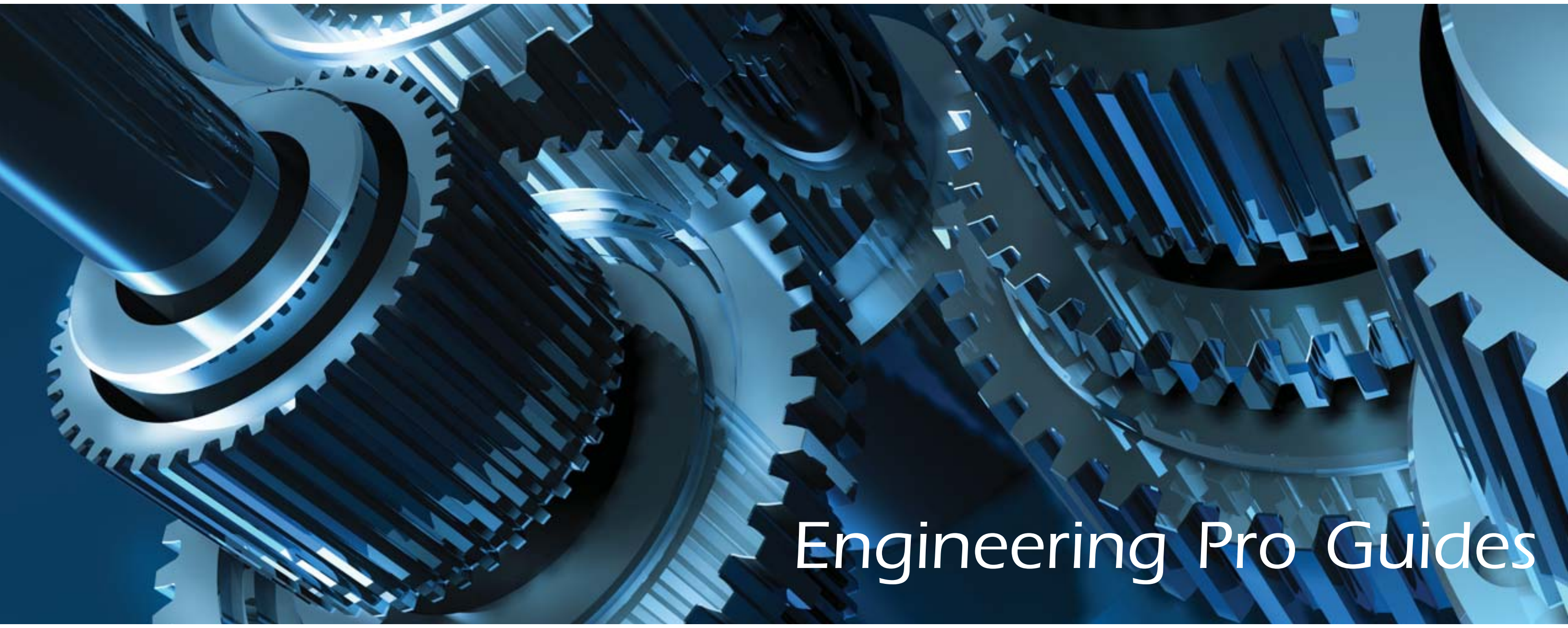
Power PE



Full Exam

- 80 exam difficulty level problems and detailed solutions
- Tests concepts not tested by other sample exams.
- Follows the exam outline and covers the main topics.
- Circuits, Electromagnetic Devices, Codes, PECs, Performance Transmission, Rotating Machines, Protection, Special Appl.

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 technical guide teaches you the key concepts and skills required to pass the Electrical - Power 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 Power Electrical PE exam will focus on the following topics as indicated by NCEES. (http://ncees.org/engineering/pe/):

I. General Power Engineering (24 questions)

A) Measurement and Instrumentation *(6 questions)*
   1 Instrument transformers
   2 Wattmeters
   3 VOM metering
   4 Insulation testing
   5 Ground resistance testing
B) Special Applications *(8 questions)*
   1 Lightning and surge protection
   2 Reliability
   3 Illumination engineering
   4 Demand and energy management calculations
   5 Engineering economics
C) Codes and Standards *(10 questions)*
   1 National Electrical Code (NEC)
   2 National Electrical Safety Code (NESC)

2. Grounding and Bonding Electrical Systems: https://www.engineereducators.com/docs/groundingandbonding2-2.pdf this book shows the basic grounding designs and also covers the grounding testing, which is needed for the Measurement and Instrumentation section.

3. An Introduction to Symmetrical Components, System Modeling and Fault Calculation: https://conferences.wsu.edu/forms/hrs/HRS15/Lectures/Concurrent/SymmetricalComponents.pdf this books covers the symmetrical components and every type of fault you need for the PE exam.

4.8 IEEE Color Books

By IEEE

The IEEE Color Books contain a lot of information that is used in nearly all of the recommended references. There are 13 volumes and each book is given a color as shown in the list below. For the purposes of the exam you should only get the items in **bold**.

Red Book™— IEEE STD 141™-1993 (R1999), Recommended Practice for the Electric Power Distribution for Industrial Plants

Green Book™— IEEE STD 142™-2007, Recommended Practice for Grounding of Industrial and Commercial Power Systems

This book will help you to understand the purpose of grounding and the different approaches to grounding. There is also information on lightning protection in this book.

Gray Book™— IEEE STD 241™-1990 (R1997), Recommended Practice for Electrical Power Systems in Commercial Buildings

Buff Book™— IEEE STD 242™-2001, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

This book will help you to understand short circuit calculations, time current coordination graphs and different approaches to the protection of various types of equipment like motors, generators, transformers, buses and conductors.

Brown Book™— IEEE STD 399™-1997, Recommended Practice for Industrial and Commercial Power Systems Analysis

This book provides background on the various power system analysis studies. This analysis includes power flow and harmonics. If you need more background information on these items, then this book should be of help.

Orange Book™— IEEE STD 446™-1995 (R2000), Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications

Gold Book™— IEEE STD 493™-2007, Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems

White Book™— IEEE STD 602™-2007, Recommended Practice for Electrical Systems in Health Care Facilities

Bronze Book™— IEEE STD 739™-1995 (R2000), Recommended Practice for Energy Management in Industrial and Commercial Facilities

Yellow Book™— IEEE STD 902™-1998, Guide for Maintenance, Operation, and Safety of Industrial and Commercial Power Systems

Blue Book™— IEEE STD 1015™-2006, Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems

Emerald Book™— IEEE STD 1100™-2005, Recommended Practice for Powering and Grounding Electronic Equipment

Violet Book™— IEEE STD 551™-2006, Recommended Practice for Short-Circuit Calculations in Industrial and Commercial Power Systems

SECTION 2
AM SESSION QUESTIONS

QUESTION 1 – CIRCUIT ANALYSIS

A three phase, 500 kVA load is served by a $13.2\angle 0^\circ$ kV line. The load has a power factor of 0.85 leading. What is the line to neutral impedance of the load?

(A) $295.8 + j183.4\ \Omega$

(B) $295.8 - j183.4\ \Omega$

(C) $512.3 - j317.7\ \Omega$

(D) $512.3 + j317.7\ \Omega$

QUESTION 2 – CIRCUIT ANALYSIS

A three-phase, wye connected, balanced load consumes 100 kW and is rated at 480 V (line voltage). If one of the load's phases is removed ($Z_{phase\ A} = 0$), what is the new power consumption? Assume a power factor of 1.0.

(A) 50 kW

(B) 66 kW

(C) 75 kW

(D) 100 kW

QUESTION 14 – DEVICES AND POWER ELECTRONIC CIRCUITS

A single phase, 120V (RMS) AC power supply provides power to a load with an impedance of 10 + j0 ohms. A 120V battery is also in series with this load. What is the max voltage at the resistor?

(A) 120V

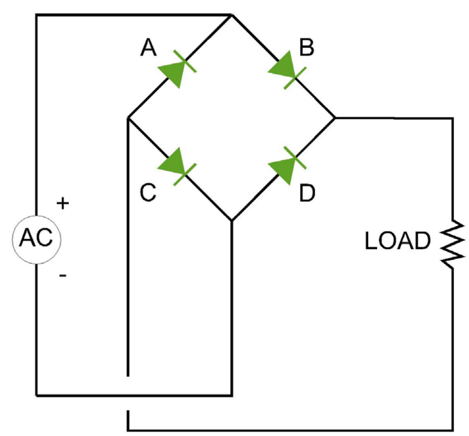
(B) 208V

(C) 240V

(D) 290V

QUESTION 15 – DEVICES AND POWER ELECTRONIC CIRCUITS

The load in the circuit below experiences an effective voltage of 200 V. If diode A fails open, then what will be the effective voltage seen by the load? Assume the load is purely resistive with a load of R.



(A) 100 V

(B) 120 V

(C) 141 V

(D) 200 V

QUESTION 38 – TRANSMISSION AND DISTRIBUTION

A line to line fault occurs between phases A and B of a three phase generator. What is the sum of the short circuit currents through all three phases (A, B and C)? Assume there is no neutral and the positive, negative and zero sequence impedances are all equal to 0.01 pu.

(A) 0 pu

(B) 50 pu

(C) 87 pu

(D) 100 pu

QUESTION 39 – TRANSMISSION AND DISTRIBUTION

Which of the following is most likely not a primary purpose of bonding or electrically connecting two objects together?

(A) Minimize the voltage difference between the two objects.

(B) Provide a connection to earth (ground).

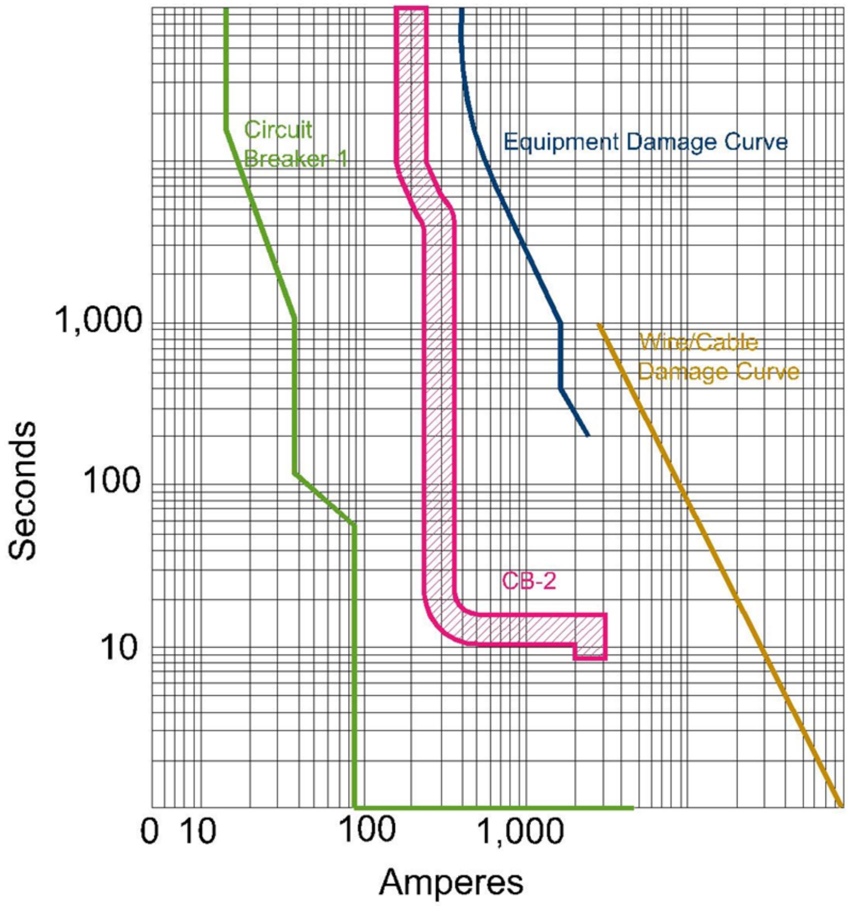
(C) Prevent sparking between two objects.

(D) Allow high currents to pass through the objects with minimal arcing.

SECTION 3
PM SESSION QUESTIONS

QUESTION 51 - PROTECTION

If circuit breaker 1 fails during a short circuit condition of 1,000 amps, then what is the maximum time that the fault be resolved?



(A) Instantaneous

(B) 10 seconds

(C) 18 seconds

(D) The fault will not be cleared until the equipment becomes damaged.

QUESTION 68 – SPECIAL APPLICATIONS

Which of the following locations is most appropriate location for a surge protection device?

(A) In series at the point of use of a critical load.

(B) In parallel with the power supply service entrance to a computer server facility.

(C) On a conductor prior to a VFD, in order to limit harmonics.

(D) On a conductor that serves equipment with low power factors.

QUESTION 69 – SPECIAL APPLICATIONS

The following is the electricity bill for a customer for a day. Calculate the total bill based on the following costs. Cost per kWH = $0.25. Demand charge = $5.00 per max kW.

	KW	kWH		KW	kWH		KW	kWH
Hour 1	2	2	Hour 9	25	25	Hour 17	5	5
Hour 2	2	2	Hour 10	25	25	Hour 18	5	5
Hour 3	2	2	Hour 11	70	70	Hour 19	5	5
Hour 4	2	2	Hour 12	25	25	Hour 20	5	5
Hour 5	2	2	Hour 13	25	25	Hour 21	5	5
Hour 6	2	2	Hour 14	25	25	Hour 22	5	5
Hour 7	2	2	Hour 15	25	25	Hour 23	5	5
Hour 8	2	2	Hour 16	25	25	Hour 24	5	5

(A) $255.50

(B) $300.75

(C) $425.25

(D) $503.25

QUESTION 80 – CODES AND STANDARDS

A single phase, 250 kcmil, branch uncoated copper THWN conductors in steel conduit, serves a load located 1,000' from the panel. The panel is rated at a voltage of $480\angle 0°$ volts. The load is 100 amps at 0.95 lagging power factor. What is the total voltage drop from the panel to the load?

(A) 5 V

(B) 7.5 V

(C) 10 V

(D) 15 V

SECTION 4
AM SESSION SOLUTIONS

SOLUTION 9 – CIRCUIT ANALYSIS

A 480V∠0°, ideal, wye connected generator supplies power to an ideal, delta connected load. The transmission line between the generator and load has an impedance of 1+j2 per phase. The load has an impedance of 15+j10 per phase. What is the line current?

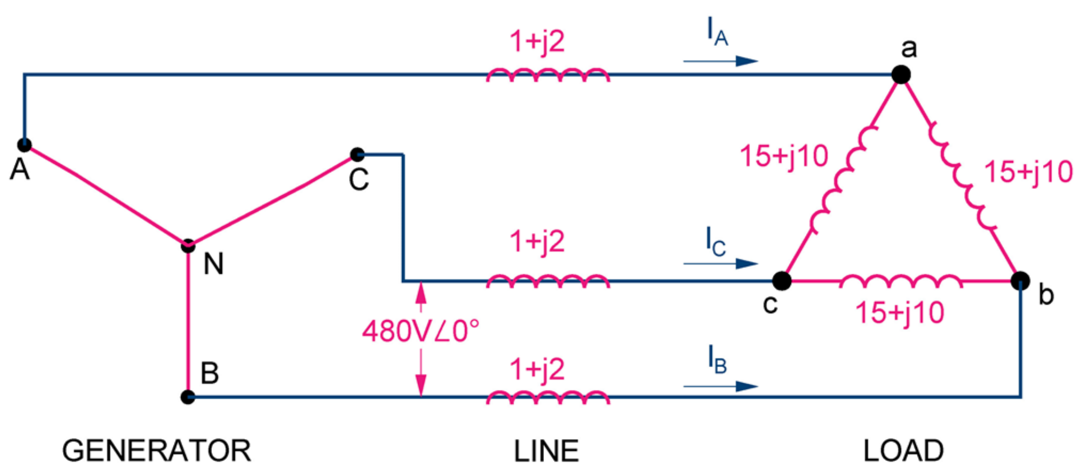
(A) 8 A

(B) 14 A

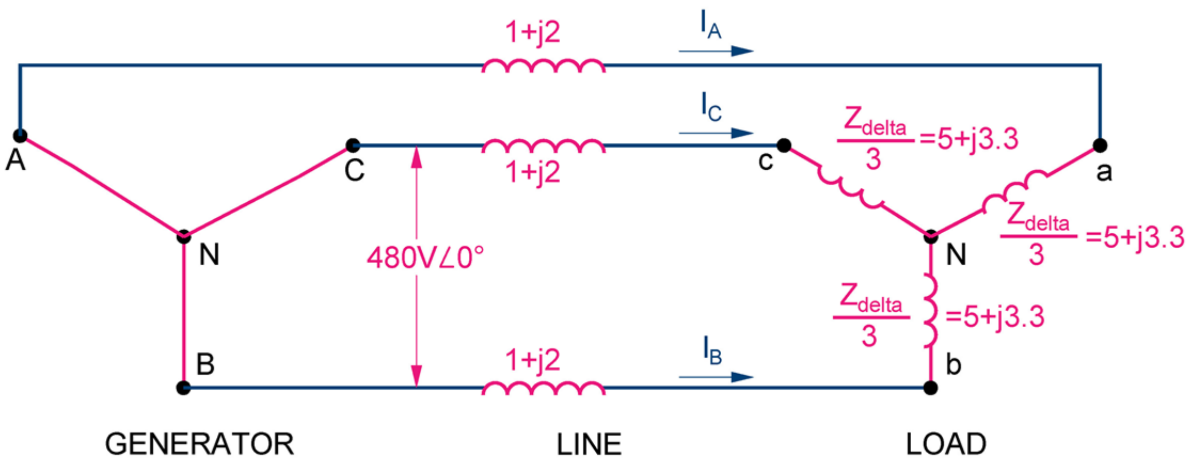
(C) 20 A

(D) 35 A

On the exam, I recommend using figures to help you to visualize the problem, in the event that the PE exam does not provide a figure. If you check the website, you can download the technical study guide for the power pe exam for these types of figures. The line voltage of 480 volts is shown for the wye generator. The per phase line impedances of 1+J2 are also shown. Finally the delta load with per phase impedances of 15+j10 is shown.

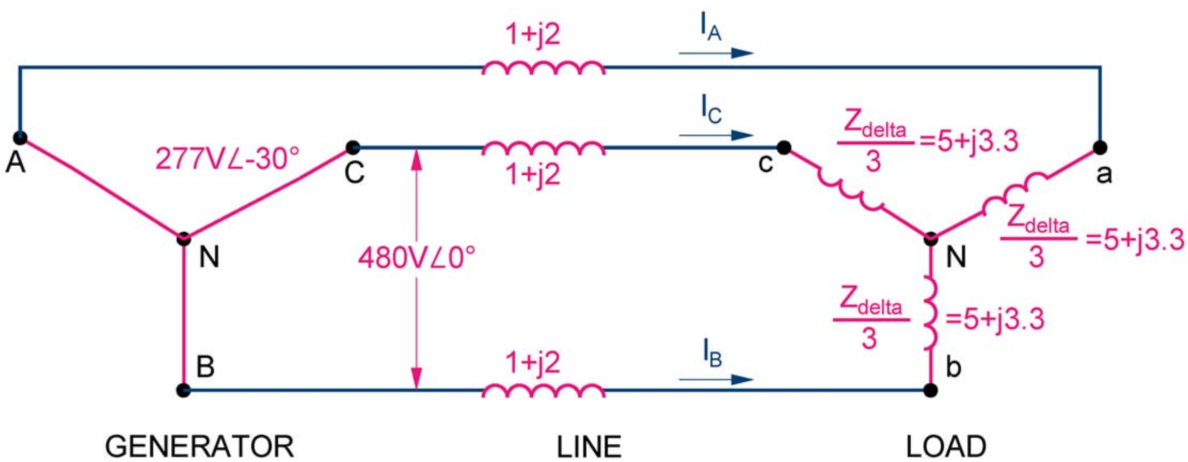


In order to complete this problem you must first convert the delta load to an equivalent wye load. This will help to make a simpler circuit for solving for the line current, since the line current is equal to the phase current. The conversion for delta to wye impedances is to divide the delta impedance by 3.



$$Z_{wye} = \frac{Z_{delta}}{3} = \frac{15 + j10}{3} = 5 + j3.33$$

The next step is to convert the line voltage to phase voltage, to get a simpler circuit for solving for the line current. The phase voltage will be the voltage from C-N. The conversion from line voltage to phase voltage is to divide the line voltage by root 3 and subtract the 30 degree angle.



Now the drop along this phase includes the line impedance and the load impedance. With this simple circuit you now have the impedance and voltage and can therefore solve for the current.

$$I_{line} = \frac{V}{Z_{load} + Z_{line}} = \frac{277V\angle -30°}{5 + j3.33 + 1 + j2} = \frac{277V\angle -30°}{6 + j5.33} =$$

$$I_{line} = \frac{277V\angle -30°}{6 + j5.33} = \frac{277V\angle -30°}{8.03\angle 41.6°} = 34.5\angle -71.6°$$

The correct answer is most nearly, ***(D)*** $\mathbf{35\ A}$

SOLUTION 36 – TRANSMISSION AND DISTRIBUTION

A waveform has an equivalent voltage of 480V with a THD of 20%. What is the RMS of the fundamental frequency?

This question requires the use of the following two equations.

$$V_{eq} = 480V = \sqrt{V_{fundamental}^2 + V_{harmonics}^2}$$

$$THD = 20\% = \frac{V_{harmonics}}{V_{fundamenetal}}$$

Since you want the fundamental voltage then use the THD equation and put the harmonics voltage in terms of the fundamental voltage.

$$V_{harmonics} = 0.2 * V_{fundamenetal}$$

Now substitute into the first equation.

$$V_{eq} = 480V = \sqrt{V_{fundamental}^2 + 0.2^2 * V_{fundamental}^2}$$

$$480V = \sqrt{1.04 * V_{fundamental}^2}$$

$$230{,}400 = 1.04 * V_{fundamental}^2$$

$$V_{fundamenetal} = 471V$$

The correct answer is most nearly, **(D) 471V.**

SECTION 5
PM SESSION SOLUTIONS

QUESTION 41 – TRANSMISSION AND DISTRIBUTION

A power supply serves a 40 HP, 480V motor at 85% power factor and a 10 HP, 480V motor at 95% power factor. The motors are three phase induction motors. What size power factor correction capacitors must be provided to the power supply in order to achieve a total power factor of 95%?

First calculate the combined power factor of the two motors.

$$P_1 = 40\ HP * \frac{0.7457\ KW}{1\ HP} = 29.8\ KW$$

$$S_1 = 29.8\ KW \frac{1}{0.85} = 35.1\ KVA$$

$$P_2 = 10\ HP * \frac{0.7457\ KW}{1\ HP} = 7.5\ KW$$

$$S_2 = 7.5\ KW \frac{1}{0.95} = 7.8\ KVA$$

$$P_1 + P_2 = 37.3\ KW\ \&\ S_1 + S_2 = 42.9\ KVA$$

$$PF_{1+2} = \frac{37.3}{42.9} = 0.87$$

In order to get to 0.95 PF, you can use the PF correction tables provided in the Engineering Pro Guides Technical Study Guide Cheat Sheets.

$$Q_L = 42.9\ KVA * (0.207) = 8.9\ KVAR$$

Or you can find the current reactive power and the required new reactive power.

$$Q_{current} = \sin(\cos^{-1}(0.87)) * 42.9\ KVA = 21.2\ KVAR$$

$$Q_{new} = \sin(\cos^{-1}(0.95)) * 42.9\ KVA * \left(\frac{0.87}{0.95}\right) = 12.3\ KVAR$$

You can also find Q_new by using the tangent of the power and the power factor 0.95

$$\theta_{new} = \tan^{-1}\left(\frac{Q_{new}}{37.3KW}\right) = \cos^{-1}(0.95)$$

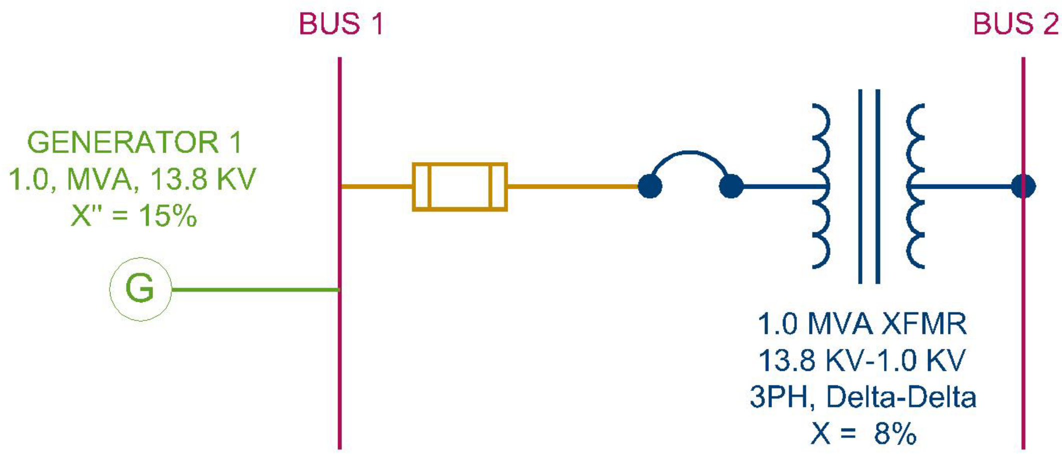
$$\tan^{-1}\left(\frac{Q_{new}}{37.3KW}\right) = 18.2 \rightarrow \frac{Q_{new}}{37.3KW} = \tan(18.2°) \rightarrow Q_{new} = 12.3\ KVAR$$

$$Q_L = Q_{current} - Q_{new} = 21.2 - 12.3 = 8.9\ KVAR$$

The correct answer is most nearly, **(B) 8.9 KVAR**.

QUESTION 54 - PROTECTION

If a phase A to phase B fault occurs at Bus 2, what will be the short circuit current in phase A at Bus 2? Assume the positive and negative sequence impedances are equal for all components.



Since Bus 2 is the desired fault location, assume a base of 1 MVA and 1 KV.

$$Z_{base,480\,V\,zone} = \frac{(1\,kV)^2}{1\,MVA} = 1\,\Omega$$

Since the generator and transformer have the same power values, the impedances are on the same base.

$$Z_{gen\,1} = Z_{gen\,2} = j0.15\,pu$$

$$Z_{xfmr\,1} = Z_{xfmr\,2} = j0.08\,pu$$

Now find the base current on the 1 KV side.

$$I_{base} = \frac{1\,MVA * 1{,}000}{\sqrt{3} * 1\,KV} = 577.4\,A$$

Next divide the base current by the sum of the per unit impedances, since all the impedances are in series from the power source to the fault location. Remember you also need to add the negative sequence impedances which are the same as the positive sequence impedances.

$$I_{a1} = \frac{I_{base}}{Z_{1,gen\,1} + Z_{2,gen\,1} + Z_{1,xfmr} + Z_{2,xfmr}} = \frac{577.4\,A}{(j0.15\,pu + j.08\,pu) * 2} = \frac{577.4\,A}{j0.46}$$

$$I_{a1} = 1{,}255\,A$$

QUESTION 69 – SPECIAL APPLICATIONS

The following is the electricity bill for a customer for a day. Calculate the total bill based on the following costs. Cost per kWH = $0.25. Demand charge = $5.00 per max kW.

	KW	kWH		KW	kWH		KW	kWH
Hour 1	2	2	Hour 9	25	25	Hour 17	5	5
Hour 2	2	2	Hour 10	25	25	Hour 18	5	5
Hour 3	2	2	Hour 11	70	70	Hour 19	5	5
Hour 4	2	2	Hour 12	25	25	Hour 20	5	5
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Hour 6	2	2	Hour 14	25	25	Hour 22	5	5
Hour 7	2	2	Hour 15	25	25	Hour 23	5	5
Hour 8	2	2	Hour 16	25	25	Hour 24	5	5

The total kWH is found with the below equation:

$$Total\ KWH = 8 * 2 + 25 * 7 + 70 + 5 * 8 = 301\ kWh$$

$$Consumption\ charge = 301\ kWh * \$0.25/kwh = \$75.25$$

The demand charge is found by taking the max kW

$$Demand\ charge = 70\ kW * \$5/kW = \$350$$

The total energy bill is the sum of the consumption charge and demand charge.

$$Total\ Cost = \$75.25 + \$350 = \$425.25$$

The correct answer is most nearly, **(C) $425.25**.

QUESTION 79 – CODES AND STANDARDS

An induction motor has the following nameplate values: 500 hp, 4,160 volts, 75 amps, 1,700 rpm, 60 hz, 3 Phase, 0.75 pf, code G, insulation class F, continuous duty. What is the maximum locked rotor current (amperes) for this motor?

The motor code letter is given as G. Using Table 430.7(B) of the 2014 NEC, the maximum locked-rotor motor input is 6.29 kVA/hp.

Therefore,

$$Locked\ Rotor\ KVA = 6.29\frac{kVA}{hp} * 500hp = 3{,}145\ kVA$$

Calculate the locked rotor amps:

$$I = \frac{S}{\sqrt{3} * V}$$

$$So, \qquad LRA = \frac{3{,}145\ kVA}{\sqrt{3} * 4.16kV} = 436.5\ A$$

The power factor is not used, since Table 430.7(B) provides the apparent power (kVA) per hp.

The correct answer is most nearly, (D). 437 A.

SECTION 6
CONCLUSION

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

Electrical PE Exam – Power

AM Session -Sample Exam Diagnostics

#	Major Category	Correct?
1	Circuit Analysis	
2	Circuit Analysis	
3	Circuit Analysis	
4	Circuit Analysis	
5	Circuit Analysis	
6	Circuit Analysis	
7	Circuit Analysis	
8	Circuit Analysis	
9	Circuit Analysis	
10	Devices and Power Electronic Circuits	
11	Devices and Power Electronic Circuits	
12	Devices and Power Electronic Circuits	
13	Devices and Power Electronic Circuits	
14	Devices and Power Electronic Circuits	
15	Devices and Power Electronic Circuits	
16	Devices and Power Electronic Circuits	
17	Rotating Machines	
18	Rotating Machines	
19	Rotating Machines	
20	Rotating Machines	
21	Rotating Machines	
22	Rotating Machines	
23	Rotating Machines	
24	Rotating Machines	
25	Rotating Machines	
26	Rotating Machines	
27	Electromagnetic Devices	
28	Electromagnetic Devices	
29	Electromagnetic Devices	
30	Electromagnetic Devices	
31	Electromagnetic Devices	
32	Electromagnetic Devices	
33	Transmission and Distribution	
34	Transmission and Distribution	
35	Transmission and Distribution	
36	Transmission and Distribution	
37	Transmission and Distribution	
38	Transmission and Distribution	
39	Transmission and Distribution	
40	Transmission and Distribution	

Electrical PE Exam – Power

PM Session -Sample Exam Diagnostics

#	Major Category	Correct?
41	Transmission and Distribution	
42	Transmission and Distribution	
43	Power System Performance	
44	Power System Performance	
45	Power System Performance	
46	Power System Performance	
47	Power System Performance	
48	Power System Performance	
49	Protection	
50	Protection	
51	Protection	
52	Protection	
53	Protection	
54	Protection	
55	Protection	
56	Protection	
57	Measurement and Instrumentation	
58	Measurement and Instrumentation	
59	Measurement and Instrumentation	
60	Measurement and Instrumentation	
61	Measurement and Instrumentation	
62	Measurement and Instrumentation	
63	Special Applications	
64	Special Applications	
65	Special Applications	
66	Special Applications	
67	Special Applications	
68	Special Applications	
69	Special Applications	
70	Special Applications	
71	Codes & Standards	
72	Codes & Standards	
73	Codes & Standards	
74	Codes & Standards	
75	Codes & Standards	
76	Codes & Standards	
77	Codes & Standards	
78	Codes & Standards	
79	Codes & Standards	
80	Codes & Standards	