NCEES
advancing licensure for engineers and surveyors

FE

other disciplines

practice exam

ISBN 978-1-947801-04-2

Printed in the United States of America
1st printing January 2020

CONTENTS

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

17. The mass (g) of H_2SO_4 required to produce 1,000 mL of 0.25N H_2SO_4 is most nearly:

- ○ A. 12.3
- ○ B. 24.5
- ○ C. 49.0
- ○ D. 98.0

18. Consider the following equation:

$$K = \frac{[C]^2[D]^2}{[A]^4[B]}$$

The equation above is the formulation of the chemical equilibrium constant equation for which of the following reactions?

- ○ A. $C_2 + D_2 \leftrightarrow A_4 + B$
- ○ B. $4A + B \leftrightarrow 2C + 2D$
- ○ C. $4C + 2D \leftrightarrow 2A + B$
- ○ D. $A_4 + B \leftrightarrow C_2 + D_2$

19. Place the numbers in the correct position in the equation to balance the reaction. Some numbers may be used more than once.

_____ CH_4 + _____ O_2 → _____ CO_2 + _____ H_2O

1 2 3 4

26. An engineer is asked to sign and seal a set of drawings for a project. Under which of the following circumstances would this be acceptable?

Select **all** that apply.

- ☐ A. The drawings were developed by other licensed engineers, each of whom has signed and sealed the documents in their disciplines.
- ☐ B. The plans were developed by the engineer in his or her area of practice.
- ☐ C. The plans are copies of an existing design that was originally developed by another engineering firm.
- ☐ D. The engineer is a licensed electrical engineer, and the plans are for a structural design.
- ☐ E. The drawings were developed and signed/sealed by other engineers who work for the engineer.
- ☐ F. The plans were developed by engineers at another firm and are not signed and sealed by them.

27. Intellectual property is the creative product of the intellect and, as a category, normally includes things such as inventions, symbols, literary works, patents, and designs.

Match each product commonly used to protect intellectual property to its corresponding description.

Description	Product
1. The product is a "brand" name for an intellectual asset and includes a word, name, symbol, or device that distinguishes and identifies the source of a good or service.	A. Copyright
2. The product grants legally protected rights to the owner of the new, useful, and inventive item.	B. Industrial Design
3. The product applies to original literary, dramatic, musical, or artistic works from the moment of creation and can be registered and serve as proof of ownership.	C. Patent
4. The product protects the appearance of new items—including shapes, colors, and any other visual features—and protects the items from being used or sold by others.	D. Trademark

28. Pat Smith, a licensed professional engineer and university professor, was retained by an attorney representing a group of people in a nearby town. The plaintiffs claimed they were repeatedly subjected to low water pressure. In addition, several water samples collected from the area of distribution contained coliform bacteria.

Based on available schematics for the water system piping layout and elevated tank elevations, Dr. Smith calculated water could not reliably reach the area of distribution. Dr. Smith also concluded the service pumps were failing, causing pump components to wear out prematurely and increasing the probability of cross connections.

Which of the following actions should Dr. Smith take?

Select **all** that apply.

- ☐ A. Tell the local newspaper.
- ☐ B. Provide the findings to the plaintiffs' attorney.
- ☐ C. Report the design deficiency to the state engineering board.
- ☐ D. Notify the local health department that there is a risk to public health.
- ☐ E. Notify the water utility and its engineer of the findings.
- ☐ F. Publicize the findings in a professional journal article documenting design lessons to be learned.
- ☐ G. Notify the local engineering society.

49. A quantity of 7,700 L of fuel is loaded to an airplane before a flight. The fueling equipment has a conversion factor listed as 1.77 lbm/L. The mass (kg) of fuel loaded on the plane is most nearly:

- ○ A. 1,975
- ○ B. 4,350
- ○ C. 6,190
- ○ D. 13,630

50. The position of a particle that moves along a straight line is defined by the relation $x = t^3 + 8t^2 - 12t + 30$, where x is expressed in feet and t in seconds. The acceleration (ft/sec^2) of the particle at the time that the velocity is zero is _____.

Enter your response in the blank.

51. A particle traveled in a straight line in such a way that its distance s from a given point on that line after time t was $s = 20t^3 - t^4$. The rate of change of acceleration at time $t = 2$ is:

- ○ A. 72
- ○ B. 144
- ○ C. 192
- ○ D. 208

89. If the complex power is 1,500 VA with a power factor of 0.866 lagging, the reactive power (VAR) is most nearly:

- ○ A. 0
- ○ B. 750
- ○ C. 1,300
- ○ D. 1,500

90. Which of the following statements regarding a clamp-on current probe are true?

Select **all** that apply.

- ☐ A. When current is measured in a 3-phase machine, a clamp-on current probe must be clamped around all three current-carrying conductors.
- ☐ B. When current is measured in a three-wire (line, neutral, and ground) 120-V ac single-phase power cord, the clamp-on current probe should clamp around all three conductors.
- ☐ C. An ac clamp-on current probe acts as a transformer to determine the ac current.
- ☐ D. A dc clamp-on current probe uses the Hall effect to determine the dc current passing though the power conductor.
- ☐ E. A small clamp-on current probe will still give a correct measurement if it wraps around a thick conductor and does not completely close.

91. Which of the following are properties of balanced 3-phase power systems?

Select **all** that apply.

- ☐ A. All 3-phase voltages have equal magnitude and are 90° apart.
- ☐ B. Three-phase systems transmit alternating currents.
- ☐ C. Neutral wire, if present, carries no current.
- ☐ D. Three-phase systems can produce rotating magnetic field.
- ☐ E. In a wye connection, the line voltage equals the phase voltage.

NEXT→

SOLUTIONS

16. Refer to the Acids, Bases, and pH (aqueous solutions) section in the Chemistry chapter of the *FE Reference Handbook*.

$$\text{pH} = \log_{10}\left[\frac{1}{\left[\text{H}^+\right]}\right]$$

$$= \log_{10}\left[\frac{1}{\left[1 \times 10^{-7}\right]}\right] = 7$$

THE CORRECT ANSWER IS: C

17. Refer to the Definitions section in the Chemistry and Biology chapter of the *FE Reference Handbook*.

Basis: 1,000 ml = 1 L of 0.25N H_2SO_4

$$\therefore \text{M}_{\text{SA}} = \frac{0.25}{2} = 0.125 \text{ mol}$$

and

$$\text{W}_{\text{SA}} = (0.125 \text{ mol})(98 \text{ g/mol})$$

$$= 12.3 \text{ g}$$

$$1\ell\left(\frac{0.25 \text{ equivalent } H_2SO_4}{\ell}\right) = 0.25 \text{ equivalent } H_2SO_4$$

MW H_2SO_4:

H: (1)(2)	=	2
S: (32)(1)	=	32
O: (16)(4)	=	64
		98

$$1 \text{ mol} = 2 \text{ equivalents so } \frac{98}{2} = 49 \text{ g } \frac{H_2SO_4}{\text{equivalent}}$$

$$(0.25 \text{ equivalent})(H_2SO_4)\frac{49\text{g } H_2SO_4}{\text{equivalent}} = 12.3 \text{ g}$$

THE CORRECT ANSWER IS: A

18. Refer to the Chemistry chapter of the *FE Reference Handbook* for the equilibrium constant of a chemical reaction.

$4A + B \leftrightarrow 2C + 2D$

THE CORRECT ANSWER IS: B

19. Refer to the Chemistry chapter of the *FE Reference Handbook*.

In a balanced reaction, the number of atoms of each element must be the same on both sides of the reaction.

Carbon:	$A*1 + B*0 = C*1 + D*0$	$A = C$
Hydrogen:	$A*4 + B*0 = C*0 + D*2$	$2A = D$
Oxygen:	$A*0 + B*2 = C*2 + D*1$	$2B = 2C + D$

Let $A = 1$, then $C = 1$
$D = 2$
$B = 2$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

$\underline{1}\ CH_4 + \underline{2}\ O_2 \rightarrow \underline{1}\ CO_2 + \underline{2}\ H_2O$

THE CORRECT ANSWERS ARE SHOWN ABOVE.

20. Refer to the Measurement section in the Instrumentation, Measurement, and Control chapter of the *FE Reference Handbook*.

$R = R_o\,[1 + \alpha(T - T_o)]$

$$\Delta R = \frac{dR}{dT}\Delta T$$

$= R_o \alpha \Delta T$

$= (100\ \Omega)\ (0.004°C^{-1})\ (10°C)$

$= 4.0\ \Omega$

THE CORRECT ANSWER IS: C

26. Refer to the Model Law in the *FE Reference Handbook*.

Option A: "Licensees may accept assignments and assume responsibility for coordination of an entire project, provided that each technical segment is signed and sealed by the licensee responsible for preparation of that technical segment."

Options B and E. "Licensees shall not affix their signatures or seals to any plans or documents dealing with subject matter in which they lack competence, nor to any such plan or document not prepared under their responsible charge."

THE CORRECT ANSWERS ARE: A, B, E

27. Refer to the Intellectual Property section in the Ethics and Professional Practice chapter of the *FE Reference Handbook* for definitions.

1. D, Trademark
2. C, Patent
3. A, Copyright
4. B, Industrial design

THE CORRECT ANSWERS ARE SHOWN ABOVE.

28. Option B is correct as it is Dr. Smith's obligation to the client.

Options D and E are correct because as a P.E., Dr. Smith is obligated to protect public health and safety. However, sharing calculations or detailed findings are not appropriate unless Dr. Smith's client, the attorney, agrees to the disclosure of the finding or Dr. Smith is so ordered by a court.

Options A, F, and G are not correct because Dr. Smith does not have all the design information and disclosure would violate Dr. Smith's client obligation.

Option C is not correct because Dr. Smith does not have the detailed design or calculations to determine the design was deficient.

THE CORRECT ANSWERS ARE: B, D, E

48. 1. Free-body diagram of the box

By inspection, there are only two forces acting on the box, its weight and the force of cord CE. The box has a weight of (6 kg) * (9.81 m/s^2) = 58.9 N.

2. Free-body diagram of the knot

When the knot at C is isolated from its surroundings, its free-body diagram shows three forces: cords CBA and CE and spring CD. The diagram includes magnitudes and directions.

3. Free-body diagram of Cord CE

When cord CE is isolated from its surroundings, its free-body diagram shows only two forces acting on it, the force of the box and the force of the know (equal in magnitude and opposite in direction).

4. Free-body diagram of Cord AB

When the know at C is isolated from its surroundings, its free-body diagram shows three forces: cords CBA and CE and spring CD. The diagram includes magnitudes and directions.

THE CORRECT ANSWERS ARE SHOWN ABOVE.

49. The volume is 7,700 L, and the conversion factor is 1.77 lbm/L, which is a density.

Density × volume = mass, which is asked for in units of kg, not units of lbm.

7,700 L (1.77 lbm/L) = 13,629 lbm (0.454 kg/lbm) = 6,187.566 kg = 6,190 kg

THE CORRECT ANSWER IS: C

50. For position, $x = t^3 + 8t^2 - 12t + 30$

For velocity, $v = dx/dt = 3t^2 + 16t - 12 \rightarrow (3t - 2)(t + 6) = 0$; only $t = 2/3$ sec corresponds to a time after the motion has begun.

For acceleration, $a = dv/dt = 6t + 16$ at $t = 2/3$ sec, $a = 6(2/3) + 16 = 20$ ft/sec^2

THE CORRECT ANSWER IS: 20

51. First, the velocity is:

$$v = s' = 60t^2 - 4t^3$$

Then, the acceleration is:

$$a = s'' = 120t - 12t^2$$

Finally, the rate of change of acceleration is:

$$a' = s''' = 120 - 24t$$

When $t = 2$:

$$a' = 120 - 24(2) = 120 - 48 = 72$$

THE CORRECT ANSWER IS: A

52. Refer to the section Plane Motion of a Rigid Body—Kinematics (Instantaneous Center of Rotation) in the Dynamics chapter of the *FE Reference Handbook*.

The crank and rod are two rigid bodies. At the moment when θ = 90°, v_P is desired (piston speed).

v_C = 50 mm × 377 rad/s = 18,850 mm/s

Both points are on the rod. By the method of instantaneous centers, the center of rotation is located where the line at P, ⊥ to v_P, intersects the line at C, ⊥ to v_C.

v_C is parallel to v_P so these meet at infinity. Thus the rotation of rod PC is 0, or $\omega_{PC} = 0$.

Since there is no rotation at this instant, *all* points of the rod move with the same velocity and

$v_P = v_C = 18{,}850$ mm/s because $\bar{v}_P = \bar{v}_C + \bar{\omega}_{PC} \times \bar{r}_{P/C}$ and $\omega_{PC} = 0$.

THE CORRECT ANSWER IS: C

89. Refer to the Complex Power section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook*.

S = apparent power
P = real power
Q = reactive power

$S = P + jQ = |S| \cos \theta + j\,|S| \sin \theta$

$\cos \theta = \text{pf} = 0.866$

$Q = (1{,}500 \text{ VA}) \sin[\cos^{-1}0.866] = 750 \text{ VAR}$

THE CORRECT ANSWER IS: B

90. Options C and D are correct. Clamp-on current probes sense the electromagnetic field produced by the current passing through the power conductor that it surrounds. AC probes act as a transformer. DC probes use a Hall effect sensor.

THE CORRECT ANSWERS ARE: C, D

91. Refer to the Balanced Three-Phase (3-ϕ) Systems section in the Electrical and Computer Engineering chapter of the FE Reference Handbook.

AC power is a main feature of 3-phase transmission. The system is balanced, so there is no current in the neutral wire. Since there are 3 phases, they can be arranged to create a rotating magnetic field, which is useful for electric motors that are fed directly with 3-phase power.

THE CORRECT ANSWER IS: B, C, D

92. Refer to the Properties of Single-Component Systems section in the Thermodynamics chapter of the *FE Reference Handbook*.

Entropy is a thermodynamic property. It is designed only on the current conditions, not on history, and therefore determined by knowledge (measurement) of current state, not on the path used to reach it.

THE CORRECT ANSWER IS: B