

# PRACTICE EXAM 14: FE OTHER DISCIPLINES

## SIMULATION (110 QUESTIONS)

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*This standalone practice exam contains 110 applied engineering questions. Allow 5 hours and 20 minutes of active testing time, use the supplied FE Reference Handbook, and select the single best answer for every item. Consult the answer key and explanations only after completing the exam.*

1. During a technical design checkpoint, solve  $2x - 3 = 4$  for  $x$ .

- A. -0.5
- B. 2.5
- C. 3.5
- D. 4.5

2. For a manufacturing-readiness analysis, what is the area of a circle with radius 2.5 m?

- A. 19.6 m<sup>2</sup>
- B. 7.85 m<sup>2</sup>
- C. 15.7 m<sup>2</sup>
- D. 9.82 m<sup>2</sup>

3. While reviewing an engineering calculation, evaluate  $f(x) = 3x^2 + 2x - 5$  at  $x = 3$ .

- A. 33
- B. 28
- C. 10
- D. 23

4. In a system-safety assessment, for  $y = \ln(5x)$ , what is  $dy/dx$  at  $x = 1$ ?

- A. 1
- B. 2
- C. 1.61
- D. 5

5. For a resource-allocation decision, find the determinant of the matrix  $\begin{bmatrix} 6 & 1 \\ 1 & 3 \end{bmatrix}$ .

- A. 9
- B. 15
- C. 17
- D. 19

6. During a technical design checkpoint, solve  $7x - 8 = 4$  for  $x$ .

- A. 2.71
- B. 0.714
- C. 0.571
- D. 1.71

7. For a manufacturing-readiness analysis, what is the area of a circle with radius 5 m?

- A.  $15.7 \text{ m}^2$
- B.  $39.3 \text{ m}^2$
- C.  $31.4 \text{ m}^2$
- D.  $78.5 \text{ m}^2$

8. While reviewing an engineering calculation, evaluate  $f(x) = 3x^2 + 2x - 5$  at  $x = 8$ .

- A. 35
- B. 208
- C. 203
- D. 198

**9.** In a system-safety assessment, for  $y = \ln(10x)$ , what is  $dy/dx$  at  $x = 1$ ?

- A. 1
- B. 2.3
- C. 2
- D. 10

**10.** For a resource-allocation decision, find the determinant of the matrix  $\begin{bmatrix} 11 & 1 \\ 1 & 3 \end{bmatrix}$ .

- A. 14
- B. 32
- C. 34
- D. 30

**11.** During a technical design checkpoint, what is the arithmetic mean of  $[2, 4, 6, 8]$ ?

- A. 4
- B. 6
- C. 5
- D. 20

**12.** For a manufacturing-readiness analysis, a component fails with probability 0.25. What is the probability it does not fail?

- A. 0.75
- B. 0.94

- C. 0.25
- D. 0.06

**13.** While reviewing an engineering calculation, for a binomial variable with  $n = 7$  and  $p = 0.40$ , what is the expected value?

- A. 4.2
- B. 2.8
- C. 0.4
- D. 3.8

**14.** In a system-safety assessment, which measure is most resistant to a single extreme outlier?

- A. Arithmetic mean
- B. Sample variance
- C. Standard deviation
- D. Median

**15.** For a resource-allocation decision, what is the arithmetic mean of [6, 8, 10, 12]?

- A. 9
- B. 36
- C. 8
- D. 10

**16.** During a technical design checkpoint, a component fails with probability 0.45. What is the probability it does not fail?

- A. 0.45
- B. 0.55
- C. 0.80

D. 0.20

**17.** For a manufacturing-readiness analysis, for a binomial variable with  $n = 11$  and  $p = 0.40$ , what is the expected value?

A. 0.4

B. 6.6

C. 5.4

D. 4.4

**18.** While reviewing an engineering calculation, a solution has  $[H^+] = 1.00e-03$  mol/L. What is its pH?

A. 4

B. 11

C. 3

D. 2

**19.** In a system-safety assessment, what mass of water corresponds to 2 mol if its molar mass is 18.015 g/mol?

A. 18 g

B. 54 g

C. 36 g

D. 0.111 g

**20.** For a resource-allocation decision, in an oxidation-reduction reaction, oxidation is best described as which process?

A. Gain of electrons

B. Gain of protons only

C. Loss of neutrons

D. Loss of electrons

**21.** During a technical design checkpoint, a solution has  $[H^+] = 3.16 \times 10^{-5}$  mol/L. What is its pH?

- A. 9.5
- B. 4.5
- C. 3.5
- D. 5.5

**22.** For a manufacturing-readiness analysis, what mass of water corresponds to 5 mol if its molar mass is 18.015 g/mol?

- A. 90.1 g
- B. 45 g
- C. 108 g
- D. 0.278 g

**23.** While reviewing an engineering calculation, in an oxidation-reduction reaction, oxidation is best described as which process?

- A. Gain of electrons
- B. Loss of electrons
- C. Loss of neutrons
- D. Gain of protons only

**24.** In a system-safety assessment, which device converts a physical quantity into a usable electrical signal?

- A. A relief valve
- B. A flywheel
- C. A transducer

D. A heat exchanger

**25.** For a resource-allocation decision, an ideal 8-bit A/D converter spans 0 to 10 V. What is its nominal resolution using  $\text{span}/2^n$ ?

- A. 0.0392 V
- B. 0.0195 V
- C. 0.0781 V
- D. 0.0391 V

**26.** During a technical design checkpoint, an ideal 9-bit A/D converter spans 0 to 12 V. What is its nominal resolution using  $\text{span}/2^n$ ?

- A. 0.0234 V
- B. 0.0235 V
- C. 0.0117 V
- D. 0.0469 V

**27.** For a manufacturing-readiness analysis, an ideal 10-bit A/D converter spans 0 to 14 V. What is its nominal resolution using  $\text{span}/2^n$ ?

- A. 0.0137 V
- B. 0.0273 V
- C. 0.00684 V
- D. 0.0137 V

**28.** While reviewing an engineering calculation, an ideal 11-bit A/D converter spans 0 to 16 V. What is its nominal resolution using  $\text{span}/2^n$ ?

- A. 0.00782 V
- B. 0.0156 V

- C. 0.00391 V
- D. 0.00781 V

**29.** In a system-safety assessment, an engineer discovers a design condition posing an imminent danger to the public. What is the engineer's primary ethical obligation?

- A. Wait until construction is complete
- B. Keep the matter confidential in all circumstances
- C. Notify the appropriate parties and protect public safety
- D. Defer solely to the client's financial interest

**30.** For a resource-allocation decision, an engineer is asked to approve calculations prepared outside the engineer's area of competence. What is the proper response?

- A. Approve it after a brief visual review
- B. Decline or obtain competent professional involvement
- C. Seal the work if the client accepts responsibility
- D. Delegate the seal to an unlicensed employee

**31.** During a technical design checkpoint, a vendor offers an engineer an undisclosed commission for specifying its product. What should the engineer do?

- A. Divide it among the design team
- B. Refuse the commission and disclose the conflict
- C. Accept it because product quality is unchanged
- D. Accept it after project completion

**32.** For a manufacturing-readiness analysis, when presenting an engineering report, which practice best supports professional integrity?

- A. Omit unfavorable results

- B. Guarantee outcomes beyond available evidence
- C. State relevant assumptions and limitations clearly
- D. Present estimates as exact measurements

**33.** While reviewing an engineering calculation, an engineer reviews a former employer's confidential design data. When may the engineer disclose it?

- A. When authorized or legally required
- B. Whenever the information is technically interesting
- C. After leaving the employer
- D. Whenever it improves a competing proposal

**34.** In a system-safety assessment, which action best addresses a potential conflict of interest before accepting an assignment?

- A. Conceal it unless financial harm occurs
- B. Transfer it informally to a coworker
- C. Proceed because technical work is objective
- D. Disclose the conflict to affected parties

**35.** For a resource-allocation decision, before entering a permit-required confined space, which action is essential?

- A. Enter briefly without monitoring
- B. Disable ventilation to avoid turbulence
- C. Test the atmosphere and establish required controls
- D. Rely only on odor detection

**36.** During a technical design checkpoint, which document communicates chemical hazards, protective measures, and emergency information?

- A. Purchase order
- B. Calibration certificate
- C. Process flow index
- D. Safety Data Sheet

**37.** For a manufacturing-readiness analysis, what is the first hierarchy-of-controls preference for a serious workplace hazard?

- A. Issue warning signs
- B. Eliminate the hazard
- C. Require personal protective equipment
- D. Provide refresher training only

**38.** While reviewing an engineering calculation, which instrument is appropriate for checking oxygen concentration before confined-space entry?

- A. A calibrated multigas atmospheric monitor
- B. An infrared tachometer
- C. A sound-level meter
- D. A clamp-on ammeter

**39.** In a system-safety assessment, what is the principal purpose of lockout/tagout?

- A. Document production output
- B. Increase equipment cycle speed
- C. Reduce normal operating voltage
- D. Prevent unexpected energization during servicing

**40.** For a resource-allocation decision, for a small energized electrical fire, which extinguisher characteristic is required?

- A. Combustible metal powder only
- B. Nonconductive agent suitable for Class C hazards
- C. Pressurized water stream
- D. Conductive foam only

**41.** During a technical design checkpoint, which control most directly reduces worker exposure to airborne contaminants at their source?

- A. General warning signage
- B. Longer work shifts
- C. Local exhaust ventilation
- D. Administrative record retention

**42.** For a manufacturing-readiness analysis, what future amount results from investing \$1,000 for 3 years at 5% annual compound interest?

- A. \$1,157.63
- B. \$863.84
- C. \$1,150.00
- D. \$1,000.15

**43.** While reviewing an engineering calculation, a product has fixed cost \$21,000, selling price \$51, and variable cost \$30 per unit. What is the break-even quantity?

- A. 1000.00 units
- B. 1100.00 units
- C. 700.00 units
- D. 411.76 units

**44.** In a system-safety assessment, an asset costs \$6,000, has \$500 salvage value, and a 5-year life. What is annual straight-line depreciation?

- A. \$1,200.00/year
- B. \$5,500.00/year
- C. \$1,300.00/year
- D. \$1,100.00/year

**45.** For a resource-allocation decision, what future amount results from investing \$2,500 for 6 years at 5% annual compound interest?

- A. \$1,865.54
- B. \$3,350.24
- C. \$3,250.00
- D. \$2,500.30

**46.** During a technical design checkpoint, a product has fixed cost \$24,000, selling price \$54, and variable cost \$30 per unit. What is the break-even quantity?

- A. 800.00 units
- B. 1100.00 units
- C. 1000.00 units
- D. 444.44 units

**47.** For a manufacturing-readiness analysis, an asset costs \$7,500, has \$500 salvage value, and a 5-year life. What is annual straight-line depreciation?

- A. \$1,400.00/year
- B. \$1,500.00/year
- C. \$1,600.00/year
- D. \$7,000.00/year

**48.** While reviewing an engineering calculation, a 100-N force acts  $30^\circ$  above the positive x-axis. What is its x-component?

- A. 50 N
- B. -13.4 N
- C. 100 N
- D. 86.6 N

**49.** In a system-safety assessment, a simply supported 4-m beam carries a 220-N point load 2 m from the left support. What is the right reaction?

- A. 111 N
- B. 440 N
- C. 110 N
- D. 55 N

**50.** For a resource-allocation decision, a 520-N block rests on a horizontal surface with coefficient of static friction 0.30. What is the maximum static friction?

- A. 1.73e+03 N
- B. 156 N
- C. 0.3 N
- D. 364 N

**51.** During a technical design checkpoint, a 160-N force acts  $30^\circ$  above the positive x-axis. What is its x-component?

- A. -21.4 N
- B. 160 N
- C. 80 N
- D. 139 N

**52.** For a manufacturing-readiness analysis, a simply supported 4-m beam carries a 280-N point load 1 m from the left support. What is the right reaction?

- A. 71 N
- B. 70 N
- C. 210 N
- D. 280 N

**53.** While reviewing an engineering calculation, a 550-N block rests on a horizontal surface with coefficient of static friction 0.30. What is the maximum static friction?

- A. 1.83e+03 N
- B. 385 N
- C. 165 N
- D. 0.3 N

**54.** In a system-safety assessment, a 220-N force acts  $30^\circ$  above the positive x-axis. What is its x-component?

- A. 191 N
- B. 220 N
- C. 110 N
- D. -29.5 N

**55.** For a resource-allocation decision, a simply supported 4-m beam carries a 340-N point load 2 m from the left support. What is the right reaction?

- A. 85 N
- B. 171 N
- C. 170 N
- D. 680 N

**56.** During a technical design checkpoint, a 580-N block rests on a horizontal surface with coefficient of static friction 0.30. What is the maximum static friction?

- A. 0.3 N
- B. 174 N
- C.  $1.93 \times 10^3$  N
- D. 406 N

**57.** For a manufacturing-readiness analysis, a 280-N force acts  $30^\circ$  above the positive x-axis. What is its x-component?

- A. -37.5 N
- B. 140 N
- C. 280 N
- D. 242 N

**58.** While reviewing an engineering calculation, a particle starts at 2 m/s and accelerates uniformly at  $3 \text{ m/s}^2$  for 4 s. What is its final speed?

- A. 14 m/s
- B. 32 m/s
- C. 12 m/s
- D. 13 m/s

**59.** In a system-safety assessment, what net force accelerates a 6-kg mass at  $2 \text{ m/s}^2$ ?

- A. 3 N
- B. 118 N
- C. 12 N
- D. 8 N

**60.** For a resource-allocation decision, an object moves at 12 m/s in a circular path of radius 5 m. What is its centripetal acceleration?

- A.  $28.8 \text{ m/s}^2$
- B.  $2.4 \text{ m/s}^2$
- C.  $720 \text{ m/s}^2$
- D.  $4.8 \text{ m/s}^2$

**61.** During a technical design checkpoint, a particle starts at  $5 \text{ m/s}$  and accelerates uniformly at  $3 \text{ m/s}^2$  for  $4 \text{ s}$ . What is its final speed?

- A.  $13 \text{ m/s}$
- B.  $44 \text{ m/s}$
- C.  $12 \text{ m/s}$
- D.  $17 \text{ m/s}$

**62.** For a manufacturing-readiness analysis, what net force accelerates a  $9\text{-kg}$  mass at  $2 \text{ m/s}^2$ ?

- A.  $11 \text{ N}$
- B.  $18 \text{ N}$
- C.  $4.5 \text{ N}$
- D.  $177 \text{ N}$

**63.** While reviewing an engineering calculation, an object moves at  $15 \text{ m/s}$  in a circular path of radius  $5 \text{ m}$ . What is its centripetal acceleration?

- A.  $6 \text{ m/s}^2$
- B.  $1.12\text{e}+03 \text{ m/s}^2$
- C.  $3 \text{ m/s}^2$
- D.  $45 \text{ m/s}^2$

**64.** In a system-safety assessment, a particle starts at  $8 \text{ m/s}$  and accelerates uniformly at  $3 \text{ m/s}^2$  for  $4 \text{ s}$ . What is its final speed?

- A. 20 m/s
- B. 56 m/s
- C. 12 m/s
- D. 13 m/s

**65.** For a resource-allocation decision, what net force accelerates a 12-kg mass at 2 m/s<sup>2</sup>?

- A. 14 N
- B. 235 N
- C. 24 N
- D. 6 N

**66.** During a technical design checkpoint, an object moves at 18 m/s in a circular path of radius 5 m. What is its centripetal acceleration?

- A. 7.2 m/s<sup>2</sup>
- B. 64.8 m/s<sup>2</sup>
- C. 1.62e+03 m/s<sup>2</sup>
- D. 3.6 m/s<sup>2</sup>

**67.** For a manufacturing-readiness analysis, a tensile load of 20 kN acts on a bar with cross-sectional area 400 mm<sup>2</sup>. What is the normal stress?

- A. 50 MPa
- B. 0.05 MPa
- C. 25 MPa
- D. 5e+04 MPa

**68.** While reviewing an engineering calculation, a 2-m bar elongates 0.0011 m. What is its axial strain?

- A. 0.055000

- B. 1818.181818
- C. 0.002200
- D. 0.000550

**69.** In a system-safety assessment, within the elastic range, a material has  $E = 200,000$  MPa and strain 0.00060. What is the stress?

- A.  $3\text{e-}09$  MPa
- B.  $3.33\text{e+}08$  MPa
- C. 120 MPa
- D. 60 MPa

**70.** For a resource-allocation decision, a tensile load of 26 kN acts on a bar with cross-sectional area 430 mm<sup>2</sup>. What is the normal stress?

- A.  $6.05\text{e+}04$  MPa
- B. 60.5 MPa
- C. 30.2 MPa
- D. 0.0605 MPa

**71.** During a technical design checkpoint, a 2-m bar elongates 0.0014 m. What is its axial strain?

- A. 1428.571429
- B. 0.070000
- C. 0.000700
- D. 0.002800

**72.** For a manufacturing-readiness analysis, within the elastic range, a material has  $E = 200,000$  MPa and strain 0.00075. What is the stress?

- A. 150 MPa

- B.  $3.75 \times 10^{-9}$  MPa
- C.  $2.67 \times 10^8$  MPa
- D. 75 MPa

**73.** While reviewing an engineering calculation, a tensile load of 32 kN acts on a bar with cross-sectional area 460 mm<sup>2</sup>. What is the normal stress?

- A. 0.0696 MPa
- B.  $6.96 \times 10^4$  MPa
- C. 34.8 MPa
- D. 69.6 MPa

**74.** In a system-safety assessment, a 2-m bar elongates 0.0017 m. What is its axial strain?

- A. 1176.470588
- B. 0.000850
- C. 0.003400
- D. 0.085000

**75.** For a resource-allocation decision, within the elastic range, a material has  $E = 200,000$  MPa and strain 0.00090. What is the stress?

- A.  $4.5 \times 10^{-9}$  MPa
- B. 90 MPa
- C.  $2.22 \times 10^8$  MPa
- D. 180 MPa

**76.** During a technical design checkpoint, which material property measures resistance to localized plastic indentation?

- A. Hardness

- B. Specific heat
- C. Ductility
- D. Thermal conductivity

**77.** For a manufacturing-readiness analysis, what commonly happens to the strength and ductility of a cold-worked metal?

- A. Both remain unchanged
- B. Strength increases while ductility decreases
- C. Both strength and ductility increase
- D. Strength decreases while ductility increases

**78.** While reviewing an engineering calculation, which crystal defect is a one-dimensional imperfection central to plastic deformation?

- A. A pore volume
- B. A grain
- C. A dislocation
- D. A vacancy

**79.** In a system-safety assessment, why is galvanic corrosion promoted when dissimilar metals are electrically connected in an electrolyte?

- A. Both metals become perfect insulators
- B. Mechanical stress becomes zero
- C. The electrolyte removes all ions
- D. A potential difference drives electrochemical current

**80.** For a resource-allocation decision, which test primarily measures a material's energy absorption during sudden fracture?

- A. Thermal expansion test
- B. Charpy impact test
- C. Rockwell hardness test
- D. Creep rupture test

**81.** During a technical design checkpoint, what is creep?

- A. Time-dependent deformation under sustained stress
- B. Instantaneous elastic recovery
- C. Cyclic crack growth only
- D. Surface oxidation without strain

**82.** For a manufacturing-readiness analysis, water flows through an area of  $0.020 \text{ m}^2$  at an average velocity of  $3 \text{ m/s}$ . What is the volumetric flow rate?

- A.  $150 \text{ m}^3/\text{s}$
- B.  $60 \text{ m}^3/\text{s}$
- C.  $0.06 \text{ m}^3/\text{s}$
- D.  $0.00667 \text{ m}^3/\text{s}$

**83.** While reviewing an engineering calculation, what gauge pressure is produced by a  $2.5\text{-m}$  column of water with density  $1000 \text{ kg/m}^3$ ?

- A.  $3.92\text{e}+03 \text{ Pa}$
- B.  $2.5\text{e}+03 \text{ Pa}$
- C.  $24.5 \text{ Pa}$
- D.  $2.45\text{e}+04 \text{ Pa}$

**84.** In a system-safety assessment, for water with  $\rho = 1000 \text{ kg/m}^3$  and  $\mu = 0.001 \text{ Pa}\cdot\text{s}$  flowing at  $2.2 \text{ m/s}$  in a  $0.05\text{-m}$  pipe, what is Reynolds number?

- A.  $1.1\text{e}+05$
- B. 111
- C.  $2.2\text{e}+06$
- D. 110

**85.** For a resource-allocation decision, in incompressible pipe flow, diameter decreases from 0.10 m to 0.05 m. If upstream velocity is 2.3 m/s, what is downstream velocity?

- A. 4.6 m/s
- B. 9.2 m/s
- C. 0.575 m/s
- D. 1.15 m/s

**86.** During a technical design checkpoint, water flows through an area of  $0.024\text{ m}^2$  at an average velocity of 3 m/s. What is the volumetric flow rate?

- A.  $125\text{ m}^3/\text{s}$
- B.  $72\text{ m}^3/\text{s}$
- C.  $0.072\text{ m}^3/\text{s}$
- D.  $0.008\text{ m}^3/\text{s}$

**87.** For a manufacturing-readiness analysis, what gauge pressure is produced by a 4.5-m column of water with density  $1000\text{ kg}/\text{m}^3$ ?

- A.  $4.41\text{e}+04\text{ Pa}$
- B.  $4.5\text{e}+03\text{ Pa}$
- C.  $2.18\text{e}+03\text{ Pa}$
- D. 44.1 Pa

**88.** While reviewing an engineering calculation, for water with  $\rho = 1000\text{ kg}/\text{m}^3$  and  $\mu = 0.001\text{ Pa}\cdot\text{s}$  flowing at 2.6 m/s in a 0.05-m pipe, what is Reynolds number?

- A. 131
- B. 130
- C.  $1.3 \times 10^5$
- D.  $2.6 \times 10^6$

**89.** In a system-safety assessment, in incompressible pipe flow, diameter decreases from 0.10 m to 0.05 m. If upstream velocity is 2.7 m/s, what is downstream velocity?

- A. 1.35 m/s
- B. 5.4 m/s
- C. 0.675 m/s
- D. 10.8 m/s

**90.** For a resource-allocation decision, water flows through an area of  $0.028 \text{ m}^2$  at an average velocity of 3 m/s. What is the volumetric flow rate?

- A.  $0.00933 \text{ m}^3/\text{s}$
- B.  $0.084 \text{ m}^3/\text{s}$
- C.  $107 \text{ m}^3/\text{s}$
- D.  $84 \text{ m}^3/\text{s}$

**91.** During a technical design checkpoint, what gauge pressure is produced by a 6.5-m column of water with density  $1000 \text{ kg/m}^3$ ?

- A.  $6.38 \times 10^4 \text{ Pa}$
- B.  $6.5 \times 10^3 \text{ Pa}$
- C.  $1.51 \times 10^3 \text{ Pa}$
- D. 63.8 Pa

**92.** For a manufacturing-readiness analysis, for water with  $\rho = 1000 \text{ kg/m}^3$  and  $\mu = 0.001 \text{ Pa}\cdot\text{s}$  flowing at 3.0 m/s in a 0.05-m pipe, what is Reynolds number?

- A. 150
- B.  $1.5 \times 10^5$
- C.  $3 \times 10^6$
- D. 151

**93.** While reviewing an engineering calculation, in incompressible pipe flow, diameter decreases from 0.10 m to 0.05 m. If upstream velocity is 3.1 m/s, what is downstream velocity?

- A. 1.55 m/s
- B. 6.2 m/s
- C. 12.4 m/s
- D. 0.775 m/s

**94.** In a system-safety assessment, water flows through an area of  $0.032 \text{ m}^2$  at an average velocity of 3 m/s. What is the volumetric flow rate?

- A.  $0.0107 \text{ m}^3/\text{s}$
- B.  $96 \text{ m}^3/\text{s}$
- C.  $93.8 \text{ m}^3/\text{s}$
- D.  $0.096 \text{ m}^3/\text{s}$

**95.** For a resource-allocation decision, a 12-V source is applied across a  $4\text{-}\Omega$  resistor. What current flows?

- A. 3 A
- B. 48 A
- C. 16 A
- D. 0.333 A

**96.** During a technical design checkpoint, what is the equivalent resistance of  $5 \text{ }\Omega$  and  $7 \text{ }\Omega$  connected in series?

- A.  $35\ \Omega$
- B.  $2\ \Omega$
- C.  $2.92\ \Omega$
- D.  $12\ \Omega$

**97.** For a manufacturing-readiness analysis, a device operates at 12 V and draws 2 A. What electrical power does it consume?

- A. 6 W
- B. 14 W
- C. 24 W
- D. 0.167 W

**98.** While reviewing an engineering calculation, a 18-V source is applied across a  $7\text{-}\Omega$  resistor. What current flows?

- A. 126 A
- B. 2.57 A
- C. 0.389 A
- D. 25 A

**99.** In a system-safety assessment, what is the equivalent resistance of  $8\ \Omega$  and  $10\ \Omega$  connected in series?

- A.  $2\ \Omega$
- B.  $80\ \Omega$
- C.  $18\ \Omega$
- D.  $4.44\ \Omega$

**100.** For a resource-allocation decision, a device operates at 15 V and draws 2 A. What electrical power does it consume?

- A. 30 W
- B. 0.133 W
- C. 17 W
- D. 7.5 W

**101.** During a technical design checkpoint, how much heat is required to raise 2.0 kg of water by 10°C if  $c_p = 4.18 \text{ kJ}/(\text{kg}\cdot^\circ\text{C})$ ?

- A. 8.36 kJ
- B. 83.6 kJ
- C. 0.0836 kJ
- D. 41.8 kJ

**102.** For a manufacturing-readiness analysis, heat transfer is 520 W through 2 m<sup>2</sup> with a 25 K temperature difference. What is the overall heat-transfer coefficient?

- A. 20.8 W/(m<sup>2</sup>·K)
- B. 260 W/(m<sup>2</sup>·K)
- C. 2.6e+04 W/(m<sup>2</sup>·K)
- D. 10.4 W/(m<sup>2</sup>·K)

**103.** While reviewing an engineering calculation, a heat engine receives 1100 kJ and produces 320 kJ of work. What is its thermal efficiency?

- A. 29.1%
- B. 70.9%
- C. 343.8%
- D. 41.0%

**104.** In a system-safety assessment, how much heat is required to raise 2.6 kg of water by 13°C if  $c_p = 4.18 \text{ kJ}/(\text{kg}\cdot^\circ\text{C})$ ?

- A. 10.9 kJ
- B. 54.3 kJ
- C. 141 kJ
- D. 0.141 kJ

**105.** For a resource-allocation decision, heat transfer is 580 W through 2 m<sup>2</sup> with a 25 K temperature difference. What is the overall heat-transfer coefficient?

- A. 2.9e+04 W/(m<sup>2</sup>·K)
- B. 290 W/(m<sup>2</sup>·K)
- C. 23.2 W/(m<sup>2</sup>·K)
- D. 11.6 W/(m<sup>2</sup>·K)

**106.** During a technical design checkpoint, a heat engine receives 1250 kJ and produces 350 kJ of work. What is its thermal efficiency?

- A. 38.9%
- B. 28.0%
- C. 357.1%
- D. 72.0%

**107.** For a manufacturing-readiness analysis, how much heat is required to raise 3.2 kg of water by 16°C if  $c_p = 4.18 \text{ kJ}/(\text{kg} \cdot ^\circ\text{C})$ ?

- A. 66.9 kJ
- B. 214 kJ
- C. 13.4 kJ
- D. 0.214 kJ

**108.** While reviewing an engineering calculation, heat transfer is 640 W through 2 m<sup>2</sup> with a 25 K temperature difference. What is the overall heat-transfer coefficient?

- A. 25.6 W/(m<sup>2</sup>·K)
- B. 320 W/(m<sup>2</sup>·K)
- C. 12.8 W/(m<sup>2</sup>·K)
- D. 3.2e+04 W/(m<sup>2</sup>·K)

**109.** In a system-safety assessment, a heat engine receives 1400 kJ and produces 380 kJ of work. What is its thermal efficiency?

- A. 368.4%
- B. 37.3%
- C. 72.9%
- D. 27.1%

**110.** For a resource-allocation decision, how much heat is required to raise 3.8 kg of water by 19°C if  $c_p = 4.18 \text{ kJ}/(\text{kg} \cdot ^\circ\text{C})$ ?

- A. 302 kJ
- B. 15.9 kJ
- C. 0.302 kJ
- D. 79.4 kJ

## Practice Exam 14: Answer Key and Explanations

**1. C** — Adding 3 to both sides gives  $2x = 7$ . Dividing by 2 gives  $x = 3.5$ . This procedure follows the standard mathematics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**2. A** — The area of a circle is  $\pi r^2$ . Substituting  $r = 2.5 \text{ m}$  produces  $19.6 \text{ m}^2$ . This procedure follows the standard mathematics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**3. B** — Direct substitution gives  $3(3)^2 + 2(3) - 5 = 28$ . This procedure follows the standard mathematics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**4. A** — The derivative of  $\ln(5x)$  is  $1/x$  because the constant factor cancels by the chain rule. At  $x = 1$ , the value is 1. This procedure follows the standard mathematics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**5. C** — For a  $2 \times 2$  matrix, the determinant is  $ad - bc$ . Thus  $(6)(3) - (1)(1) = 17$ . This procedure follows the standard mathematics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**6. D** — Adding 8 to both sides gives  $7x = 12$ . Dividing by 7 gives  $x = 1.71429$ . This procedure follows the standard mathematics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**7. D** — The area of a circle is  $\pi r^2$ . Substituting  $r = 5$  m produces  $78.5$  m<sup>2</sup>. This procedure follows the standard mathematics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**8. C** — Direct substitution gives  $3(8)^2 + 2(8) - 5 = 203$ . This procedure follows the standard mathematics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**9. A** — The derivative of  $\ln(10x)$  is  $1/x$  because the constant factor cancels by the chain rule. At  $x = 1$ , the value is 1. This procedure follows the standard mathematics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**10. B** — For a  $2 \times 2$  matrix, the determinant is  $ad - bc$ . Thus  $(11)(3) - (1)(1) = 32$ . This procedure follows the standard mathematics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**11. C** — The arithmetic mean equals the sum of all observations divided by their number. The sum is 20, and dividing by four gives 5. This procedure follows the standard probability and statistics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**12. A** — Failure and nonfailure are complementary outcomes, so their probabilities sum to one. Therefore  $1 - 0.25 = 0.75$ . This procedure follows the standard probability and statistics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**13. B** — A binomial random variable has expected value  $np$ . Multiplying 7 trials by success probability 0.40 gives 2.8. This procedure follows the standard probability and statistics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**14. D** — The median depends on the ordered position of observations rather than their magnitudes. A single extreme value can strongly shift the mean, variance, and standard deviation, but usually leaves the middle position unchanged. This procedure follows the standard probability and statistics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**15. A** — The arithmetic mean equals the sum of all observations divided by their number. The sum is 36, and dividing by four gives 9. This procedure follows the standard probability and statistics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**16. B** — Failure and nonfailure are complementary outcomes, so their probabilities sum to one. Therefore  $1 - 0.45 = 0.55$ . This procedure follows the standard probability and statistics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**17. D** — A binomial random variable has expected value  $np$ . Multiplying 11 trials by success probability 0.40 gives 4.4. This procedure follows the standard probability and statistics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**18. C** — By definition,  $\text{pH} = -\log_{10}[\text{H}^+]$ . Substituting  $1.00\text{e-}03 \text{ mol/L}$  gives  $\text{pH} = 3$ . This procedure follows the standard chemistry relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**19. C** — Mass equals moles multiplied by molar mass. Therefore  $2 \text{ mol} \times 18.015 \text{ g/mol} = 36.030 \text{ g}$ . This procedure follows the standard chemistry relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**20. D** — Oxidation is the loss of electrons, while reduction is the gain of electrons. Tracking oxidation numbers provides the same conclusion: the oxidized species experiences an increase in oxidation state. This procedure follows the standard chemistry relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**21. B** — By definition,  $\text{pH} = -\log_{10}[\text{H}^+]$ . Substituting  $3.16\text{e-}05 \text{ mol/L}$  gives  $\text{pH} = 4.5$ . This procedure follows the standard chemistry relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**22. A** — Mass equals moles multiplied by molar mass. Therefore  $5 \text{ mol} \times 18.015 \text{ g/mol} = 90.075 \text{ g}$ . This procedure follows the standard chemistry relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**23. B** — Oxidation is the loss of electrons, while reduction is the gain of electrons. Tracking oxidation numbers provides the same conclusion: the oxidized species experiences an increase in oxidation state. This procedure follows the standard chemistry relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**24. C** — A transducer senses a physical variable such as pressure, temperature, or displacement and converts it into an electrical signal suitable for measurement or control. The other devices perform mechanical or thermal functions rather than signal conversion. This procedure follows the standard instrumentation and controls relationship used in the FE Reference Handbook.

**25. D** — An ideal 8-bit converter divides the full-scale span into  $2^8$  levels. Thus the nominal step is  $10/2^8 = 0.039062 \text{ V}$ . This procedure follows the standard instrumentation and controls relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**26. A** — An ideal 9-bit converter divides the full-scale span into  $2^9$  levels. Thus the nominal step is  $12/2^9 = 0.023438 \text{ V}$ . This procedure follows the standard instrumentation and controls relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**27. A** — An ideal 10-bit converter divides the full-scale span into  $2^{10}$  levels. Thus the nominal step is  $14/2^{10} = 0.013672 \text{ V}$ . This procedure follows the standard instrumentation and controls relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**28. D** — An ideal 11-bit converter divides the full-scale span into  $2^{11}$  levels. Thus the nominal step is  $16/2^{11} = 0.0078125 \text{ V}$ . This procedure follows the standard instrumentation and controls relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**29. C** — Engineers must hold paramount the safety, health, and welfare of the public. The engineer should promptly communicate the danger through appropriate channels and, when necessary, notify authorities rather than allowing confidentiality or commercial pressure to override public protection. This procedure follows the standard engineering ethics and societal impacts relationship used in the FE Reference Handbook.

**30. B** — Engineers should perform and approve services only in areas of competence. The proper course is to decline the assignment or involve a qualified professional who can take responsible charge. Client consent does not cure a lack of competence. This procedure follows the standard engineering ethics and societal impacts relationship used in the FE Reference Handbook.

**31. B** — An undisclosed commission creates a financial conflict that can compromise objective professional judgment. Refusing it and disclosing the attempted arrangement preserves transparency and the duty of faithful service to the employer or client. This procedure follows the standard engineering ethics and societal impacts relationship used in the FE Reference Handbook.

**32. C** — Clear disclosure of assumptions, limitations, uncertainty, and supporting evidence allows readers to evaluate the work honestly. Omitting adverse information or overstating precision misleads decision-makers and conflicts with an engineer's duty to issue objective and truthful statements. This procedure follows the standard engineering ethics and societal impacts relationship used in the FE Reference Handbook.

**33. A** — Confidential information remains protected after employment ends. Disclosure is appropriate only with authorization or when required by law or overriding public-safety duties. Personal advantage, competition, and technical interest do not eliminate the obligation. This procedure follows the standard engineering ethics and societal impacts relationship used in the FE Reference Handbook.

**34. D** — Early disclosure allows affected parties to make informed decisions and establish safeguards or consent. A conflict can influence judgment even when the engineer believes the technical work remains objective, so silence is not an adequate response. This procedure follows the standard engineering ethics and societal impacts relationship used in the FE Reference Handbook.

**35. C** — Confined spaces may contain oxygen deficiency, toxic contaminants, or flammable atmospheres that cannot be detected reliably by human senses. Atmospheric testing, ventilation, permits, communication, and rescue provisions address these hazards before entry. This procedure follows the standard safety, health, and environment relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**36. D** — A Safety Data Sheet provides standardized information about a chemical's hazards, handling, storage, exposure controls, personal protective equipment, and emergency response. Commercial and calibration records do not serve this hazard-communication purpose. This procedure follows the standard safety, health, and environment relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**37. B** — Elimination removes the hazard at its source and is therefore the most effective control. Engineering and administrative controls follow, while personal protective equipment is generally the last line of defense because it depends on correct selection and use. This procedure follows the standard safety, health, and environment relationship used in the FE Reference Handbook.

**38. A** — A calibrated atmospheric monitor directly measures oxygen and may also detect combustible and toxic gases. Sound, rotational-speed, and electrical-current instruments cannot establish whether the

breathing atmosphere is safe. This procedure follows the standard safety, health, and environment relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**39. D** — Lockout/tagout isolates hazardous energy and prevents equipment from starting or releasing stored energy while personnel perform service or maintenance. It is an energy-control procedure, not an operating-efficiency or production-record system. This procedure follows the standard safety, health, and environment relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**40. B** — Energized electrical equipment requires an extinguishing agent that does not conduct electricity. Water can expose the user to shock. Once power is removed, the underlying fuel class may govern, but energized conditions require Class C suitability. This procedure follows the standard safety, health, and environment relationship used in the FE Reference Handbook.

**41. C** — Local exhaust ventilation captures airborne contaminants close to where they are generated, preventing dispersion into the breathing zone. Signs and records communicate or document hazards but do not physically remove contaminants, while longer shifts can increase exposure. This procedure follows the standard safety, health, and environment relationship used in the FE Reference Handbook.

**42. A** — Compound future worth is  $F = P(1 + i)^n$ . Substituting  $P = \$1,000$ ,  $i = 0.05$ , and  $n = 3$  gives  $F = \$1,157.63$ . This procedure follows the standard engineering economics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**43. A** — At break-even, total contribution equals fixed cost. Contribution per unit is  $\$51 - \$30 = \$21$ ; therefore quantity is  $\$21,000/\$21 = 1000.00$  units. This procedure follows the standard engineering economics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**44. D** — Straight-line depreciation spreads depreciable basis, cost minus salvage value, evenly over useful life. Thus  $(\$6,000 - \$500)/5 = \$1,100.00$  per year. This procedure follows the standard engineering economics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**45. B** — Compound future worth is  $F = P(1 + i)^n$ . Substituting  $P = \$2,500$ ,  $i = 0.05$ , and  $n = 6$  gives  $F = \$3,350.24$ . This procedure follows the standard engineering economics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**46. C** — At break-even, total contribution equals fixed cost. Contribution per unit is  $\$54 - \$30 = \$24$ ; therefore quantity is  $\$24,000/\$24 = 1000.00$  units. This procedure follows the standard engineering economics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**47. A** — Straight-line depreciation spreads depreciable basis, cost minus salvage value, evenly over useful life. Thus  $(\$7,500 - \$500)/5 = \$1,400.00$  per year. This procedure follows the standard engineering economics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**48. D** — Resolving the force along  $x$  gives  $F_x = F \cos \theta$ . Therefore  $100 \cos 30^\circ = 86.6$  N. This procedure follows the standard statics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**49. C** — Taking moments about the left support gives  $R_r(4) = 220(2)$ . Hence the right reaction is 110 N. This procedure follows the standard statics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**50. B** — Maximum static friction is  $\mu_s N$ . Multiplying 0.30 by the normal force 520 N gives 156 N. This procedure follows the standard statics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**51. D** — Resolving the force along  $x$  gives  $F_x = F \cos \theta$ . Therefore  $160 \cos 30^\circ = 139$  N. This procedure follows the standard statics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**52. B** — Taking moments about the left support gives  $R_r(4) = 280(1)$ . Hence the right reaction is 70 N. This procedure follows the standard statics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**53. C** — Maximum static friction is  $\mu_s N$ . Multiplying 0.30 by the normal force 550 N gives 165 N. This procedure follows the standard statics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**54. A** — Resolving the force along  $x$  gives  $F_x = F \cos \theta$ . Therefore  $220 \cos 30^\circ = 191$  N. This procedure follows the standard statics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**55. C** — Taking moments about the left support gives  $R_r(4) = 340(2)$ . Hence the right reaction is 170 N. This procedure follows the standard statics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**56. B** — Maximum static friction is  $\mu_s N$ . Multiplying 0.30 by the normal force 580 N gives 174 N. This procedure follows the standard statics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**57. D** — Resolving the force along x gives  $F_x = F \cos \theta$ . Therefore  $280 \cos 30^\circ = 242$  N. This procedure follows the standard statics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**58. A** — For constant acceleration,  $v = u + at$ . Substitution gives  $2 + 3(4) = 14$  m/s. This procedure follows the standard dynamics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**59. C** — Newton's second law gives net force  $F = ma$ . Multiplying 6 kg by  $2 \text{ m/s}^2$  produces 12 N. This procedure follows the standard dynamics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**60. A** — Centripetal acceleration is  $a^c = v^2/r$ . Using  $v = 12 \text{ m/s}$  and  $r = 5 \text{ m}$  gives  $28.8 \text{ m/s}^2$  directed toward the center. This procedure follows the standard dynamics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**61. D** — For constant acceleration,  $v = u + at$ . Substitution gives  $5 + 3(4) = 17$  m/s. This procedure follows the standard dynamics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**62. B** — Newton's second law gives net force  $F = ma$ . Multiplying 9 kg by  $2 \text{ m/s}^2$  produces 18 N. This procedure follows the standard dynamics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**63. D** — Centripetal acceleration is  $a^c = v^2/r$ . Using  $v = 15 \text{ m/s}$  and  $r = 5 \text{ m}$  gives  $45 \text{ m/s}^2$  directed toward the center. This procedure follows the standard dynamics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**64. A** — For constant acceleration,  $v = u + at$ . Substitution gives  $8 + 3(4) = 20$  m/s. This procedure follows the standard dynamics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**65. C** — Newton's second law gives net force  $F = ma$ . Multiplying 12 kg by  $2 \text{ m/s}^2$  produces 24 N. This procedure follows the standard dynamics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**66. B** — Centripetal acceleration is  $a^c = v^2/r$ . Using  $v = 18 \text{ m/s}$  and  $r = 5 \text{ m}$  gives  $64.8 \text{ m/s}^2$  directed toward the center. This procedure follows the standard dynamics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**67. A** — Normal stress is  $\sigma = P/A$ . Because  $1 \text{ N/mm}^2$  equals 1 MPa,  $(20 \times 1000)/400 = 50 \text{ MPa}$ . This procedure follows the standard strength of materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**68. D** — Engineering strain is change in length divided by original length. Thus  $\epsilon = 0.0011/2 = 0.000550$ , a dimensionless ratio. This procedure follows the standard strength of materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**69. C** — Hooke's law in uniaxial loading is  $\sigma = E\epsilon$ . Multiplication gives  $200,000 \text{ MPa} \times 0.00060 = 120 \text{ MPa}$ . This procedure follows the standard strength of materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**70. B** — Normal stress is  $\sigma = P/A$ . Because  $1 \text{ N/mm}^2$  equals 1 MPa,  $(26 \times 1000)/430 = 60.5 \text{ MPa}$ . This procedure follows the standard strength of materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**71. C** — Engineering strain is change in length divided by original length. Thus  $\epsilon = 0.0014/2 = 0.000700$ , a dimensionless ratio. This procedure follows the standard strength of materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**72. A** — Hooke's law in uniaxial loading is  $\sigma = E\epsilon$ . Multiplication gives  $200,000 \text{ MPa} \times 0.00075 = 150 \text{ MPa}$ . This procedure follows the standard strength of materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**73. D** — Normal stress is  $\sigma = P/A$ . Because  $1 \text{ N/mm}^2$  equals 1 MPa,  $(32 \times 1000)/460 = 69.6 \text{ MPa}$ . This procedure follows the standard strength of materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**74. B** — Engineering strain is change in length divided by original length. Thus  $\epsilon = 0.0017/2 = 0.000850$ , a dimensionless ratio. This procedure follows the standard strength of materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**75. D** — Hooke's law in uniaxial loading is  $\sigma = E\epsilon$ . Multiplication gives  $200,000 \text{ MPa} \times 0.00090 = 180 \text{ MPa}$ . This procedure follows the standard strength of materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**76. A** — Hardness characterizes resistance to indentation, scratching, or localized plastic deformation. Ductility concerns deformation before fracture, while thermal conductivity and specific heat describe heat transfer and energy storage rather than mechanical indentation resistance. This procedure follows the standard materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**77. B** — Cold working raises dislocation density, making further slip more difficult. Consequently yield strength and hardness increase, while the capacity for additional plastic deformation decreases. Annealing can reverse these effects through recovery and recrystallization. This procedure follows the standard materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**78. C** — A dislocation is a line defect whose motion enables plastic slip at stresses far below the theoretical shear strength of a perfect crystal. Vacancies are point defects, grains are crystal regions, and pores are three-dimensional discontinuities. This procedure follows the standard materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**79. D** — Dissimilar metals generally have different electrode potentials. Electrical connection plus an ionic path completes a galvanic cell, causing the more active metal to act as the anode and corrode preferentially. This procedure follows the standard materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**80. B** — The Charpy test measures energy absorbed when a notched specimen fractures under a swinging impact. It is useful for assessing notch toughness and ductile-to-brittle behavior, unlike hardness, creep, or thermal expansion tests. This procedure follows the standard materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**81. A** — Creep is progressive, time-dependent strain under a sustained load, often important at elevated temperature. It differs from immediate elastic deformation, fatigue crack growth under cyclic loading, and chemical oxidation without mechanical deformation. This procedure follows the standard materials relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors.

**82. C** — For uniform average velocity, volumetric flow rate is  $Q = Av$ . Multiplying  $0.020 \text{ m}^2$  by  $3 \text{ m/s}$  gives  $0.060 \text{ m}^3/\text{s}$ . This procedure follows the standard fluid mechanics relationship used in the FE

Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**83. D** — Hydrostatic gauge pressure is  $p = \rho gh$ . Substituting  $1000 \text{ kg/m}^3$ ,  $9.81 \text{ m/s}^2$ , and  $2.5 \text{ m}$  gives  $2.45\text{e}+04 \text{ Pa}$ . This procedure follows the standard fluid mechanics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**84. A** — Pipe Reynolds number is  $Re = \rho vD/\mu$ . Substitution gives  $(1000)(2.2)(0.05)/(0.001) = 1.1\text{e}+05$ , indicating turbulent flow. This procedure follows the standard fluid mechanics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**85. B** — Continuity requires  $A_1v_1 = A_2v_2$ . Area varies with diameter squared, so  $v_2 = v_1(0.10/0.05)^2 = 9.2 \text{ m/s}$ . This procedure follows the standard fluid mechanics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**86. C** — For uniform average velocity, volumetric flow rate is  $Q = Av$ . Multiplying  $0.024 \text{ m}^2$  by  $3 \text{ m/s}$  gives  $0.072 \text{ m}^3/\text{s}$ . This procedure follows the standard fluid mechanics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**87. A** — Hydrostatic gauge pressure is  $p = \rho gh$ . Substituting  $1000 \text{ kg/m}^3$ ,  $9.81 \text{ m/s}^2$ , and  $4.5 \text{ m}$  gives  $4.41\text{e}+04 \text{ Pa}$ . This procedure follows the standard fluid mechanics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**88. C** — Pipe Reynolds number is  $Re = \rho vD/\mu$ . Substitution gives  $(1000)(2.6)(0.05)/(0.001) = 1.3\text{e}+05$ , indicating turbulent flow. This procedure follows the standard fluid mechanics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**89. D** — Continuity requires  $A_1v_1 = A_2v_2$ . Area varies with diameter squared, so  $v_2 = v_1(0.10/0.05)^2 = 10.8 \text{ m/s}$ . This procedure follows the standard fluid mechanics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**90. B** — For uniform average velocity, volumetric flow rate is  $Q = Av$ . Multiplying  $0.028 \text{ m}^2$  by  $3 \text{ m/s}$  gives  $0.084 \text{ m}^3/\text{s}$ . This procedure follows the standard fluid mechanics relationship used in the FE

Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**91. A** — Hydrostatic gauge pressure is  $p = \rho gh$ . Substituting  $1000 \text{ kg/m}^3$ ,  $9.81 \text{ m/s}^2$ , and  $6.5 \text{ m}$  gives  $6.38\text{e}+04 \text{ Pa}$ . This procedure follows the standard fluid mechanics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**92. B** — Pipe Reynolds number is  $Re = \rho v D / \mu$ . Substitution gives  $(1000)(3.0)(0.05)/(0.001) = 1.5\text{e}+05$ , indicating turbulent flow. This procedure follows the standard fluid mechanics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**93. C** — Continuity requires  $A_1 v_1 = A_2 v_2$ . Area varies with diameter squared, so  $v_2 = v_1(0.10/0.05)^2 = 12.4 \text{ m/s}$ . This procedure follows the standard fluid mechanics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**94. D** — For uniform average velocity, volumetric flow rate is  $Q = Av$ . Multiplying  $0.032 \text{ m}^2$  by  $3 \text{ m/s}$  gives  $0.096 \text{ m}^3/\text{s}$ . This procedure follows the standard fluid mechanics relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**95. A** — Ohm's law gives  $I = V/R$ . Dividing  $12 \text{ V}$  by  $4 \Omega$  gives  $3 \text{ A}$ . This procedure follows the standard basic electrical engineering relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**96. D** — Series resistances carry the same current and add directly. Therefore  $R_{eq} = 5 + 7 = 12 \Omega$ . This procedure follows the standard basic electrical engineering relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**97. C** — Electrical power for a DC load is  $P = VI$ . Multiplying  $12 \text{ V}$  by  $2 \text{ A}$  gives  $24 \text{ W}$ . This procedure follows the standard basic electrical engineering relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**98. B** — Ohm's law gives  $I = V/R$ . Dividing  $18 \text{ V}$  by  $7 \Omega$  gives  $2.57 \text{ A}$ . This procedure follows the standard basic electrical engineering relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct. The result is consistent with the given engineering conditions and assumptions.

**99. C** — Series resistances carry the same current and add directly. Therefore  $R_{eq} = 8 + 10 = 18 \Omega$ . This procedure follows the standard basic electrical engineering relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**100. A** — Electrical power for a DC load is  $P = VI$ . Multiplying 15 V by 2 A gives 30 W. This procedure follows the standard basic electrical engineering relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**101. B** — For sensible heating with constant specific heat,  $Q = mc_p\Delta T$ . Multiplying  $2.0 \times 4.18 \times 10$  gives 83.6 kJ. This procedure follows the standard thermodynamics and heat transfer relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**102. D** — The rate relation is  $q = UA\Delta T$ . Solving for U gives  $520/(2 \times 25) = 10.4 \text{ W}/(\text{m}^2\cdot\text{K})$ . This procedure follows the standard thermodynamics and heat transfer relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**103. A** — Thermal efficiency is net work output divided by heat input. Thus  $\eta = 320/1100 = 0.291$ , or 29.1%. This procedure follows the standard thermodynamics and heat transfer relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**104. C** — For sensible heating with constant specific heat,  $Q = mc_p\Delta T$ . Multiplying  $2.6 \times 4.18 \times 13$  gives 141 kJ. This procedure follows the standard thermodynamics and heat transfer relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**105. D** — The rate relation is  $q = UA\Delta T$ . Solving for U gives  $580/(2 \times 25) = 11.6 \text{ W}/(\text{m}^2\cdot\text{K})$ . This procedure follows the standard thermodynamics and heat transfer relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**106. B** — Thermal efficiency is net work output divided by heat input. Thus  $\eta = 350/1250 = 0.280$ , or 28.0%. This procedure follows the standard thermodynamics and heat transfer relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**107. B** — For sensible heating with constant specific heat,  $Q = mc_p\Delta T$ . Multiplying  $3.2 \times 4.18 \times 16$  gives 214 kJ. This procedure follows the standard thermodynamics and heat transfer relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**108. C** — The rate relation is  $q = UA\Delta T$ . Solving for  $U$  gives  $640/(2 \times 25) = 12.8 \text{ W}/(\text{m}^2 \cdot \text{K})$ . This procedure follows the standard thermodynamics and heat transfer relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**109. D** — Thermal efficiency is net work output divided by heat input. Thus  $\eta = 380/1400 = 0.271$ , or 27.1%. This procedure follows the standard thermodynamics and heat transfer relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.

**110. A** — For sensible heating with constant specific heat,  $Q = mc_p\Delta T$ . Multiplying  $3.8 \times 4.18 \times 19$  gives 302 kJ. This procedure follows the standard thermodynamics and heat transfer relationship used in the FE Reference Handbook. Checking units and signs also eliminates the remaining distractors. The design review confirms the keyed response is correct.