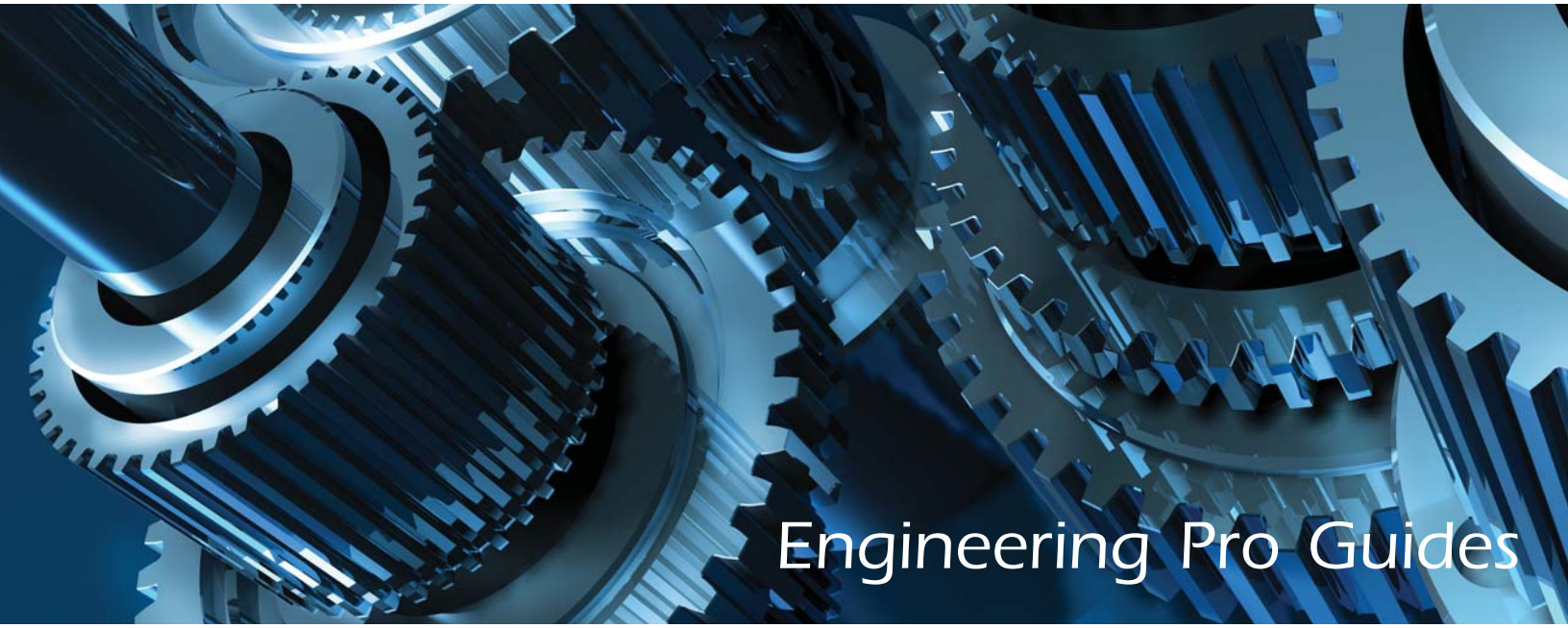
Mechanical PE Full Exam



Machine Design & Materials

- 80 exam difficulty level problems
- Covers Mechanical PE Machine Design & Materials 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 and teach you 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 Machine Design & Materials 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 book 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 Machine Design & Materials Mechanical PE exam will focus on the following topics as indicated by NCEES. (http://ncees.org/engineering/pe/):

I. Principles (40 questions)

A) Basic Engineering Practice *(9 questions)*
   1 Engineering terms and symbols
   2 Interpretation of technical drawings
   3 Quality assurance/quality control (QA/QC)
   4 Project management and economic analysis
   5 Units and conversions
   6 Design methodology (e.g., identifying requirements, risk assessment, verification/validation)

B) Engineering Science and Mechanics *(10 questions)*
   1 Statics
   2 Kinematics
   3 Dynamics

C) Material Properties *(8 questions)*
   1 Physical (e.g., density, melting point, optical)
   2 Chemical (e.g., corrosion, alloys, oxidation)

http://www.awc.org/pdf/codes-standards/publications/design-aids/AWC-DA6-BeamFormulas-0710.pdf

4.7.2 Welding Symbol Guide and Chart

This website provides a quick reference to various beam configurations and their shear/moment diagrams. ***Topics Covered: Section 2.0 – Basic Engineering Practice (9 Questions)***

https://app.aws.org/itrends/2009/07/it200907/it0709-14.pdf

https://app.aws.org/mwf/attachments/64/225364/AWSWeldSymbolchart.pdf

4.7.3 Control Charts and Tables of Constants for Control Charts

These items are useful for solving quality control problems. You should have the control charts tabbed in one of your references or you can print out these tables too. ***Topics Covered: Section 2.0 – Basic Engineering Practice (9 Questions)***

https://www.stat.auckland.ac.nz/~wild/ChanceEnc/Ch13.pdf

http://web.mit.edu/2.810/www/files/readings/ControlChartConstantsAndFormulae.pdf

4.7.4 Vibration Isolation

The following website is a concise, practical guide to selecting vibration isolation. It also provides some background information on vibration topics like frequency, displacement, forcing vs. natural and transmissibility. ***Topics Covered: Section 6.0 – Vibration (3 Questions)***

http://www.novibration.com/isoselect.pdf

4.7.5 Websites for Machine Design Standards

The following organizations produce standards that are used in the Machine Design field and you should be knowledgeable of these organizations for the Codes and Standards topic in Section 9.0 Supportive Knowledge. ***Topics Covered: Section 9.0 – Supportive Knowledge (10 Questions)***

American National Standards Institute (ANSI): https://www.ansi.org/

American Society for Testing and Materials (ASTM): https://www.astm.org/

American Welding Society (AWS): https://www.aws.org/

American Society of Mechanical Engineers (ASME): https://www.asme.org/

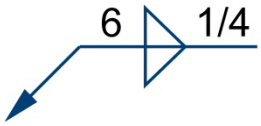
Underwriters Laboratories (UL): https://standardscatalog.ul.com/

Society of Automotive Engineers (SAE): http://www.sae.org/

SECTION 2
AM SESSION QUESTIONS

QUESTION 3 – BASIC ENGINEERING PRACTICE

Which of the following statements, best describes the below weld symbol?



(A) A ¼" fillet weld, 6" long, on the arrow side of the joint.

(B) A ¼" fillet weld, 6 times, on the arrow side of the joint.

(C) A 6" fillet weld, 1/4" long, on the arrow and other side of the joint.

(D) A ¼" fillet weld, 6" long, on the arrow and other side of the joint.

QUESTION 4 – BASIC ENGINEERING PRACTICE

Determine the length of the critical path for the following machining process.

Machining Process	Duration (minutes)	Dependency
A	5	Start
B	2	Start
C	3	A & B
D	5	Start
E	6	Start
F	4	D & E
G	2	C & F
H	5	G
I	7	G
J	3	H
Finish	0	I & J

(A) 17 minutes

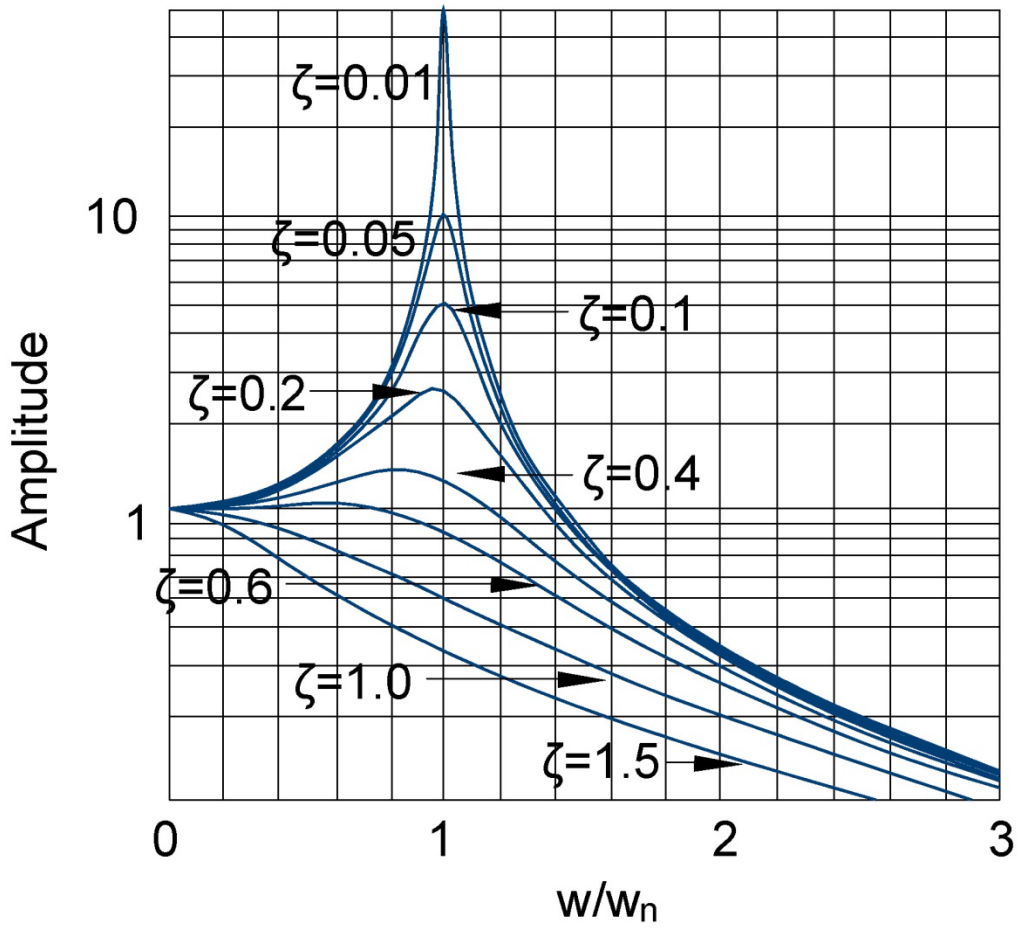
(B) 18 minutes

(C) 19 minutes

(D) 20 minutes

QUESTION 40 – VIBRATION

The amplitude of a mechanical system must be limited below 3 at all frequencies. The natural frequency of the system is 10 rad/s. The amplitude must be less than 0.8 for an excited frequency of 16 rad/s. The system must also not be overdamped or critically damped. What is the closest damping ratio that meets all of these requirements?



(A) 0.1

(B) 0.2

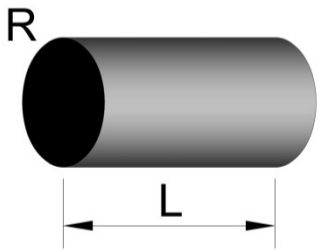
(C) 1.0

(D) 1.5

SECTION 3
PM SESSION QUESTIONS

QUESTION 49 - MECHANICAL COMPONENTS

A cylindrical pressure vessel is capped at one end with a bolted lid. The maximum hoop stress of the pressure vessel is 25 ksi and the maximum tension stress in the bolts is 50 ksi. The tensile area of the bolt is 0.79 in^2. The pressure vessel diameter is 2' and the length of the pressure vessel is 10'. What is the maximum internal pressure in the pressure vessel and what is the number of bolts required to bolt the lid? Assume a thin walled pressure vessel with thickness of 3/8" and there is no other exterior force besides atmosphere.



The answer is most nearly,

(A) 780 psi, 9 bolts

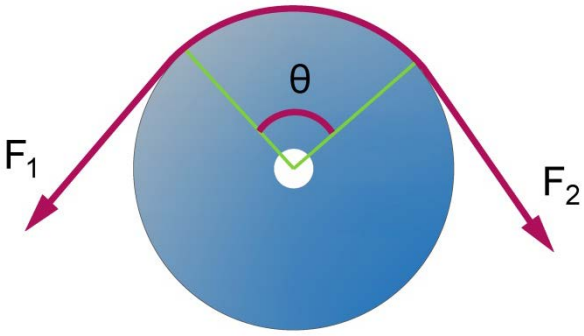
(B) 1,005 psi, 10 bolts

(C) 1,212 psi, 11 bolts

(D) 1,490 psi, 12 bolts

QUESTION 50 - MECHANICAL COMPONENTS

A brake band is used to slow down a shaft of diameter 18". The tension F_1 is 100 lbs and the tension F_2 is 20 lbs. The angle of wrap is 90 degrees. The coefficient of friction is 0.25 and the width of the band is 2". What is the torque provided by the band brake?



(A) $970\ lb-in$

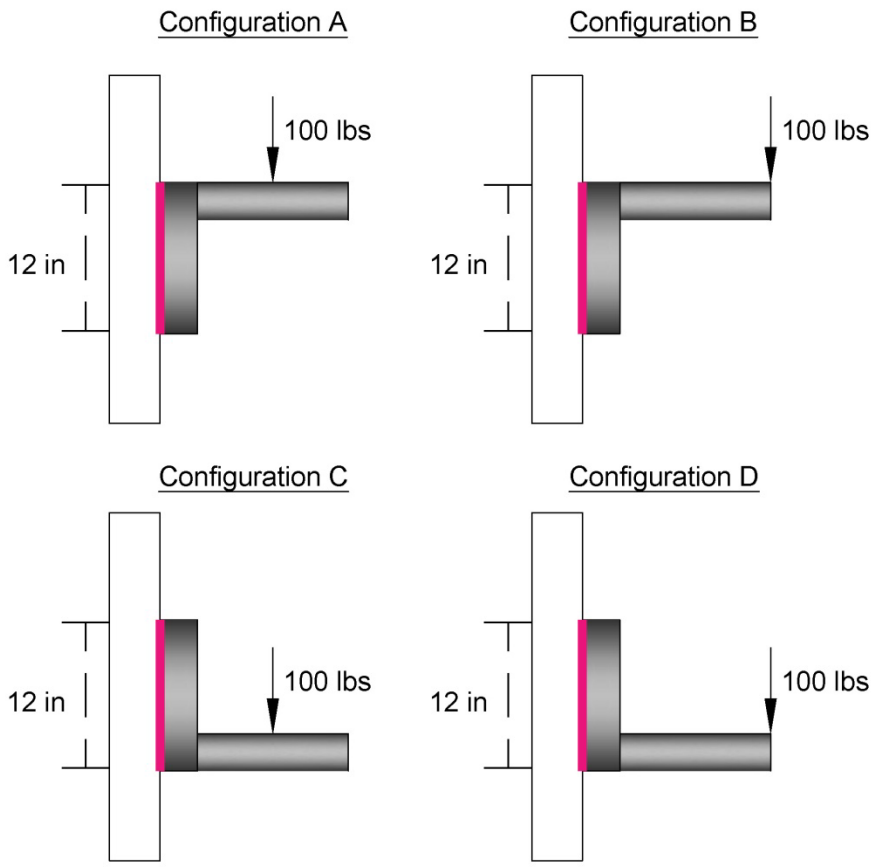
(B) $1{,}230\ lb-in$

(C) $1{,}770\ lb-in$

(D) $2{,}000\ lb-in$

QUESTION 67 – JOINTS & FASTENERS

Which of the following configurations incurs the largest peel stress?



(A) Configuration A

(B) Configuration B

(C) Configuration C

(D) Configuration D

QUESTION 79 – SUPPORTIVE KNOWLEDGE

ASTM E18-07 Standard Test Methods for Rockwell Hardness of Metallic Materials governs the hardness testing for metallic materials. Which of the following statements about this standard and hardness testing is true?

(A) A minor load must first be applied to the surface to break the surface and to reduce surface effects.

(B) The major load must be immediately removed after impact, in order to provide standard results.

(C) A tungsten carbide ball must be used for the Rockwell A scale.

(D) A diamond penetrator must be used for the Rockwell B scale.

QUESTION 80 – SUPPORTIVE KNOWLEDGE

Which of the following variables will vary during a series of peel tests in accordance with ASTM-D3330 Standard Test Method for Peel Adhesion of Pressure Sensitive Tape?

(A) Length of peel

(B) Peel speed

(C) Measured force

(D) Temperature of adhesive.

SECTION 4
AM SESSION SOLUTIONS

SOLUTION 6 – BASIC ENGINEERING PRACTICE

A machined product is measured and the following shows six samples, each with 15 observations per sample.

Sample	Mean	Range
1	78.1	14.1
2	72.1	8.5
3	63.7	18.1
4	89.4	18.9
5	80.8	9.2
6	78.8	14.7

What are the LCL and UCL for the range chart?

First find, $\bar{R}$

$$\bar{R} = 13.9$$

Next, use the following equations to find UCL and LCL.

$$LCL = D_3 * \bar{R} = 13.9 * 0.347 = 4.8$$

$$UCL = D_4 * \bar{R} = 13.9 * 1.653 = 23.0$$

Use the charts to find the control chart variables.

n	A2	A3	~~c4~~	B3	B4	~~d2~~	~~1/d2~~	~~d3~~	D3	D4
15	0.223	0.789	~~0.9823~~	0.428	1.572	~~3.472~~	~~0.2880~~	~~0.756~~	0.347	1.653
16	0.212	0.763	~~0.9835~~	0.448	1.552	~~3.532~~	~~0.2831~~	~~0.750~~	0.363	1.637
17	0.203	0.739	~~0.9845~~	0.466	1.534	~~3.588~~	~~0.2787~~	~~0.744~~	0.378	1.622
18	0.194	0.718	~~0.9854~~	0.482	1.518	~~3.640~~	~~0.2747~~	~~0.739~~	0.391	1.609
19	0.187	0.698	~~0.9862~~	0.497	1.503	~~3.689~~	~~0.2711~~	~~0.733~~	0.404	1.596
20	0.180	0.680	~~0.9869~~	0.510	1.490	~~3.735~~	~~0.2677~~	~~0.729~~	0.415	1.585

The correct answer is most nearly, **(A) $\boldsymbol{UCL = 23.0; LCL = 14.8}$.**

(A) $UCL = 23.0; LCL = 14.8$

(B) $UCL = 13.9; LCL = 13.9$

(C) $UCL = 18.9; LCL = 8.5$

(D) $UCL = 13.9; LCL = 8.5$

SOLUTION 21 – MATERIAL PROPERTIES

Which bolt material is least likely to suffer galvanic corrosion when used on a copper flange exposed to seawater? Copper has an anodic index of -0.35 V.

Galvanic corrosion is caused by the electrical contact of two dissimilar metals in an electrolytic medium. In this case, the electrolyte is seawater. The anodic index ranks the electrochemical potential of each metal. The farther apart the two metals are in the rank, the higher the possibility for ionic movement and therefore the more likely galvanic corrosion will occur.

However, this question asks for the least likely to suffer galvanic corrosion, thus we are looking for the metal with the anodic index closes to copper.

The metal with the anodic index closest to copper is brass.

Correct answer is D.

(A) Hot Dip Galvanized Steel, -1.20 V

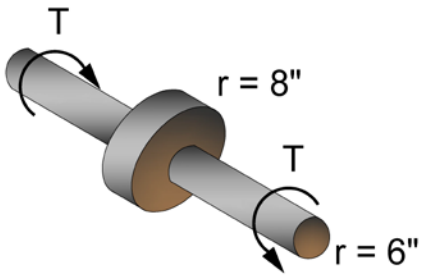
(B) Aluminum, -0.95 V

(C) 316 Stainless Steel, -0.05V

(D) Brass, -0.40 V

SOLUTION 31 – STRENGTH OF MATERIALS

The following shaft experiences a torque of 1,000 lb-ft. The shaft has a radius of 6” and it is connected to a similar shaft by a coupling. The coupling has a radius of 8”. What is the maximum shear stress in the shaft?



(A) 35 psi

(B) 50 psi

(C) 85 psi

(D) 100 psi

The maximum shear stress in a shaft can be found with the following equation.

$$\tau_{max} = \frac{Tc}{J}$$

The torque is given and the second polar moment of area can be found for a solid shaft. The distance, “c” is the distance from the center of the shaft to the surface of the shaft, which is the radius of the shaft.

$$\tau_{max} = \frac{(1{,}000\ lb - ft) * \frac{12\ in}{1\ ft} * (6\ in)}{(\frac{\pi}{2} * (6\ in)^4)}$$

$$\tau_{max} = 35.4\ psi$$

The correct answer is most nearly, (A) 35 psi.

SECTION 5
PM SESSION SOLUTIONS

QUESTION 48 – MECHANICAL COMPONENTS

Background: A 10 BHP motor operates for 4000 hours in the year. The motor is 85% efficient and the power factor is 0.85. Energy cost is $0.25 per kilowatt-hour.

Problem: How much does it cost to operate the motor in one year?

(A) $5,222

(B) $9,014

(C) $10,320

(D) $13,699

Convert fan brake horsepower to motor horsepower.

$$P_{motor[HP]} = \frac{P_{pump[BHP]}}{\varepsilon_{motor}}$$

$$P_{motor[HP]} = \frac{10\ BHP}{0.85} = 11.8\ HP$$

Determine the amount of power supplied to the motor, use power factor.

$$P_{supplied\ to\ motor} = \frac{P_{motor[HP]}}{PF} = \frac{11.8\ HP}{0.85} = 13.8\ HP$$

Find the kilowatt-hours(kwh) consumed.

$$P_{supplied\ to\ motor,watts} = I * V$$

$$13.8\ HP * \frac{0.7457\ KW}{HP} * 4{,}000\ \frac{hrs}{year} = 41{,}267.8\ kwh$$

Find the cost ($) with the electricity cost.

$$41{,}267.8\ kwh * \frac{\$0.25}{kwh} = \$10{,}317$$

The correct answer is most nearly. **(C), $10,320**

QUESTION 54 - MECHANICAL COMPONENTS

A rectangular key (L = 24 in, W = 1 in, H= 1 in) is used to engage a shaft that is rotating at a speed of 1,000 RPM, with a torque of 3,150 lbs-in. The shaft has a diameter of 12 in. What is the shear stress in the key?

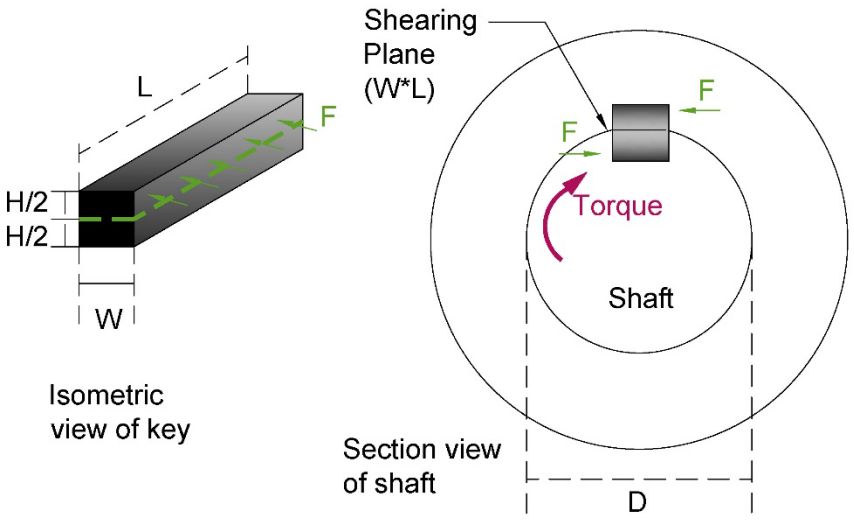
(A) 22 psi

(B) 45 psi

(C) 123 psi

(D) 250 psi

The shear stress in the key is found by finding the shear force and the area that experiences shear. This can be seen in the below figure and equation.



$$\tau = \frac{F}{A} = \frac{Torque}{\left(\frac{D}{2}\right) * WL}$$

Now plug in the values to the shear stress equation

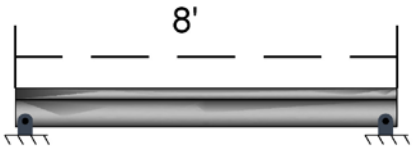
$$\tau = \frac{3{,}150\ lbs - in}{(6\ in) * (1\ in) * (24\ in)}$$

$$\tau = 22\ psi$$

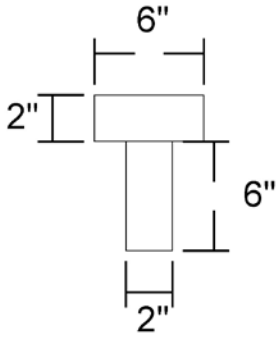
The correct answer is most nearly, **(A) 22 psi.**

QUESTION 68 – JOINTS & FASTENERS

A point force of 1,000 lbs is applied at the center of the built-up beam. The beam is constructed of (2) 2" x 6" beams as shown in the cross section. An adhesive is used to join the two beams together. Assume the moment of inertia is equal to 136 in^4. What is the maximum shear stress in the adhesive?



Side View



Cross Section

(A) 11 psi

(B) 22 psi

(C) 44 psi

(D) 88 psi

The point force will cause a shear force between the two beams. This shear force is equal to the shear stress in the beam. The maximum shear stress for this beam can be found in the beam diagrams in Section 3.0 Engineering Science and Mechanics.

$$V = \frac{P}{2} = \frac{1{,}000}{2} lbs = 500\ lbs$$

The first moment of area is found by taking the area above the shear plane (adhesive) and multiplying this value from the neutral axis to the centroid of the above area.

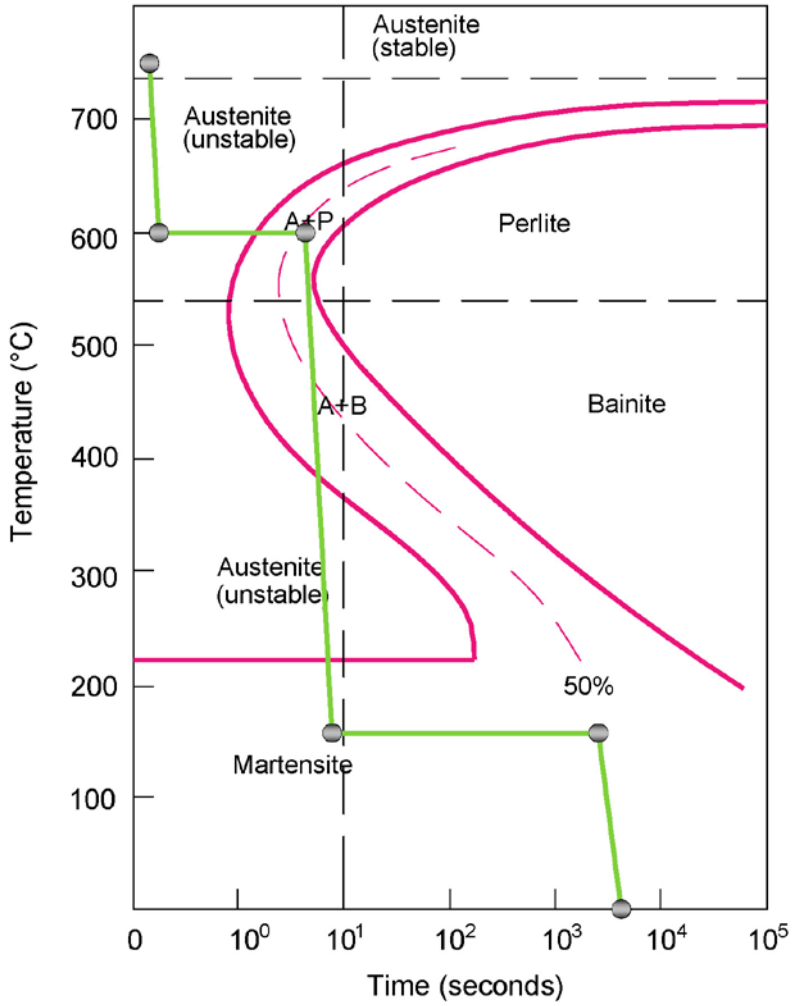
$$Q_z = (2\ in) * (6\ in * 2\ in) = 24\ in^3$$

The shear stress in the adhesive is found through the below equation.

$$\tau = \frac{V_y[lbs] * Q_x[in^3]}{I_x[in^4] * t\ [in]}$$

$$V_y = shear\ force; t = thickness\ (in) = 2in$$

$$Q_z = first\ moment\ of\ area; I_z = second\ moment\ of\ area\ about\ z - axis$$



The first two steps will cause more than half of the steel to turn to perlite. The remaining will turn to martensite in the final steps.

The correct answer is most nearly, **(C) 80% pearlite, 20% martensite.**

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

Mechanical PE Exam – Machine Design & Materials
AM Session -Sample Exam Diagnostics

#	Major Category	Correct?
1	Basic Engineering Practice	
2	Basic Engineering Practice	
3	Basic Engineering Practice	
4	Basic Engineering Practice	
5	Basic Engineering Practice	
6	Basic Engineering Practice	
7	Basic Engineering Practice	
8	Basic Engineering Practice	
9	Basic Engineering Practice	
10	Engineering Science & Mechanics	
11	Engineering Science & Mechanics	
12	Engineering Science & Mechanics	
13	Engineering Science & Mechanics	
14	Engineering Science & Mechanics	
15	Engineering Science & Mechanics	
16	Engineering Science & Mechanics	
17	Engineering Science & Mechanics	
18	Engineering Science & Mechanics	
19	Engineering Science & Mechanics	
20	Material Properties	
21	Material Properties	
22	Material Properties	
23	Material Properties	
24	Material Properties	
25	Material Properties	
26	Material Properties	
27	Material Properties	
28	Material Properties	
29	Material Properties	
30	Material Properties	
31	Material Properties	
32	Material Properties	
33	Material Properties	
34	Material Properties	
35	Material Properties	
36	Material Properties	
37	Material Properties	
38	Vibration	
39	Vibration	
40	Vibration	

Mechanical PE Exam – Machine Design & Materials
PM Session -Sample Exam Diagnostics

#	Major Category	Correct?
41	Mechanical Components	
42	Mechanical Components	
43	Mechanical Components	
44	Mechanical Components	
45	Mechanical Components	
46	Mechanical Components	
47	Mechanical Components	
48	Mechanical Components	
49	Mechanical Components	
50	Mechanical Components	
51	Mechanical Components	
52	Mechanical Components	
53	Mechanical Components	
54	Mechanical Components	
55	Mechanical Components	
56	Mechanical Components	
57	Mechanical Components	
58	Mechanical Components	
59	Joints & Fasteners	
60	Joints & Fasteners	
61	Joints & Fasteners	
62	Joints & Fasteners	
63	Joints & Fasteners	
64	Joints & Fasteners	
65	Joints & Fasteners	
66	Joints & Fasteners	
67	Joints & Fasteners	
68	Joints & Fasteners	
69	Joints & Fasteners	
70	Joints & Fasteners	
71	Supportive Knowledge	
72	Supportive Knowledge	
73	Supportive Knowledge	
74	Supportive Knowledge	
75	Supportive Knowledge	
76	Supportive Knowledge	
77	Supportive Knowledge	
78	Supportive Knowledge	
79	Supportive Knowledge	
80	Supportive Knowledge	