FE

industrial and systems practice exam
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About NCEES
NCEES is a nonprofit organization made up of the U.S. engineering and surveying licensing boards in all 50 states, U.S. territories, and the District of Columbia. We develop and score the exams used for engineering and surveying licensure in the United States. NCEES also promotes professional mobility through its services for licensees and its member boards.

Engineering licensure in the United States is regulated by licensing boards in each state and territory. These boards set and maintain the standards that protect the public they serve. As a result, licensing requirements and procedures vary by jurisdiction, so stay in touch with your board (ncees.org/licensing-boards).

Exam Format
The FE exam contains 110 questions and is administered year-round via computer at approved Pearson VUE test centers. A 6-hour appointment time includes a tutorial, the exam, and a break. You’ll have 5 hours and 20 minutes to complete the actual exam.

In addition to traditional multiple-choice questions with one correct answer, the FE exam uses common alternative item types such as

- Multiple correct options—allows multiple choices to be correct
- Point and click—requires examinees to click on part of a graphic to answer
- Drag and drop—requires examinees to click on and drag items to match, sort, rank, or label
- Fill in the blank—provides a space for examinees to enter a response to the question

To familiarize yourself with the format, style, and navigation of a computer-based exam, view the demo on ncees.org/ExamPrep.

Examinee Guide
The NCEES Examinee Guide is the official guide to policies and procedures for all NCEES exams. During exam registration and again on exam day, examinees must agree to abide by the conditions in the Examinee Guide, which includes the CBT Examinee Rules and Agreement. You can download the Examinee Guide at ncees.org/exams. It is your responsibility to make sure you have the current version.

Scoring and reporting
Exam results for computer-based exams are typically available 7–10 days after you take the exam. You will receive an email notification from NCEES with instructions to view your results in your MyNCEES account. All results are reported as pass or fail.

Updates on exam content and procedures
Visit us at ncees.org/exams for updates on everything exam-related, including specifications, exam-day policies, scoring, and corrections to published exam preparation materials. This is also where you will register for the exam and find additional steps you should follow in your state to be approved for the exam.
PRACTICE EXAM
14. You and your design group are competing for a multidisciplinary concept project. Your firm is the lead group in the design professional consortium formed to compete for the project. Your consortium has been selected as the first to enter fee negotiations with the project owner. During the negotiations, the amount you have to cut from your fee to be awarded the contract will require dropping one of the consortium members whose staff has special capabilities not available from the staff of the remaining consortium members. Can your remaining consortium ethically accept the contract?

- A. No, because an engineer may not accept a contract to coordinate a project with other professional firms providing capabilities and services that must be provided by hired consultants.
- B. Yes, if your remaining consortium members hire a few new lower-cost employees to do the special work that would have been provided by the consortium member that has been dropped.
- C. No, not if the owner is left with the impression that the consortium is still fully qualified to perform all the required tasks.
- D. Yes, if in accepting an assignment to coordinate the project, a single person will sign and seal all the documents for the entire work of the consortium.

15. A new sander costs $3,600 and has an annual maintenance cost of $400. Salvage value after 7 years is $600. If the interest rate is 10%, the present worth is most nearly:

- A. –$1,640
- B. –$3,290
- C. –$3,600
- D. –$5,240

16. A factory can buy and install energy-saving equipment at a cost of $450,000. The equipment will save $65,000 in energy costs each year for 10 years. The equipment’s salvage value at that time will be $50,000. The firm evaluates energy-saving projects at an interest rate of 6%. The present worth of this equipment to the nearest $100 is ______________.

Enter your response in the blank.
17. Match each of the costs below with its correct category.

<table>
<thead>
<tr>
<th>Variable Costs</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Depreciation</td>
</tr>
<tr>
<td></td>
<td>Consumables</td>
</tr>
<tr>
<td></td>
<td>Direct Labor</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fixed Costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Property Tax</td>
</tr>
<tr>
<td></td>
<td>Raw Materials</td>
</tr>
<tr>
<td></td>
<td>Salaries</td>
</tr>
</tbody>
</table>
29. The following data have been collected:

<table>
<thead>
<tr>
<th>Test</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>85</td>
</tr>
<tr>
<td>2</td>
<td>87</td>
</tr>
<tr>
<td>3</td>
<td>95</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
</tr>
<tr>
<td>5</td>
<td>85</td>
</tr>
<tr>
<td>6</td>
<td>88</td>
</tr>
<tr>
<td>7</td>
<td>90</td>
</tr>
<tr>
<td>8</td>
<td>90</td>
</tr>
<tr>
<td>9</td>
<td>91</td>
</tr>
</tbody>
</table>

Which of the following statements are true?

Select all that apply.

- [ ] A. The mean is larger than both the mode and the median.
- [ ] B. The mean and the median are equal.
- [ ] C. The mean and the mode are equal.
- [ ] D. The median and the mode are equal.
- [ ] E. The median is larger than both the mode and the mean.
- [ ] F. The mean is smaller than both the median and the mode.
34. The flowchart for a computer program contains the following segment:

VAR = 0
→ IF VAR < 5 THEN VAR = VAR + 2

OTHERWISE EXIT LOOP
LOOP

What is the value of VAR at the conclusion of this routine?

○ A. 0
○ B. 2
○ C. 4
○ D. 6

35. The final value of Q in the following flowchart is ____________.

Answer to the nearest integer.
51. Consider a flexible manufacturing system used to fabricate semiconductor wafers. It consists of a load/unload chamber, an orient chamber A, three identical process chambers (B, C, D), a cool-down chamber E, and a robot that can move a single wafer at a time. Each of the chambers A–E can process a single wafer at a time, and the load/unload station can hold up to 100 wafers. A batch of wafers is loaded into the load/unload station, and wafers are routed individually to Chamber A, then to one of the three chambers (B, C, or D), then to Chamber E, and then back to the load/unload chamber. The figure shows deterministic process times. Assume the robot move times are negligible compared to process times. If more than one of chambers B–D is available, the order of preference for moving a wafer from A is B, then C, then D. Mark the bottleneck operation in this system.
90. Consider a double-sampling plan for a population consisting of 10,000 items. The size of the first sample is 200, the acceptance number on this sample is 2, and the rejection number is 6. The size of the second sample is 350, and the cumulative acceptance and rejection numbers are 6 and 7, respectively. Using the notations \(P(x \leq a)\) and \(P(x \leq b)\) to indicate probabilities of at most \(a\) and \(b\) rejects in Samples I and II, respectively, the correct equation for the probability of acceptance of the plan is:

- **A.** \(P_a = P(x \leq 2)_I + P(x \leq 6)_II\)
- **B.** \(P_a = P(x \leq 2)_I + P(x = 3)_I P(x \leq 3)_II + P(x = 4)_I P(x \leq 2)_II + P(x = 5)_I P(x \leq 1)_II\)
- **C.** \(P_a = [1 - P(x \leq 5)_I] [1 - P(x \leq 6)_II]\)
- **D.** \(P_a = P(x \leq 2)_I + P(x = 3)_I P(x \leq 6)_II + P(x = 4)_I P(x \leq 6)_II + P(x = 5)_I P(x \leq 6)_II\)

91. Match the quality management tool with the function each serves.

<table>
<thead>
<tr>
<th>Management Tool</th>
<th>Function of Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fishbone Diagram</td>
<td>Assists in conducting root cause analysis</td>
</tr>
<tr>
<td>Pareto Chart</td>
<td>Compares customer requirements to design specifications</td>
</tr>
<tr>
<td>Control Chart</td>
<td>Measures process stability over time</td>
</tr>
<tr>
<td>House of Quality</td>
<td>Graphically represents the 80/20 rule</td>
</tr>
</tbody>
</table>

\[ S = \text{apparent power} \]
\[ P = \text{real power} \]
\[ Q = \text{reactive power} \]

\[ S = P + jQ = |S| \cos \theta + j|S| \sin \theta \]
\[ \cos \theta = pf = 0.866 \]
\[ Q = (1,500 \text{ VA}) \sin[\cos^{-1}0.866] = 750 \text{ VAR} \]

**THE CORRECT ANSWER IS: B**

11. Refer to the Ethics chapter of the FE Reference Handbook. Section B in the Rules of Professional Conduct states the following:

Licensees shall undertake assignments only when qualified by education or experience in the specific technical fields of engineering or surveying involved.

**THE CORRECT ANSWER IS: C**


**THE CORRECT ANSWER IS: A**


**THE CORRECT ANSWER IS: D**


**THE CORRECT ANSWER IS: A**

\[ PW = -3,600 - 400 \left( \frac{P}{A}, 10\%, 7 \right) + 600 \left( \frac{P}{F}, 10\%, 7 \right) \]

\[ = -3,600 - 400 (4.8684) + 600 (0.5132) \]

\[ = -5,239.4 \]

THE CORRECT ANSWER IS: D


\[ PW = -450,000 + 65,000 \left( \frac{P}{A}, 6\%, 10 \right) + 50,000 \left( \frac{P}{F}, 6\%, 10 \right) \]

\[ PW = -450,000 + 65,000 (7.3601) + 50,000 (0.5584) \]

\[ = -450,000 + 478,406.5 + 27,920 \]

\[ = $56,326.50 \text{ to the nearest } $100 \]

\[ = $56,300 \]

THE CORRECT ANSWER IS: $56,300
17. Variable costs are costs that vary with output. Fixed costs do not vary with the volume of production. Examinees should be familiar with these concepts.

**Variable Costs**
- Direct Labor
- Consumables
- Raw Materials

**Fixed Costs**
- Property Tax
- Salaries
- Building
- Depreciation

THE CORRECTLY SORTED COSTS ARE SHOWN ABOVE.

18. Refer to the Break-Even Analysis section in the Engineering Economics chapter of the *FE Reference Handbook*.

<table>
<thead>
<tr>
<th>Item</th>
<th>Year 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pallets</td>
<td>(2,000 \times $500/100) = $10,000</td>
</tr>
<tr>
<td>Tiedown straps</td>
<td>(25,000 \times $600/1,000) = $15,000</td>
</tr>
<tr>
<td>Tiedown clips</td>
<td>(50,000 \times $100/1,000) = $5,000</td>
</tr>
<tr>
<td>Banding tools</td>
<td>(8 \times $50.00) = $400</td>
</tr>
<tr>
<td>(\Sigma)</td>
<td>($30,400)</td>
</tr>
</tbody>
</table>

\[
\text{Reduction in Labor Cost/yr} = (\$30/\text{hr})(8 \text{ hr/day})(320 \text{ days})(0.10) = \$7,680
\]

\[
\text{Reduction in Breakage} = \frac{(50,000 + 53,000 + 49,000)(0.15)}{3} = \$7,600
\]

Total Annual Savings = \$15,280

Payback Period = \(\frac{\$30,400}{\$15,280}\) = 1.989 yr

THE CORRECT ANSWER IS: D
29. Refer to the Dispersion, Mean, Median, and Mode Values section in the Engineering Probability and Statistics chapter of the *FE Reference Handbook*.

\[
\text{Mean} = \frac{1}{N} \sum_{i=1}^{N} x_i = \frac{801}{9} = 89
\]

<table>
<thead>
<tr>
<th>95</th>
<th>91</th>
<th>90</th>
<th>90</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>88</td>
<td>87</td>
<td>85</td>
<td>85</td>
<td></td>
</tr>
</tbody>
</table>

The mean of the sample is 89. The median of the sample is 90. The mode of the sample is 90. Therefore, the median and mode are equal, and both are larger than the mean.

**THE CORRECT ANSWERS ARE: D AND F**

30. Refer to the Dispersion, Mean, Median, and Mode Values section in the Engineering Probability and Statistics chapter of the *FE Reference Handbook*.

\[
\sum_{i=1}^{n} x_i
\]

Estimate of the mean = \( \hat{\mu} = \bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} = 9.0319 \)

\[
\sum_{i=1}^{n} (x_i - \bar{x})^2
\]

Estimate of standard deviation = \( \hat{\sigma} = s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}} = 0.004254 \)

**THE CORRECT ANSWER IS: C**
FE INDUSTRIAL AND SYSTEMS SOLUTIONS


<table>
<thead>
<tr>
<th>Step</th>
<th>VAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>
EXIT LOOP

At the conclusion of the routine, VAR = 6.

THE CORRECT ANSWER IS: D

35. First Iteration of Loop
Q = 1 + 2 = 3
K = 2 \times 3 = 6
3 > 3 NO!

Second Iteration of Loop
Q = 3 + 2 = 5
K = 6 \times 5 = 30
5 > 3 YES!

\[ \therefore Q = 5 \]

THE CORRECT ANSWER IS: 5

36. Examinees are expected to be familiar with basic spreadsheet functions.

The following formulas are in the first five rows of Column B:
1. $A1^3 + A1^2 - 3$
2. $A2^3 + A1^2 - 3$
3. $A3^3 + A1^2 - 3$
4. $A4^3 + A1^2 - 3$
5. $A5^3 + A1^2 - 3$

In spreadsheet equation format, the formula in Cell B5 is

$A5^3 + A1^2 - 3$

THE CORRECT ANSWER IS: C
50. Productivity is a ratio of output/input. Throughput is an output; operating expense and inventory are inputs. Therefore, throughput/operating expense is a productivity measure. None of the other options reflect the output/input format.

THE CORRECT ANSWER IS: A

51. Examinees are expected to be familiar with addressing bottlenecks in manufacturing operations.

Chamber E is the bottleneck operation. This system can be thought of as a serial system with three process steps. Process step 1 (orient) has a production rate of 1 wafer/30 sec. Process step 2 (B–D) has a production rate of 1 wafer/60 sec since there are three processors. Process step 3 (E) has a production rate of 1 wafer/120 sec and is therefore the bottleneck.

THE CORRECT ANSWER IS SHADED ABOVE.

From the data used to develop the correct charts, $\bar{X} = 17.17$ and $R = 4.13$. The control limits for $n = 5$ are:

$UCL_{\bar{X}} = 17.17 + 0.577 \times 4.13 = 19.55$

$LCL_{\bar{X}} = 17.17 - 0.577 \times 4.13 = 14.79$

$LCL_R = 0$

$UCL_R = 2.114 \times 4.13 = 8.73$

For the given observations, $\bar{X} = 19.36$, $R = 9.3$

**THE CORRECT ANSWER IS: B**

89. Refer to the Process Capability section in the Industrial and Systems Engineering chapter of the FE Reference Handbook.

$C_p$ indicates how well the process can perform if it is "centered" in the specification band.

**THE CORRECT ANSWER IS: C**


The probability of acceptance is:

$P(accepted \ on \ first \ sample) + P(accepted \ on \ second \ sample \ | \ not \ accepted \ on \ first)$

$= P(x \leq 2)_{ll} + \sum_{n=3}^{5} P(x = n)_{ll} P(x \leq 6 - n)_{ll}$

$= P(x \leq 2)_{ll} + P(x = 3)_{ll} P(x \leq 3)_{ll} + P(x = 4)_{ll} P(x \leq 2)_{ll} + P(x = 5)_{ll} P(x \leq 1)_{ll}$

**THE CORRECT ANSWER IS: B**
91. Examinees are expected to be familiar with these diagrams as quality management tools.

Fishbone diagram: Assists in conducting root cause analysis

Pareto chart: Graphically represents the 80/20 rule, showing primary drivers for examples such as costs or failure likelihood

Control charts: Measures process stability over time

House of quality: Compares customer requirements to design specifications, giving complex comparison between multiple quality dimensions

THE CORRECT DEFINITIONS ARE SHOWN ABOVE.

92. Examinees are expected to be familiar with a variety of quality management tools. Quality function deployment (QFD) is a tool used within the house of quality to take customer requirements and come up with solutions to answer those requirements. TQM, Taguchi loss function, and Ishikawa are all quality management tools, but they were not developed for this purpose.

THE CORRECT ANSWER IS: B

93. Refer to the Reliability section of the Industrial and Systems Engineering chapter in the FE Reference Handbook.

Option D offers the greatest redundancy (multiple flow paths) and therefore the greatest reliability.

THE CORRECT ANSWER IS: D

94. Examinees are expected to know that product, performance, and process are part of requirements analysis. People are related to the three P's, but not included in them.

THE CORRECT ANSWER IS: C

95. Examinees are expected to know that parametric estimating and direct engineering and manufacturing estimates are based on data. Delphi is used to estimate "if and when," not normally preliminary cost estimator.

With no past historical data, estimating by analogy is the most cost effective.

THE CORRECT ANSWER IS: A