information on the NCEES topics. The P.E. Exam is meant to prove that the test taker is minimally competent to practice in the Mechanical Engineering field. The exam is less concerned with theory and more with the principle or application of the theory, skill or concept. For example, the P.E. exam is less concerned with the theory of evaporation in a cooling tower and more with the performance and selection of a cooling tower.

In summary, this book is intended to provide a sample of the necessary skills and concepts to develop a minimally competent, practicing professional engineer in the Mechanical Engineering field, capable of passing the P.E. exam. This book does this through the following means:

(1) Providing sample problems that can be completed in roughly 6 minutes per problem.

(2) Providing solutions to these problems that teach skills and concepts used by practicing Mechanical Engineers.

## 1.2 UNITS

The primary units that are used in the P.E. Exam are United States Customary System Units (USCS). As such, this guide focuses exclusively on the USCS. However, it is recommended that the test taker have a conversion book, because certain areas of the P.E. Exam may use the International System of Units (SI).

## 2.0 DISCLAIMER

In no event will Engineering Pro Guides be liable for any incidental, indirect, consequential, punitive or special damages of any kind, or any other damages whatsoever, including, without limitation, those resulting from loss of profit, loss of contracts, loss of reputation, goodwill, data, information, income, anticipated savings or business relationships, whether or not Engineering Pro Guides has been advised of the possibility of such damage, arising out of or in connection with the use of this document or any referenced documents and/or websites.

This book was created on the basis of determining an independent interpretation of the minimum required knowledge and skills of a professional engineer. In no way does this document represent the National Council of Examiners for Engineers and Surveying views or the views of any other professional engineering society.

## 3.0 HOW TO USE THIS SAMPLE EXAM

This exam can be used in multiple ways, depending on where you are in your study process. If you are at the beginning or middle, it can be used to test your competency, gain an understanding and feel for the test format, and help to highlight target areas to study. If you are at the end, it can be used to determine your preparedness for the real exam. Remember that the questions are a sample of the many topics that may be tested and are limited to fit a full exam length and therefore is not comprehensive of all concepts.

Because the exam is written to be similar to the difficulty and format of the NCEES exam, it is recommended that the test be completed in one sitting and timed for four hours to simulate the real exam. This will give you a better indication of your status of preparation for the exam. Review the exam day rules and replicate the environment for the real test as much as possible, including the type of calculator you may use and the acceptable references. Keep a watch or clock next to you to gauge your pace for 40 questions in 4 hours.

Based on the NCEES website, the following are general rules for exam day.

Allowed:

1. Snacks that are not disruptive to others
2. Watches and small clocks (highly recommended on test day, some test facilities do not have a clock)
3. Religious head coverings
4. Two straight edges: e.g. ruler, scale, protractor, triangle
5. Approved references
6. Approved calculator (2 recommended for backup)
7. Eyeglasses
8. Non electronic magnifying glass
9. (Units conversion book is also recommended)

Prohibited:

1. Cell phones
2. Hats and hoods
3. Slide charts, wheel charts, drafting compasses
4. Weapons
5. Tobacco
6. Personal Chairs
7. Eyeglass/Magnifying glass cases
8. Scratch Paper (all writing must be done in the exam booklet)

For additional references on exam day policies, exam day processes, and items to bring on your exam day, review the NCEES Examinee Guide:

<http://ncees.org/exams/examinee-guide/>

Similar to the NCEES exam, the tested topics are presented in a random order. For best use of your time, answer the questions that you know first and return to the questions that you are unfamiliar with later. Once all the known questions are answered, go through the test again and attempt to answer the remaining questions by level of difficulty. If time allows, review your answers.

If you are stuck on a question, seek the following avenues.

1. Study Guide: It is important to understand your study guides and indices. During times of uncertainty, these will likely lead you to your answers. Determine the key concept that is being asked in the question and refer to your indices or pre-tabbed sections. The answer will hopefully be found in the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Handbooks or one of the other references, listed below.
2. Process of Elimination: There are only four possible choices for each question. Ask yourself if there is an answer that does not make sense and eliminate it. Further narrow down the answer that are derived from equations or concepts that you know are not right and are instead meant to deceive the test taker. See if there are answers that are similar or separated by something like a conversion error. This may be an indication that the correct equation was used.
3. Educated Guess: Remember that there is no penalty for wrong answers. Hopefully with the process of elimination you are able to narrow down as many answers as possible and are able to create an educated guess.
4. Rules of Thumb: Rules of thumb can be used to not only speed up time, but to help lead you in the right direction.

5. If the time is almost up and there are still unanswered questions remaining, determine whether it makes sense to check for mistakes on the problems you do know how to solve, or to tackle the unanswered problems.

#### Typical Exam Verbiage/Design:

1. Most Nearly: Due to rounding differences, the exam answers will not match yours exactly and in fact may not closely resemble your answer. NCEES uses the term “most nearly” to test your confidence in your solution. When the question prompts you with “most nearly”, choose the answer that most closely matches yours, whether it be greater than or lesser to your value.
2. Irrelevant Information: The exam is intended to test your overall understanding of concepts. At times the question will include unnecessary information that is meant to misdirect you.
3. Deceiving Answers: NCEES wants to know that you are able to determine the appropriate methods for the solutions. There are answers that were intentionally produced from wrong equations to mislead the test taker. For example, you may forget a 1/2 in the formula,  $KE = (1/2)MV^2$  and there would be two answers each off by a factor of 1/2.
4. Do Not Overanalyze: The exam questions are meant to be completed in 6 minutes. Therefore, they are intended to be written as straight forward as possible. Do not be tempted to overanalyze the meaning of a question. This will only lead you down the wrong path.

#### Review the Solutions:

Once the sample test is completed, grade your results. Measure your aptitude in speed, concept comprehension, and overall score. If your score is above the 75% range then you are in good shape. This 75% score is only applicable if you have prepared completely for the exam. If you are just starting out, then please do not be worried about a low score. This number is also just a range; there is no finite score to determine passing the test. Instead, NCEES calibrates the results against practicing professional engineers. See this page <http://ncees.org/exams/scoring-process/> for a better understanding of how NCEES grades the scores.

Review the answers that you got wrong and use the solutions as a learning tool on how to address these types of problems. Compare the types of questions you are missing with the NCEES outline of topics and determine where you should focus your studying. Finally repeat as many practice problems as you can to get a better grasp of the test and to continually improve your score.





## 4.0 RECOMMENDED REFERENCES

The following references are recommended to be reviewed prior to the exam and should be used during the exam. When reviewing these references, make sure you first understand the content. These references are intended for the afternoon depth exam and are used as references by practicing Mechanical HVAC Engineers. Secondly, you should be very familiar with the indices of these references and should be able to navigate the references to find information quickly. This may require you to insert tabs into the references. Once you have completed these two tasks then you should be ready to use these references during the exam. (Tip: It is helpful to have the indices of your references printed separately to allow you to have both the index and the reference material open at the same time, making for quicker searches.)

Complete List of References for the HVAC & Refrigeration PE Exam			
	By Engineering Pro Guides	<a href="http://www.engproguides.com">www.engproguides.com</a>	
Engineering Pro Guides provides a power technical study guide that teaches the key concepts and skills necessary to pass the HVAC & Refrigeration PE Exam. If you have any suggestions to this list, please email me Justin at <a href="mailto:contact@engproguides.com">contact@engproguides.com</a>			
<b>Topic 2.0</b>	<b>Basic Engineering Practice</b>	<b>4 of 80 problems</b>	
	Units and Conversions	<a href="#">Engineering Unit Conversions</a>	
	Economic Analysis	<a href="#">Economics Factors</a>	
		<a href="#">Compound Interest Tables</a>	
	Electrical Concepts (power consumption, motor ratings, heat output, amperage)	<a href="#">ASHRAE Systems 2016</a>	Ch 45 Motors, Motor Controls and Variable Frequency Drives
<b>Topic 3.0</b>	<b>Thermodynamics</b>	<b>4 of 80 problems</b>	
	Cycles	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 2 Thermodynamics
	Properties	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 2 Thermodynamics
	Compression Process	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 2 Thermodynamics
<b>Topic 4.0</b>	<b>Psychrometrics</b>	<b>10 of 80 problems</b>	
	Heating/Cooling Processes	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 1 Psychrometrics
	Humidification/Dehumidification Processes	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 1 Psychrometrics
	Psychrometric Charts (various elevations and low temperature)	<a href="http://www.coolerado.com/pdfs/Psychrmtrcs/5000Psychrmtrc11x17.pdf">http://www.coolerado.com/pdfs/Psychrmtrcs/5000Psychrmtrc11x17.pdf</a>	
		<a href="http://www.coolerado.com/pdfs/Psychrmtrcs/7500Psychrmtrc11x17.pdf">http://www.coolerado.com/pdfs/Psychrmtrcs/7500Psychrmtrc11x17.pdf</a>	
		<a href="http://www.coolerado.com/pdfs/Psychrmtrcs/0000Psych11x17 US SI.pdf">http://www.coolerado.com/pdfs/Psychrmtrcs/0000Psych11x17 US SI.pdf</a>	

		<a href="http://www.coolerado.com/pdfs/Psychmtrcs/2500PsychmtrcLetter.pdf">http://www.coolerado.com/pdfs/Psychmtrcs/2500PsychmtrcLetter.pdf</a>	
		<a href="http://www.mitsubishielectric.ca/en/hvac/PDF/erv/RenewAire_Low_Temp.pdf">http://www.mitsubishielectric.ca/en/hvac/PDF/erv/RenewAire_Low_Temp.pdf</a>	
<b>Topic 5.0</b>	<b>Heat Transfer</b>	<b>4 of 80 problems</b>	
	Conduction	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 4 Heat Transfer
	Convection	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 4 Heat Transfer
	Radiation	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 4 Heat Transfer
<b>Topic 6.0</b>	<b>Fluid Mechanics</b>	<b>4 of 80 problems</b>	
	Incompressible Flow	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 3 Fluid Flow
	Flow Analysis	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 3 Fluid Flow
<b>Topic 7.0</b>	<b>Energy/Mass Balances</b>	<b>5 of 80 problems</b>	
	Energy & Mass Balance	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 1 Psychrometrics
		<a href="#">ASHRAE Fundamentals 2017</a>	Ch 2 Thermodynamics
<b>Topic 8.0</b>	<b>Heating/Cooling Loads</b>	<b>8 of 80 problems</b>	
	Climate Design	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 14 Climate Design Information
	Fenestration	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 15 Fenestration
	Ventilation/Infiltration	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 16 Ventilation/Infiltration
	People Loads	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 18 Nonresidential Cooling/Heating Load Calculations
	Equipment Loads	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 18 Nonresidential Cooling/Heating Load Calculations
	Envelope Loads	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 18 Nonresidential Cooling/Heating Load Calculations
		<a href="#">ASHRAE Fundamentals 2017</a>	Ch 25 Heat, Air and Moisture Control in Building Assemblies - Fundamentals
<b>Topic 9.0</b>	<b>Equipment and Components</b>	<b>18 of 80 problems</b>	
	Cooling Towers and Fluid Coolers	<a href="http://pdf.directindustry.com/pdf/spx-cooling-technologies/cooling-tower-fundamentals/34010-40110.html">http://pdf.directindustry.com/pdf/spx-cooling-technologies/cooling-tower-fundamentals/34010-40110.html</a>	
		<a href="#">ASHRAE Systems 2016</a>	Ch 40 Cooling Towers
	Boilers (efficiencies, fuels, combustion)	<a href="#">ASHRAE Systems 2016</a>	Ch 32 Boilers
		<a href="#">ASHRAE Fundamentals 2017</a>	Ch 28 Combustion and Fuels
	Furnaces	<a href="#">ASHRAE Systems 2016</a>	Ch 33 Furnaces
	Heat Exchangers (shell and	<a href="#">ASHRAE Systems 2016</a>	Ch 48 Heat Exchangers

	tube, plate and frame)		
	Condensers	<a href="#">ASHRAE Systems 2016</a>	Ch 39 Condensers
	Evaporators	<a href="#">ASHRAE Systems 2016</a>	Ch 41 Evaporative Air Cooling Equipment
	Chillers	<a href="#">ASHRAE Systems 2016</a>	Ch 42 Liquid Coolers
	Variable Refrigerant Flow DX	<a href="#">ASHRAE Systems 2016</a>	Ch 18 Variable Refrigerant Flow
	Heat Pumps	<a href="#">ASHRAE Systems 2016</a>	Ch 49 Unitary Air Conditioners and Heat Pumps
		<a href="#">ASHRAE Systems 2016</a>	Ch 9 Applied Heat Pump and Heat Recovery Systems
	Pumps (laws, efficiency, selection)	<a href="#">ASHRAE Systems 2016</a>	Ch 44 Centrifugal Pumps
	Compressors (laws, efficiency, selection)	<a href="#">ASHRAE Systems 2016</a>	Ch 38 Compressors
	Fans (laws, efficiency, selection)	<a href="#">ASHRAE Systems 2016</a>	Ch 21 Fans
	Cooling/Heating Coils	<a href="#">ASHRAE Systems 2016</a>	Ch 23 Air-Cooling and Dehumidifying Coils
		<a href="#">ASHRAE Systems 2016</a>	Ch 27 Air-Heating Coils
	Control Systems Valves	<a href="#">ASHRAE Systems 2016</a>	Ch 47 Valves
	Control Systems Dampers	<a href="http://www.metropac.com/pneu/pdfs/77-1142.pdf">http://www.metropac.com/pneu/pdfs/77-1142.pdf</a>	
	Refrigerants (properties, types)	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 29 Refrigerants
		<a href="#">ASHRAE Fundamentals 2017</a>	Ch 30 Thermophysical Properties of Refrigerants
	Expansion Valves	<a href="#">ASHRAE Refrigeration 2014</a>	Ch 1 Halocarbon Refrigeration Systems
	Accumulators	<a href="#">ASHRAE Refrigeration 2014</a>	Ch 1 Halocarbon Refrigeration Systems
<b>Topic 10.0</b>	<b>Systems and Components</b>	<b>18 of 80 problems</b>	
	Air Handlers	<a href="#">ASHRAE Systems 2016</a>	Ch 4 Air Handling and Distribution
	Duct Design	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 21 Duct Design
	Terminal Devices	<a href="https://www.titus-hvac.com/file/7561/diffusers%20eng_guidelines2013.pdf">https://www.titus-hvac.com/file/7561/diffusers%20eng_guidelines2013.pdf</a>	
		<a href="#">ASHRAE Systems 2016</a>	Ch 20 Room Air Distribution Equipment
	Hydronic	<a href="#">ASHRAE Systems 2016</a>	Ch 13 Hydronic Heating and Cooling
	Oil	<a href="http://www.eclipsenet.com/uploadedFiles/Pages/Product_Inf">http://www.eclipsenet.com/uploadedFiles/Pages/Product_Inf</a>	

		<a href="http://www.eclipsenet.com/uploadedFiles/Pages/Product_Information/Eclipse_Engineering_Guide/Engineering_Guide_EFE_825.pdf">ormation/Eclipse_Engineering_Guide/Engineering_Guide_EFE_825.pdf</a>	
	Fuel Gas	<a href="http://www.eclipsenet.com/uploadedFiles/Pages/Product_Information/Eclipse_Engineering_Guide/Engineering_Guide_EFE_825.pdf">http://www.eclipsenet.com/uploadedFiles/Pages/Product_Information/Eclipse_Engineering_Guide/Engineering_Guide_EFE_825.pdf</a>	
	Compressed Air	<a href="https://www.atlascopco.com/en-uk/compressors/compressed-air-tips/compressed-air-manual">https://www.atlascopco.com/en-uk/compressors/compressed-air-tips/compressed-air-manual</a>	
	Steam	<a href="#">ASHRAE Systems 2016</a>	Ch 11 Steam Systems
	Pipe Design	<a href="#">ASHRAE Fundamentals 2017</a>	Ch 22 Pipe Sizing
		<a href="#">ASHRAE Systems 2016</a>	Ch 46 Pipes, Tubes and Fittings
	Food Storage	<a href="#">ASHRAE Refrigeration 2014</a>	Ch 19 Food Storage
	Refrigeration Cooling & Freezing	<a href="#">ASHRAE Refrigeration 2014</a>	Ch 20 Cooling and Freezing Times of Foods
	Enthalpy Wheels	<a href="http://www.johnsoncontrols.com/~media/jci/be/united-states/airside-systems/air-handling-units/files/be_appguide_energyrecoverywheel_ahu.pdf?la=en">http://www.johnsoncontrols.com/~media/jci/be/united-states/airside-systems/air-handling-units/files/be_appguide_energyrecoverywheel_ahu.pdf?la=en</a>	
		<a href="#">ASHRAE Systems 2016</a>	Ch 26 Air to Air Energy Recovery Equipment
	Heat Pipes	<a href="#">ASHRAE Systems 2016</a>	Ch 26 Air to Air Energy Recovery Equipment
	Run-Around Systems	<a href="#">ASHRAE Systems 2016</a>	Ch 26 Air to Air Energy Recovery Equipment
	Basic Control Concepts	<a href="#">ASHRAE Applications 2015</a>	Ch 47 Design and Application of Controls
<b>Topic 11.0</b>	<b>Supportive Knowledge</b>	<b>4 of 80 problems</b>	
	Codes and Standards	<a href="#">ASHRAE Refrigeration 2014</a>	<a href="#">ASHRAE Applications 2015</a>
		<a href="#">ASHRAE Systems 2016</a>	<a href="#">ASHRAE Fundamentals 2017</a>
	Air Quality and Ventilation	ASHRAE Standard 62.1	
	Filtration	<a href="#">ASHRAE Systems 2016</a>	Ch 29 Air Cleaners for Particulate Contaminants
	Vibration Control	<a href="#">ASHRAE Fundamentals 2017</a>	Chapter 8 - Sound and Vibration
		<a href="https://www.novibes.com/images/Technical%20Section.pdf">https://www.novibes.com/images/Technical%20Section.pdf</a>	
	Acoustics	<a href="#">ASHRAE Fundamentals 2017</a>	Chapter 8 - Sound and Vibration

Please see the below link to the online version of this spreadsheet for any updates. You can also read below about a majority of the different references. If you have any suggestions or questions on the list, please email Justin at [contact@engproguides.com](mailto:contact@engproguides.com) or you can comment on the online version of the spreadsheet.

Link: <http://www.engproguides.com/hvacreferences.html>

## 4.1 ENGINEERING UNIT CONVERSIONS BOOK

By Michael Lindeburg PE

The Engineering Unit Conversions book is useful when converting between SI and US units.

Amazon Link<sup>Error! Bookmark not defined.</sup>: [Engineering Unit Conversions](#)

*Topics Covered: 2.0 Basic Engineering Practice*

## 4.2 ASHRAE HANDBOOKS

By ASHRAE

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is the guiding source for the HVAC engineer. The society publishes four handbooks that contain the essential topics and knowledge for practicing engineer: *HVAC Systems and Equipment*, *HVAC Applications*, *Refrigeration*, *Fundamentals*. Each of these handbooks is updated in a four year rotation. The handbooks are comprehensive and detailed. It is not necessary to know the extensive details of these books, but it is essential to understand their layout and know how to navigate them. If there is a question that you are unsure of in the test, these books will likely have the solution. But because there is so much information, it will be difficult to find the necessary references without at least having a familiarity with these resources.

Amazon Link<sup>Error! Bookmark not defined.</sup>: [2017 ASHRAE Handbook: Fundamentals](#)

*Topics Covered: 3.0 Thermodynamics, 4.0 Psychrometrics, 5.0 Heat Transfer, 6.0 Fluid Mechanics, 7.0 Energy/Mass Balance, 8.0 Heating/Cooling Loads, 9.0 Equipment and Components, 10.0 Systems & Equipment*

Amazon Link<sup>Error! Bookmark not defined.</sup>: [2016 ASHRAE Handbook: HVAC Systems and Equipment](#)

*Topics Covered: 9.0 Equipment and Components, 10.0 Systems & Equipment and 11.0 Supportive Knowledge*

Amazon Link<sup>Error! Bookmark not defined.</sup>: [2015 ASHRAE Handbook: HVAC Applications](#)

*Topics Covered: 9.0 Equipment and Components, 10.0 Systems & Equipment and 11.0 Supportive Knowledge*

Amazon Link<sup>Error! Bookmark not defined.</sup>: [2014 ASHRAE Handbook: Refrigeration](#)

*Topics Covered: 9.0 Equipment and Components, 10.0 Systems & Equipment and 11.0 Supportive Knowledge*

### 4.3 ASHRAE CODES & STANDARDS

By ASHRAE

ASHRAE standards are another common tool used by practicing professional HVAC engineers. The exam does not appear to be based on the latest version of the codes, since it is not referenced as a resource by NCEES. However, it is recommended at a minimum that the engineer in training be familiar with the information in each of the following codes:

Amazon Link<sup>Error! Bookmark not defined.</sup>: [ASHRAE 15, Safety Standard for Refrigeration Systems](#)

Amazon Link<sup>Error! Bookmark not defined.</sup>: [ASHRAE 55, Thermal Environmental Conditions for Human Occupancy](#)

Amazon Link<sup>Error! Bookmark not defined.</sup>: [ASHRAE 62.1, Ventilation for Acceptable Indoor Air Quality](#)

Amazon Link<sup>Error! Bookmark not defined.</sup>: [ASHRAE 90.1, Energy Standard for Building, except Low-Rise Residential Buildings](#)

*Topics Covered: 11.0 Supportive Knowledge*

### 4.4 NFPA CODES

By NFPA

The National Fire Protection Agency provides codes and standards related to fire protection. The only recommended NFPA codes are those relating to HVAC systems. These codes are NFPA 90A and NFPA 90B. The test may also ask the name of the code required for a certain application. Therefore, it is useful to also print the list of all the NFPA codes and standards.

Amazon Link<sup>Error! Bookmark not defined.</sup>: [NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems](#)

Amazon Link<sup>Error! Bookmark not defined.</sup>: [90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.](#)

[List of NFPA Codes and Standards](#)

*Topics Covered: 11.0 Supportive Knowledge*

### 4.5 MECHANICAL PE: HVAC & REFRIGERATION TECHNICAL STUDY GUIDE

By Justin Kauwale

This book is specifically written for the Mechanical PE – HVAC and Refrigeration exam. It is a comprehensive study guide and that teaches the key concepts and skills needed for the test. It

is intended to direct your learning for the need to know materials and give you a sturdy foundation in the HVAC and refrigeration principles and applications.

### [Mechanical PE: HVAC & Refrigeration Technical Study Guide](#)

Additional free material is available at [www.engproguides.com](http://www.engproguides.com)

*Topics Covered: All*

## 4.6 ONLINE ARTICLES

These websites help to fill in any gaps from the previous resources.

- Economics Factors:

[http://www.webpages.uidaho.edu/~mlowry/Teaching/EngineeringEconomy/Supplemental/Engineering\\_Economics\\_Excerpt\\_from\\_FE\\_Reference.pdf](http://www.webpages.uidaho.edu/~mlowry/Teaching/EngineeringEconomy/Supplemental/Engineering_Economics_Excerpt_from_FE_Reference.pdf)

- Compound Interest Tables:

[http://global.oup.com/us/companion.websites/9780199778126/pdf/Appendix\\_C\\_CITables.pdf](http://global.oup.com/us/companion.websites/9780199778126/pdf/Appendix_C_CITables.pdf)

- Psychrometric Charts at Various Elevations and Low Temperatures

<http://www.coolerado.com/pdfs/Psychrmtrcs/5000Psychrmtrc11x17.pdf>

<http://www.coolerado.com/pdfs/Psychrmtrcs/7500Psychrmtrc11x17.pdf>

[http://www.coolerado.com/pdfs/Psychrmtrcs/0000Psych11x17US\\_SI.pdf](http://www.coolerado.com/pdfs/Psychrmtrcs/0000Psych11x17US_SI.pdf)

<http://www.coolerado.com/pdfs/Psychrmtrcs/2500PsychrmtrcLetter.pdf>

[http://www.mitsubishielectric.ca/en/hvac/PDF/erv/RenewAire\\_Low\\_Temp.pdf](http://www.mitsubishielectric.ca/en/hvac/PDF/erv/RenewAire_Low_Temp.pdf)

- Cooling Towers:

<http://pdf.directindustry.com/pdf/spx-cooling-technologies/cooling-tower-fundamentals/34010-40110.html>

- Control System Dampers:

<http://www.metropac.com/pneu/pdfs/77-1142.pdf>

- Terminal Devices:

[https://www.titus-hvac.com/file/7561/diffusers%20eng\\_guidelines2013.pdf](https://www.titus-hvac.com/file/7561/diffusers%20eng_guidelines2013.pdf)

- Oil and Fuel Gas:

[http://www.eclipsenet.com/uploadedFiles/Pages/Product\\_Information/Eclipse\\_Engineering\\_Guide/Engineering\\_Guide\\_EFE825.pdf](http://www.eclipsenet.com/uploadedFiles/Pages/Product_Information/Eclipse_Engineering_Guide/Engineering_Guide_EFE825.pdf)

- Compressed Air:

<https://www.atlascopco.com/en-uk/compressors/compressed-air-tips/compressed-air-manual>

- Energy Recovery Devices:

[http://www.johnsoncontrols.com/~media/jci/be/united-states/airside-systems/air-handling-units/files/be\\_appguide\\_energyrecoverywheel\\_ahu.pdf?la=en](http://www.johnsoncontrols.com/~media/jci/be/united-states/airside-systems/air-handling-units/files/be_appguide_energyrecoverywheel_ahu.pdf?la=en)

- Vibration Isolation

<https://www.novibes.com/images/Technical%20Section.pdf>



# SECTION 2 QUESTIONS

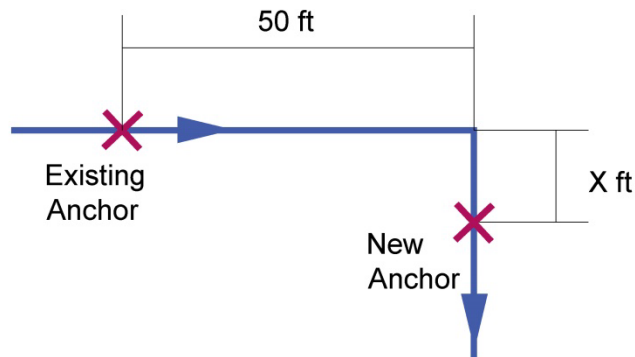
## QUESTION 1

There is a 105 foot long, 6" schedule 40 steel pipe carrying 100-psig steam, run aboveground, horizontally, suspended from the ceiling. There are no valves or other ancillary equipment on this section of pipe. According to MSS Standard SP-69, how many support hangers should be provided on this section of pipe? Assume there are already supports at the beginning and end of the section.

- (A) 4
- (B) 6
- (C) 8
- (D) 10

## QUESTION 2

A schedule 80 XS, steel, 8" OD pipe is being checked for expansion and contraction. Assume A53B steel. The pipe carries chilled water at 45°F, but when not in use, this pipe can reach a temperature of 120 °F. The pipe has an anchor located 50 feet before a 90 degree turn. What is the minimum length of pipe from the 90 degree turn to the next anchor, in order to accommodate thermal expansion of the 50 foot long section of pipe?



- (A) 8 inches
- (B) 10 inches
- (C) 2 feet
- (D) 10 feet

### QUESTION 3

An automatic door (6' x 6' 8") has a throughput of 50 people per hour. The design wind speed is 10 miles per hour. The design indoor temperature is 75 F and the design outdoor temperature is 90 F. There is no vestibule. The pressure difference across the door is 37 Pascals. What is the design infiltration rate?

- (A) 1,050 CFM
- (B) 1,800 CFM
- (C) 2,400 CFM
- (D) 3,100 CFM

### QUESTION 4

A 6" pipe carries chilled water at a design temperature of 45 F. The ambient conditions are 87 F DB, 80% RH. Insulation shall be provided around the pipe. The insulation has a thermal conductivity of 0.22 Btu-in/F-ft<sup>2</sup>. Based on the design conditions, the combined surface coefficient is 1.0 Btu/f-ft<sup>2</sup>. In order to prevent condensation, what is the minimum insulation thickness?

- (A) 0.2 inches
- (B) 1.1 inches
- (C) 2.3 inches
- (D) 3.1 inches

## QUESTION 5

A 50 ft long, 20" x 20", cold supply air duct is insulated and is located outdoors. The duct carries air at a design temperature of 55 F DB/54 F WB. The outdoor air design temperature is 90 F/87% RH. The heat transfer rate from the duct is 20 Btu/h-ft<sup>2</sup>. The heat capacity of air is 0.24 Btu/lbm-F. What is the temperature at the end of the duct run?

- (A) 55 °F
- (B) 58 °F
- (C) 60 °F
- (D) 61 °F

## QUESTION 6

The flue gas of a boiler is analyzed and shown to have the following approximate percentages by volume: 10.8% CO<sub>2</sub>, 4.6% O<sub>2</sub> and 84% N<sub>2</sub>. The fuel is propane gas (commercial) and there is negligible CO. What is the percent excess air? The P/A ratio is 0.9.

- (A) 10%
- (B) 15%
- (C) 20%
- (D) 25%

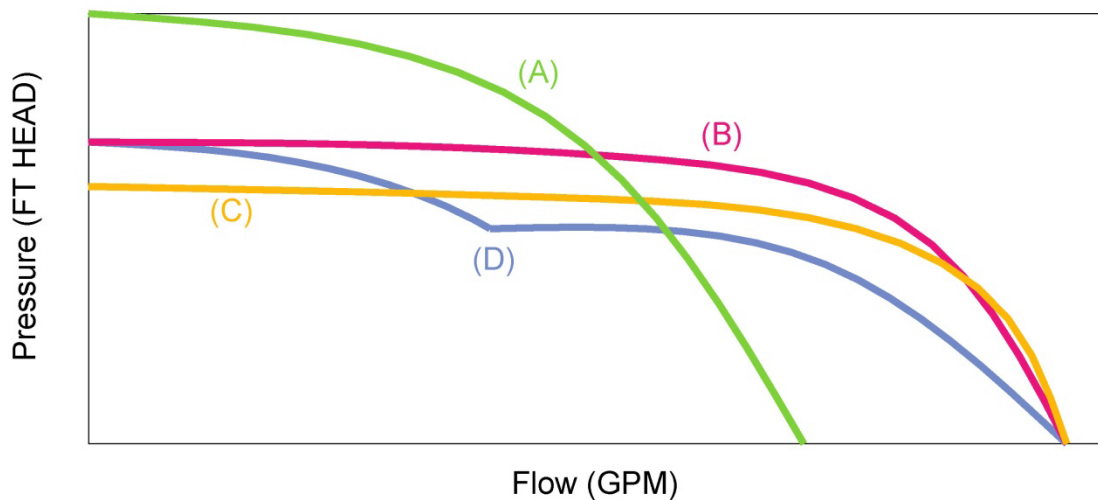
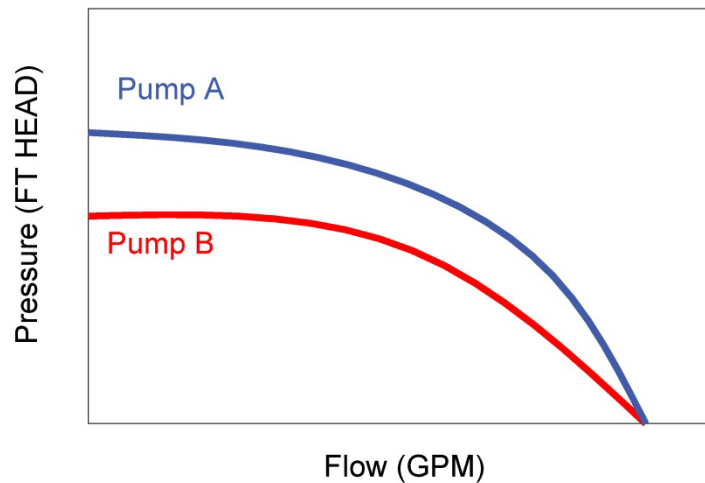
### QUESTION 39

Which of the following centrifugal pumps has the smallest footprint, given the same GPM and pressure?

- (A) Horizontal, close coupled, single stage, end suction pump
- (B) Horizontal, frame mounted, end suction pump
- (C) Vertical in-line pump
- (D) Horizontal, close coupled, two stage, end suction pump

### QUESTION 40

Pumps A and B are combined in parallel. Which of the following pump curves best represents Pumps A & B operating in parallel?



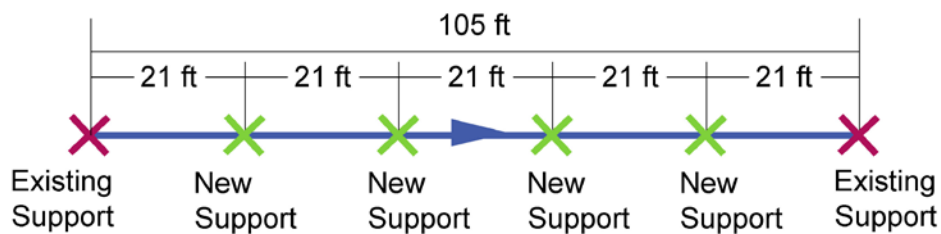
# **SECTION 3 SOLUTIONS**

## SOLUTION 1

There is a 105 foot long, 6" schedule 40 steel pipe carrying 100-psig steam, run aboveground, horizontally, suspended from the ceiling. There are no valves or other ancillary equipment on this section of pipe. According to MSS Standard SP-69, how many support hangers should be provided on this section of pipe? Assume there are already supports at the beginning and end of the section.

- (A) 4
- (B) 6
- (C) 8
- (D) 10

According to **ASHRAE Fundamentals 2017, Chapter 22 Pipe Design**, Table 11, a 6" standard steel pipe carrying steam should have hangers spaced at every 21 feet. Thus for this situation, 4 new supports are required.



The correct answer is most nearly, **(A) 4**.

## SOLUTION 11

A 10" duct must be converted to a flat oval duct in order to meet height clearances. If the minor axis of the flat oval duct is locked at 6", then what should be the major axis of the flat oval duct in order to result in the same friction as the 10" duct?

- (A) 13"
- (B) 15"
- (C) 18"
- (D) 19"

In order to solve this problem, you must navigate to **ASHRAE Fundamentals Chapter 2017, Chapter 21 Duct Design**. There is a table that gives the equivalent flat oval dimensions for various circular duct diameters. According to this table, a 10" round duct is equivalent to a 6" minor axis (a), 15" major axis (A) flat oval duct.

You can also use the equations below to double check your answer.

$$\text{Perimeter } (P) = \pi a + 2(A - a)$$

$$\text{Perimeter } (P) = \pi(6") + 2(15" - 6") = 36.85"$$

$$\text{Area } (AR) = (\pi a^2/4) + a(A - a)$$

$$\text{Area } (AR) = (\pi 6''^2/4) + 6''(15'' - 6'') = 82.27 \text{ in}^2$$

$$\text{Equivalent Diameter } (D_e) = \frac{1.55 * (\text{Area})^{0.625}}{\text{Perimeter}^{0.250}}$$

$$\text{Equivalent Diameter } (D_e) = \frac{1.55 * (82.27)^{0.625}}{36.85^{0.250}} = 9.9"$$

The correct answer is most nearly **(B) 15"**.



## SOLUTION 26

A 6 inch outer diameter pipe is insulated with a material with a thermal conductivity ( $k = 0.24 \text{ Btu} \cdot \text{in}/\text{h} \cdot \text{ft}^2 \cdot ^\circ\text{F}$ ). Insulation is applied to the pipe, which results in an outer diameter of 10 inches. The insulation is changed to a new material with a thermal conductivity ( $k = 0.31 \text{ Btu} \cdot \text{in}/\text{h} \cdot \text{ft}^2 \cdot ^\circ\text{F}$ ). What is the required change in insulation thickness from the old to new insulation needed to achieve the same R-value?

- (A) 0.8 inches
- (B) 1.2 inches
- (C) 1.6 inches
- (D) 2.0 inches

According to **ASHRAE Fundamentals 2017, Chapter 23 Insulation for Mechanical Systems**, the equation used to find the R-value for insulation on a pipe is shown below.

$$R = \frac{12 * \ln\left(\frac{D_{out}}{D_{in}}\right)}{2\pi k}$$

In order to solve this problem, you must first find the old R-value and then equate the R-value to the new R-value, but with the new thermal conductivity value and solve for the outer diameter.

$$R_{old} = \frac{12 * \ln\left(\frac{10 \text{ in}}{6 \text{ in}}\right)}{2\pi * 0.24 \text{ Btu} \cdot \text{in}/\text{h} \cdot \text{ft}^2 \cdot ^\circ\text{F}} = R_{new} = \frac{12 * \ln\left(\frac{D_{out}}{6 \text{ in}}\right)}{2\pi * 0.31 \text{ Btu} \cdot \text{in}/\text{h} \cdot \text{ft}^2 \cdot ^\circ\text{F}}$$

$$\frac{\ln\left(\frac{10 \text{ in}}{6 \text{ in}}\right) * 0.31 \text{ Btu} \cdot \text{in}/\text{h} \cdot \text{ft}^2 \cdot ^\circ\text{F}}{0.24 \text{ Btu} \cdot \text{in}/\text{h} \cdot \text{ft}^2 \cdot ^\circ\text{F}} = \ln\left(\frac{D_{out}}{6 \text{ in}}\right)$$

$$D_{out} = 11.61 \text{ in}$$

The change in insulation can be found from 10 inches to 11.61 inches.

$$\Delta = \frac{11.61 \text{ in} - 10 \text{ in}}{2} = 0.8 \text{ inches}$$

The correct answer is most nearly. **(A) 0.8 inches.**

# **SECTION 4 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](mailto: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!*