PRACTICE EXAM 8: PE MECHANICAL—THERMAL AND FLUID SYSTEMS SIMULATION (100 QUESTIONS)

This expanded practice exam contains 100 questions based on the NCEES PE Mechanical—Thermal and Fluid Systems specification effective October 2025. The official examination contains 80 questions and provides 8 hours of exam time within a 9-hour appointment. Work in both SI and USCS units, use the supplied electronic-reference approach, and select the single best answer for each question. NCEES does not publish a fixed passing score.

1. During a capacity-expansion assessment, evaluate this case: For a throttling valve operating steadily with negligible heat, work, and energy changes, the inlet and outlet values of which property are equal?

A. Specific entropy
B. Static temperature
C. Specific volume
D. Specific enthalpy

2. A senior mechanical engineer reviews the following operating result: The quality of a saturated liquid–vapor mixture is the ratio of:

A. Vapor mass to total mixture mass
B. Vapor volume to liquid volume
C. Liquid volume to total volume
D. Liquid mass to vapor mass

3. For an energy-conservation project, determine the correct response: A fluid has dynamic viscosity 0.004 Pa·s and density 800 kg/m³. What is its kinematic viscosity?

A. 3.2×10^{-3} m²/s
B. 5.0×10^{-6} m²/s

C. 5.0×10^{-3} m²/s
D. 2.0×10^{-5} m²/s

4. During a third-party technical review, analyze this thermal-fluid principle: The hydraulic diameter of a noncircular duct is defined as four times flow area divided by:

A. Total outer perimeter
B. Maximum duct width
C. Wetted perimeter
D. Equivalent circular radius

5. A utility-operations engineer investigates the following behavior: Water accelerates through a horizontal ideal nozzle from 2 m/s to 10 m/s. What pressure-head decrease accompanies the acceleration?

A. 48.9 m
B. 2.45 m
C. 9.79 m
D. 4.89 m

6. For a performance-guarantee test, solve this problem: For fully developed internal flow, the entrance region ends when:

A. The static pressure becomes constant
B. The velocity profile no longer changes axially
C. The wall shear stress becomes zero
D. The centerline velocity equals zero

7. During a preventive-maintenance review, identify the correct conclusion: A steady wall has thermal conductivity 0.50 W/(m·K), area 10 m², thickness 0.20 m, and a 20 K temperature difference. What is the conduction heat-transfer rate?

A. 500 W
B. 250 W
C. 1,000 W
D. 2,000 W

8. A system designer evaluates this equipment application: For one-dimensional steady conduction through a plane wall with constant thermal conductivity and no heat generation, the temperature profile is:

A. Parabolic through the thickness
B. Exponential through the thickness
C. Linear through the thickness
D. Uniform at every location

9. For a capital-project alternatives study, calculate or identify the requested result: A blackbody surface at absolute temperature T emits radiation proportional to:

A. The fourth power of T
B. The square of T
C. The cube of T
D. The first power of T

10. During an operating-envelope review, consider the following condition: Two thermal resistances of 0.20 K/W and 0.30 K/W are in series across a 25 K temperature difference. What heat rate passes through them?

A. 25 W
B. 125 W
C. 75 W
D. 50 W

11. A lead engineer checks this power or fluid-system scenario: In a counterflow heat exchanger, the principal advantage over parallel flow for the same terminal temperatures is generally:

A. A smaller required fluid heat capacity
B. A larger log-mean temperature difference
C. Zero heat loss to the surroundings
D. Equal outlet temperatures for both fluids

12. For construction-phase design confirmation, answer the following question: An ideal gas at constant pressure is heated from 300 K to 450 K. What is the final-to-initial specific-volume ratio?

A. 0.67
B. 1.00
C. 1.50
D. 2.25

13. During a capacity-expansion assessment, evaluate this case: For a closed system undergoing a cycle, the net change in internal energy is:

A. Zero
B. Equal to net heat transfer
C. Equal to net work input
D. Always greater than zero

14. A senior mechanical engineer reviews the following operating result: A heat engine receives 1,000 kJ and rejects 600 kJ per cycle. What is its thermal efficiency?

A. 20%
B. 60%
C. 40%
D. 67%

15. For an energy-conservation project, determine the correct response: For an adiabatic turbine operating at steady state with negligible kinetic and potential energy changes, specific work output equals:

A. The outlet enthalpy minus inlet enthalpy
B. The inlet enthalpy minus outlet enthalpy
C. The inlet internal energy only
D. The outlet flow work only

16. During a third-party technical review, analyze this thermal-fluid principle: Water flows through a pipe at 0.020 m^3/s. If the inside area is 0.010 m^2, what is the average velocity?

A. 0.2 m/s
B. 5.0 m/s
C. 20 m/s
D. 2.0 m/s

17. A utility-operations engineer investigates the following behavior: In fully developed laminar flow through a circular pipe, the Darcy friction factor is:

A. 16 divided by Reynolds number
B. 0.316 times Reynolds number
C. 64 divided by Reynolds number
D. Independent of Reynolds number

18. For a performance-guarantee test, solve this problem: A pressure increase of 196.2 kPa is applied to water with density 1,000 kg/m^3. What pressure head does this represent using $g = 9.81\ m/s^2$?

A. 10.0 m
B. 20.0 m
C. 40.0 m
D. 196.2 m

19. During a preventive-maintenance review, identify the correct conclusion: Bernoulli's equation in its basic inviscid form expresses conservation of:

A. Mechanical energy along a streamline
B. Mass across every control surface
C. Entropy for an irreversible process
D. Angular momentum about an axis

20. A system designer evaluates this equipment application: The Reynolds number for internal flow represents the ratio of:

A. Thermal diffusion to mass diffusion
B. Pressure forces to gravity forces
C. Viscous forces to surface tension
D. Inertial forces to viscous forces

21. For a capital-project alternatives study, calculate or identify the requested result: A static column of oil has density 800 kg/m^3 and depth 5 m. Using $g = 9.81\ m/s^2$, what is the gauge pressure at the bottom?

A. 4.0 kPa
B. 49.1 kPa
C. 39.2 kPa
D. 78.5 kPa

22. During an operating-envelope review, consider the following condition: For steady incompressible flow through a single-inlet, single-outlet control volume with no storage, mass conservation requires:

A. Equal inlet and outlet mass flow rates
B. Equal inlet and outlet velocities
C. Equal inlet and outlet pressures

D. Equal inlet and outlet elevations

23. A lead engineer checks this power or fluid-system scenario: At a normal shock in a perfect gas, which property necessarily increases?

A. Flow velocity
B. Mach number
C. Stagnation pressure
D. Static pressure

24. For construction-phase design confirmation, answer the following question: The Mach number is defined as the ratio of flow velocity to:

A. Kinematic viscosity
B. Local speed of sound
C. Gravitational wave speed
D. Thermal diffusivity

25. During a capacity-expansion assessment, evaluate this case: Two water streams mix adiabatically: 2 kg/s at 20°C and 3 kg/s at 60°C. With constant specific heat, what is the outlet temperature?

A. 36°C
B. 48°C
C. 40°C
D. 44°C

26. A senior mechanical engineer reviews the following operating result: For a reversible adiabatic process of an ideal gas, entropy change is:

A. Positive only
B. Zero

C. Equal to heat transfer
D. Negative only

27. For an energy-conservation project, determine the correct response: A Carnot engine operates between 600 K and 300 K. What is its maximum thermal efficiency?

A. 50%
B. 25%
C. 67%
D. 100%

28. During a third-party technical review, analyze this thermal-fluid principle: An ideal nozzle in subsonic flow primarily converts:

A. Kinetic energy into static pressure
B. Shaft work into potential energy
C. Enthalpy into kinetic energy
D. Entropy into internal energy

29. A utility-operations engineer investigates the following behavior: A receiver tank downstream of a reciprocating compressor primarily helps to:

A. Lower motor synchronous speed
B. Increase compressor clearance volume
C. Eliminate all moisture instantly
D. Reduce pulsations and store air

30. For a performance-guarantee test, solve this problem: Water hammer is caused primarily by:

A. Slow steady heating of a pipe
B. Uniform corrosion of a valve

C. Rapid change in fluid velocity
D. Gradual reduction in viscosity

31. During a preventive-maintenance review, identify the correct conclusion: A hydropneumatic accumulator stores energy by:

A. Compressing a gas volume
B. Heating a liquid at constant pressure
C. Increasing pipe friction
D. Creating liquid vapor bubbles

32. A system designer evaluates this equipment application: A pump operating point is found at the intersection of the pump curve and:

A. The motor torque curve only
B. The system head curve
C. The pipe stress curve
D. The vapor-pressure curve

33. For a capital-project alternatives study, calculate or identify the requested result: Throttling a valve in a centrifugal-pump discharge line usually moves the operating point toward:

A. Higher flow and lower pump head
B. Higher flow and higher efficiency always
C. Unchanged flow and unchanged head
D. Lower flow and higher pump head

34. During an operating-envelope review, consider the following condition: A pump adds 30 m of head to water flowing at 0.050 m^3/s. Using ρ = 1,000 kg/m^3 and g = 9.81 m/s^2, what hydraulic power is delivered?

A. 7.36 kW
B. 14.7 kW
C. 147 kW
D. 29.4 kW

35. A lead engineer checks this power or fluid-system scenario: A water pump delivers 20 kW of hydraulic power at 80% efficiency. What shaft power is required?

A. 25 kW
B. 16 kW
C. 20 kW
D. 100 kW

36. For construction-phase design confirmation, answer the following question: Cavitation in a centrifugal pump is most directly avoided by ensuring that:

A. Discharge pressure is atmospheric
B. Pump speed exceeds synchronous speed
C. Available NPSH exceeds required NPSH
D. Fluid viscosity approaches zero

37. During a capacity-expansion assessment, evaluate this case: Two identical centrifugal pumps connected in series ideally produce approximately:

A. Twice the flow at the same head
B. Half the head at the same flow
C. The same head and same flow
D. Twice the head at the same flow

38. A senior mechanical engineer reviews the following operating result: Two identical centrifugal pumps connected in parallel ideally provide approximately:

A. Twice the flow at the same head
B. Twice the head at the same flow
C. Half the flow at the same head
D. The same flow at double pressure

39. For an energy-conservation project, determine the correct response: For a piping system dominated by friction losses, system head varies approximately with:

A. The first power of flow rate
B. The inverse of flow rate
C. The square of flow rate
D. The cube root of flow rate

40. During a third-party technical review, analyze this thermal-fluid principle: A pipe carries 0.10 m^3/s with a frictional head loss of 8 m. If flow doubles and the friction factor is unchanged, what is the new head loss?

A. 16 m
B. 32 m
C. 24 m
D. 64 m

41. A utility-operations engineer investigates the following behavior: A minor-loss coefficient is K = 4.0, and velocity is 3 m/s. Using g = 9.81 m/s^2, what is the minor head loss?

A. 18.4 m
B. 0.46 m
C. 3.67 m
D. 1.84 m

42. For a performance-guarantee test, solve this problem: The purpose of a check valve in a piping system is to:

A. Throttle flow continuously
B. Prevent reverse flow
C. Relieve excessive pressure
D. Measure differential pressure

43. During a preventive-maintenance review, identify the correct conclusion: A pressure-relief valve is primarily intended to:

A. Limit system overpressure
B. Prevent all reverse flow
C. Measure pump efficiency
D. Maintain constant liquid level

44. A system designer evaluates this equipment application: For a control valve, cavitation begins when local liquid pressure falls below:

A. The downstream stagnation pressure
B. The fluid critical pressure always
C. The liquid vapor pressure
D. The atmospheric pressure always

45. For a capital-project alternatives study, calculate or identify the requested result: A 200-m pipe has Darcy friction factor 0.020, diameter 0.20 m, and average velocity 2 m/s. Using $g = 9.81\ m/s^2$, what is friction head loss?

A. 81.5 m
B. 20.4 m
C. 40.8 m
D. 4.08 m

46. During an operating-envelope review, consider the following condition: The equivalent-length method represents a fitting loss as:

A. A reduced fluid density
B. A larger pump efficiency
C. A negative elevation change
D. An added straight-pipe length

47. A lead engineer checks this power or fluid-system scenario: A fan delivers 5 m^3/s against a pressure rise of 800 Pa. What air power is delivered?

A. 0.16 kW
B. 4.0 kW
C. 6.25 kW
D. 40 kW

48. For construction-phase design confirmation, answer the following question: Fan affinity laws predict that, for unchanged geometry and density, fan pressure rise varies with:

A. The square of rotational speed
B. The first power of rotational speed
C. The cube of rotational speed
D. The inverse square of speed

49. During a capacity-expansion assessment, evaluate this case: A fan speed increases by 10% with unchanged geometry. By what factor does ideal fan power change?

A. 1.100
B. 1.331
C. 1.464
D. 1.210

50. A senior mechanical engineer reviews the following operating result: For a compressor, isentropic efficiency is commonly defined as:

A. Actual work divided by isentropic work
B. Heat rejected divided by shaft work
C. Volumetric flow divided by mass flow
D. Isentropic work divided by actual work

51. For an energy-conservation project, determine the correct response: An ideal diffuser in subsonic flow primarily converts:

A. Static pressure into kinetic energy
B. Enthalpy into chemical energy
C. Kinetic energy into static pressure
D. Potential energy into shaft work

52. During a third-party technical review, analyze this thermal-fluid principle: Reheating in a Rankine cycle is used primarily to:

A. Reduce turbine exhaust moisture
B. Lower turbine inlet temperature
C. Increase condenser backpressure
D. Eliminate the feedwater pump

53. A utility-operations engineer investigates the following behavior: Regenerative feedwater heating improves Rankine-cycle efficiency by:

A. Raising the average heat-addition temperature
B. Lowering boiler pressure to condenser pressure
C. Increasing condenser heat rejection
D. Eliminating turbine extraction flow

54. For a performance-guarantee test, solve this problem: A boiler supplies 100 MW of heat to steam while fuel input is 125 MW. What is boiler efficiency?

A. 20%
B. 80%
C. 100%
D. 125%

55. During a preventive-maintenance review, identify the correct conclusion: A power plant produces 50 MW while receiving 125 MW of fuel energy. What is the plant heat rate in kJ/kWh?

A. 12,500 kJ/kWh
B. 2,500 kJ/kWh
C. 3,600 kJ/kWh
D. 9,000 kJ/kWh

56. A system designer evaluates this equipment application: Lowering condenser pressure in a Rankine cycle generally increases turbine work because it:

A. Raises turbine exhaust enthalpy
B. Eliminates heat rejection
C. Increases the turbine expansion range
D. Raises pump inlet temperature

57. For a capital-project alternatives study, calculate or identify the requested result: The principal function of a surface condenser is to:

A. Condense exhaust steam without mixing streams
B. Superheat turbine inlet steam
C. Raise boiler pressure directly
D. Compress noncondensable gases only

58. During an operating-envelope review, consider the following condition: A condenser removes 120 MW using cooling water with a 10 K temperature rise and cp = 4.0 kJ/(kg·K). What cooling-water flow is required?

A. 12,000 kg/s
B. 300 kg/s
C. 3,000 kg/s
D. 48,000 kg/s

59. A lead engineer checks this power or fluid-system scenario: In an ideal Brayton cycle, compression occurs in the:

A. Combustor
B. Heat-recovery steam generator
C. Turbine
D. Compressor

60. For construction-phase design confirmation, answer the following question: A simple gas turbine produces 40 MW while its compressor consumes 24 MW. What is net power output?

A. 24 MW
B. 16 MW
C. 40 MW
D. 64 MW

61. During a capacity-expansion assessment, evaluate this case: A regenerator in a Brayton cycle uses turbine exhaust to:

A. Cool compressor inlet air directly
B. Preheat compressed air before combustion
C. Condense the working fluid
D. Increase compressor pressure ratio

62. A senior mechanical engineer reviews the following operating result: Intercooling between compressor stages primarily reduces:

A. Compressor work
B. Combustor heat input always
C. Generator electrical losses
D. Turbine exhaust pressure

63. For an energy-conservation project, determine the correct response: A combined-cycle plant couples a gas turbine with a:

A. Vapor-compression refrigeration cycle
B. Hydraulic accumulator cycle
C. Steam Rankine bottoming cycle
D. Closed liquid throttling cycle

64. During a third-party technical review, analyze this thermal-fluid principle: Cogeneration, or combined heat and power, improves fuel utilization by producing:

A. Only electricity at lower voltage
B. Only process steam without work
C. Compressed air without heat recovery
D. Electricity and useful thermal energy

65. A utility-operations engineer investigates the following behavior: For an ideal Otto cycle, increasing compression ratio generally:

A. Increases thermal efficiency
B. Decreases thermal efficiency
C. Leaves efficiency unchanged

D. Makes heat rejection zero

66. For a performance-guarantee test, solve this problem: An engine consumes fuel at 0.020 kg/s with heating value 42 MJ/kg and produces 280 kW. What is brake thermal efficiency?

A. 16.7%
B. 33.3%
C. 42.0%
D. 66.7%

67. During a preventive-maintenance review, identify the correct conclusion: For a four-stroke engine, one power stroke occurs for each cylinder every:

A. Four crankshaft revolutions
B. One-half crankshaft revolution
C. One crankshaft revolution
D. Two crankshaft revolutions

68. A system designer evaluates this equipment application: A hydraulic turbine receives water at 20 m^3/s through a net head of 50 m. With 90% efficiency, what shaft power is produced?

A. 4.41 MW
B. 9.81 MW
C. 8.83 MW
D. 17.7 MW

69. For a capital-project alternatives study, calculate or identify the requested result: Wind-turbine power available in the air stream varies with:

A. The square of wind speed
B. The first power of wind speed

C. The cube of wind speed
D. The inverse of wind speed

70. During an operating-envelope review, consider the following condition: The Betz limit indicates that an ideal wind turbine cannot extract more than approximately:

A. 25.0% of available wind power
B. 59.3% of available wind power
C. 100% of available wind power
D. 75.0% of available wind power

71. A lead engineer checks this power or fluid-system scenario: A turbine receives 10 kg/s of steam with an enthalpy drop of 500 kJ/kg. Neglecting losses, what power is produced?

A. 50 MW
B. 0.5 MW
C. 10 MW
D. 5.0 MW

72. For construction-phase design confirmation, answer the following question: A turbine has an isentropic enthalpy drop of 600 kJ/kg and an actual drop of 480 kJ/kg. What is its isentropic efficiency?

A. 80%
B. 125%
C. 20%
D. 288%

73. During a capacity-expansion assessment, evaluate this case: In an ideal Rankine cycle, the component that raises liquid pressure is the:

A. Steam turbine

B. Condenser
C. Feedwater pump
D. Steam generator

74. A senior mechanical engineer reviews the following operating result: Increasing boiler pressure in an ideal Rankine cycle while holding other limits appropriately fixed generally tends to:

A. Increase thermal efficiency
B. Eliminate condenser heat rejection
C. Make pump work equal turbine work
D. Force turbine exhaust to saturated liquid

75. For an energy-conservation project, determine the correct response: Superheating steam at fixed boiler pressure before turbine entry generally:

A. Decreases turbine work and increases moisture
B. Eliminates condenser pressure effects
C. Makes pump work dominate the cycle
D. Raises turbine work and reduces exit moisture

76. During a third-party technical review, analyze this thermal-fluid principle: An absorption refrigeration system is distinguished by using primarily:

A. Only mechanical compressor work
B. Thermal energy to drive refrigerant circulation
C. A hydraulic turbine for expansion
D. Direct electrical resistance cooling

77. A utility-operations engineer investigates the following behavior: A chilled-water thermal-storage tank shifts refrigeration production primarily to:

A. Periods of highest outdoor temperature only
B. Off-peak operating periods
C. Moments of maximum condenser pressure
D. Times when no electricity is available

78. For a performance-guarantee test, solve this problem: For a shell-and-tube heat exchanger, adding tube passes generally increases tube-side velocity and:

A. Tube diameter
B. Shell outside diameter
C. Pressure drop
D. Fluid saturation temperature

79. During a preventive-maintenance review, identify the correct conclusion: A heat exchanger transfers 500 kW with an overall coefficient of 1.0 kW/(m^2·K) and LMTD of 25 K. What area is required?

A. 20 m^2
B. 10 m^2
C. 25 m^2
D. 50 m^2

80. A system designer evaluates this equipment application: Heat-exchanger effectiveness is the ratio of actual heat transfer to:

A. Total ambient heat loss
B. Overall conductance only
C. Cold-stream outlet enthalpy
D. Maximum possible heat transfer

81. For a capital-project alternatives study, calculate or identify the requested result: Fouling in a heat exchanger generally causes the overall heat-transfer coefficient to:

A. Decrease
B. Increase
C. Remain exactly constant
D. Become independent of flow

82. During an operating-envelope review, consider the following condition: A counterflow exchanger has terminal temperature differences of 60 K and 20 K. Using ln(3) = 1.0986, what is the log-mean temperature difference?

A. 30.0 K
B. 40.0 K
C. 36.4 K
D. 50.0 K

83. A lead engineer checks this power or fluid-system scenario: In a cooling tower, approach is the cold-water outlet temperature minus the:

A. Entering-air dry-bulb temperature
B. Entering-air wet-bulb temperature
C. Leaving-air dew-point temperature
D. Hot-water inlet temperature

84. For construction-phase design confirmation, answer the following question: Cooling-tower range is defined as:

A. Cold-water outlet minus wet-bulb temperature
B. Condenser pressure minus tower pressure
C. Dry-bulb minus wet-bulb temperature
D. Hot-water inlet minus cold-water outlet temperature

85. During a capacity-expansion assessment, evaluate this case: A cooling tower evaporates 2.0 kg/s of water and operates at three cycles of concentration. Neglecting drift, what blowdown rate is required?

A. 0.67 kg/s
B. 2.0 kg/s
C. 6.0 kg/s
D. 1.0 kg/s

86. A senior mechanical engineer reviews the following operating result: In a basic vapor-compression refrigeration cycle, the compressor receives:

A. Low-pressure liquid refrigerant
B. High-pressure liquid refrigerant
C. Low-pressure refrigerant vapor
D. Two-phase mixture by design

87. For an energy-conservation project, determine the correct response: The expansion valve in a vapor-compression cycle is modeled ideally as a:

A. Constant-enthalpy device
B. Constant-entropy device
C. Constant-temperature device
D. Constant-pressure device

88. During a third-party technical review, analyze this thermal-fluid principle: A refrigerator removes 30 kW from a cold space while consuming 10 kW. What is its coefficient of performance?

A. 0.33
B. 3.0
C. 2.0
D. 4.0

89. A utility-operations engineer investigates the following behavior: A heat pump delivers 40 kW of heating while consuming 10 kW. What is its heating COP?

A. 0.25
B. 3.0
C. 5.0
D. 4.0

90. For a performance-guarantee test, solve this problem: For the same vapor-compression device operating between two reservoirs, COP_HP equals:

A. COP_R plus one
B. The reciprocal of COP_R
C. Exactly equal to COP_R
D. COP_R minus one

91. During a preventive-maintenance review, identify the correct conclusion: Subcooling liquid refrigerant leaving the condenser generally increases refrigeration effect by:

A. Increasing vapor quality before throttling
B. Increasing compressor suction pressure only
C. Reducing enthalpy entering the expansion valve
D. Eliminating condenser heat rejection

92. A system designer evaluates this equipment application: Superheating at the evaporator outlet is commonly used to ensure that:

A. Liquid enters the compressor
B. Vapor enters the compressor
C. Condenser pressure becomes zero
D. Expansion is isentropic

93. For a capital-project alternatives study, calculate or identify the requested result: A motor delivers 15 kW mechanically while drawing 18 kW electrically. What is motor efficiency?

A. 20.0%
B. 120%
C. 83.3%
D. 33.3%

94. During an operating-envelope review, consider the following condition: For a thin-walled cylindrical pressure vessel, hoop stress is approximately:

A. Half the longitudinal stress
B. Independent of internal pressure
C. Equal to radial stress
D. Twice the longitudinal stress

95. A lead engineer checks this power or fluid-system scenario: A component has yield strength 240 MPa and calculated working stress 80 MPa. What is the factor of safety against yielding?

A. 0.33
B. 3.0
C. 2.0
D. 4.0

96. For construction-phase design confirmation, answer the following question: An investment costs $100,000 and returns $25,000 per year with no salvage value or discounting. What is the simple payback period?

A. 4 years
B. 2 years
C. 5 years
D. 25 years

97. During a capacity-expansion assessment, evaluate this case: At an annual interest rate of 5%, what is the one-year future value of $10,000?

A. $10,500
B. $9,500
C. $10,050
D. $15,000

98. A senior mechanical engineer reviews the following operating result: In critical-path scheduling, an activity on the critical path normally has:

A. The largest direct cost
B. The smallest crew size
C. No predecessor activity
D. Zero total float

99. For an energy-conservation project, determine the correct response: Activities A and B occur sequentially and take 4 days and 6 days. What is the path duration?

A. 2 days
B. 10 days
C. 6 days
D. 24 days

100. During a third-party technical review, analyze this thermal-fluid principle: A 480-V three-phase motor draws 20 A at power factor 0.80. Using $\sqrt{3} = 1.732$, what is approximate real input power?

A. 7.68 kW
B. 11.1 kW
C. 13.3 kW
D. 19.2 kW

Practice Exam 8: Answer Key and Explanations

1. D — The steady-flow energy equation across an ideal throttling device reduces to $h_{in} = h_{out}$. Temperature and entropy may change despite constant enthalpy. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Physical direction also agrees with the governing mechanism.

2. A — Thermodynamic quality is the vapor mass fraction, defined as vapor mass divided by total liquid-plus-vapor mass. It ranges from zero to one. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Physical direction also agrees with the governing mechanism.

3. B — Kinematic viscosity is dynamic viscosity divided by density. Thus $\nu = 0.004/800 = 5.0\times10^{-6}$ m^2/s. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

4. C — Hydraulic diameter is $D_h = 4A/P_w$, where P_w is the wetted perimeter. This definition permits standard internal-flow correlations for noncircular passages. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

5. D — Bernoulli's equation gives the pressure-head decrease as $(V_2^2-V_1^2)/(2g) = (100-4)/(19.62) = 4.89$ m. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Physical direction also agrees with the governing mechanism. Boundary conditions must be confirmed before applying the relation.

6. B — Hydrodynamically fully developed flow exists when the normalized velocity profile no longer varies in the axial direction, although pressure continues to decrease. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Physical direction also agrees with the governing mechanism.

7. A — Fourier's law gives $Q = kA\Delta T/L = 0.50(10)(20)/0.20 = 500$ W. Heat flows toward lower temperature; the requested magnitude is positive. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

8. C — The governing equation reduces to $d^2T/dx^2 = 0$. Integrating twice produces a linear temperature distribution between the prescribed wall-surface temperatures. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

9. A — The Stefan–Boltzmann law states that total blackbody emissive power equals σT^4. Surface emissivity multiplies this value for a real gray surface. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

10. D — Series thermal resistances add, giving 0.50 K/W. Dividing the total temperature difference by total resistance gives Q = 25/0.50 = 50 W. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Physical direction also agrees with the governing mechanism.

11. B — Counterflow maintains a more uniform temperature difference along the exchanger and commonly provides a larger log-mean temperature difference than parallel flow. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

12. C — For an ideal gas at constant pressure, specific volume is directly proportional to absolute temperature. Thus v_2/v_1 = 450/300 = 1.50. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

13. A — Internal energy is a state property. Because a cycle returns the system to its initial state, its net internal-energy change is zero. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Physical direction also agrees with the governing mechanism.

14. C — Net work is the difference between heat input and heat rejection, or 400 kJ. Thermal efficiency is 400/1,000 = 0.40, or 40 percent. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

15. B — The steady-flow energy equation reduces to w_out = h_in − h_out when heat transfer and changes in kinetic and potential energies are negligible. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

16. D — Continuity for incompressible flow gives average velocity V = Q/A. Substitution gives 0.020/0.010 = 2.0 m/s. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

17. C — For fully developed laminar circular-pipe flow using the Darcy definition, f = 64/Re. The Fanning factor would instead be one-fourth as large. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Physical direction also agrees with the governing mechanism.

18. B — Pressure head is $\Delta p/(\rho g)$. Using 196,200 Pa divided by 1,000(9.81) gives 20.0 m of water. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

19. A — Bernoulli's equation relates pressure, velocity, and elevation heads and represents conservation of mechanical energy along a streamline under its assumptions. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

20. D — Reynolds number compares inertia with viscous effects. It is the primary similarity parameter used to distinguish laminar, transitional, and turbulent internal-flow regimes. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Physical direction also agrees with the governing mechanism.

21. C — Hydrostatic gauge pressure is ρgh. Multiplying 800(9.81)(5) gives 39,240 Pa, which is 39.2 kPa. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Boundary conditions must be confirmed before applying the relation.

22. A — Steady mass conservation requires that mass entering equal mass leaving when no accumulation occurs. Velocity, pressure, and elevation may still change. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

23. D — Across a normal shock, static pressure, static temperature, density, and entropy rise, while Mach number, velocity, and stagnation pressure decrease. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

24. B — Mach number equals the local fluid velocity divided by the local acoustic speed. It characterizes compressibility effects and flow regime. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

25. D — An adiabatic mixing energy balance gives the mass-weighted temperature: [2(20)+3(60)]/5 = 44°C when both streams have the same constant specific heat. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

26. B — A reversible adiabatic process is isentropic. With no heat transfer and no entropy generation, the system's entropy remains constant. Units and signs remain consistent with the stated assumptions.

The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

27. A — Carnot efficiency is $1 - T_L/T_H$ using absolute temperatures. Therefore $1 - 300/600 = 0.50$, or 50 percent. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

28. C — A nozzle accelerates fluid by converting a decrease in enthalpy and static pressure into increased kinetic energy, with negligible shaft work. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

29. D — A receiver dampens cyclic pressure and flow pulsations, stores compressed air, and reduces frequent compressor cycling during fluctuating demand. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

30. C — Rapid valve closure or pump trip changes fluid momentum abruptly, producing a pressure wave that travels through the piping system. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

31. A — An accumulator uses a compressed gas cushion to store hydraulic energy, absorb pressure transients, and supply short-duration flow. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

32. B — The operating point simultaneously satisfies the head produced by the pump and the head required by the piping system at the same flow. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

33. D — Closing the valve increases system resistance, steepens the system curve, and shifts its intersection with the pump curve toward lower flow and higher head. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

34. B — Hydraulic power is ρgQH. Multiplication gives $1{,}000(9.81)(0.050)(30) = 14{,}715$ W, or approximately 14.7 kW. Units and signs remain consistent with the stated assumptions. The distractors

reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Boundary conditions must be confirmed before applying the relation.

35. A — Pump efficiency equals hydraulic output divided by shaft input. Required shaft power is therefore 20/0.80 = 25 kW. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

36. C — Adequate net positive suction head keeps local pressure above the liquid vapor pressure. NPSH available should exceed NPSH required with an appropriate margin. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

37. D — Series pump heads add at a common flow rate. Parallel pumps instead combine flow capacities at a common system head. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

38. A — Parallel pump flow rates add at a common head. Actual operation depends on the intersection of the combined pump curve and system curve. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

39. C — In turbulent systems with nearly constant friction factor, velocity is proportional to flow and friction head is proportional to velocity squared, hence Q^2. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

40. B — Frictional head loss varies with the square of flow rate under the stated assumption. Doubling flow multiplies loss by four: $8(2^2) = 32$ m. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

41. D — Minor head loss is $K V^2/(2g)$. Substitution gives $4(3^2)/(2\times9.81) = 1.84$ m. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism. Boundary conditions must be confirmed before applying the relation.

42. B — A check valve opens for forward flow and closes when the pressure tendency reverses. It protects equipment from backflow without routine operator action. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

43. A — A relief valve opens at a set pressure to discharge fluid and protect vessels or piping from pressure exceeding allowable limits. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

44. C — Liquid cavitation begins when local static pressure drops below vapor pressure, creating vapor bubbles that later collapse as pressure recovers. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

45. C — Darcy–Weisbach gives $h_f = f(L/D)V^2/(2g)$. Substitution gives $0.020(200/0.20)(4/19.62) = 40.8$ m. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism. Boundary conditions must be confirmed before applying the relation.

46. D — Equivalent length converts a fitting's minor loss to the length of straight pipe that would produce the same friction loss at that flow. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

47. B — Fluid power for a fan is volumetric flow multiplied by pressure rise. Thus $5\times800 = 4{,}000$ W, or 4.0 kW. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

48. A — For geometrically unchanged operation, flow varies with speed, pressure rise with speed squared, and power with speed cubed. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

49. B — The fan power affinity law gives $P_2/P_1 = (N_2/N_1)^3$. Therefore $1.10^3 = 1.331$. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Physical direction also agrees with the governing mechanism. Boundary conditions must be confirmed before applying the relation.

50. D — A real compressor requires more work than an isentropic compressor for the same pressure ratio. Efficiency is ideal isentropic work divided by actual work. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

51. C — A diffuser decreases velocity and raises static pressure. With negligible heat and work, stagnation enthalpy remains essentially constant. Units and signs remain consistent with the stated

assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

52. A — Reheat expands steam in stages and adds heat between stages, increasing exhaust quality and often improving turbine work and cycle performance. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

53. A — Bleeding some steam to preheat feedwater raises the average temperature at which external heat is supplied, improving cycle efficiency. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

54. B — Boiler efficiency is useful heat transferred to the working fluid divided by fuel-energy input. Thus 100/125 = 0.80, or 80 percent. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

55. D — Heat rate equals fuel input divided by electric output, converted using 3,600 kJ/kWh. The ratio 125/50 = 2.5, so heat rate is 2.5×3,600 = 9,000 kJ/kWh. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

56. C — A lower condenser pressure permits steam to expand to a lower exhaust enthalpy, increasing turbine specific work and often cycle efficiency. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

57. A — A surface condenser transfers exhaust-steam heat through tube walls to cooling water, maintaining separation while creating low turbine backpressure. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

58. C — The water energy balance is $Q = m \cdot c_p \Delta T$. Therefore m = 120,000 kW/[4.0 kJ/(kg·K)×10 K] = 3,000 kg/s. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

59. D — The compressor raises working-fluid pressure before heat addition. The combustor adds heat, and the turbine expands the hot gas to produce work. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Physical direction also agrees with the governing mechanism.

60. B — Net gas-turbine output is turbine work minus compressor work. The difference is 40 − 24 = 16 MW. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

61. B — Regeneration recovers exhaust heat to warm compressor discharge before fuel is added, reducing required fuel input for a given turbine inlet temperature. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Physical direction also agrees with the governing mechanism.

62. A — Cooling the gas between compression stages lowers its specific volume and reduces subsequent compression work, especially with suitable pressure ratios. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

63. C — A heat-recovery steam generator captures gas-turbine exhaust energy to power a steam Rankine cycle, increasing total plant efficiency. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

64. D — Combined heat and power recovers thermal energy that would otherwise be rejected while simultaneously producing electric or mechanical power. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

65. A — Ideal Otto-cycle efficiency increases with compression ratio for a fixed specific-heat ratio, although real engines face knock and material constraints. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

66. B — Fuel power is 0.020×42,000 = 840 kW. Brake thermal efficiency is 280/840 = 0.333, or approximately 33.3 percent. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

67. D — A four-stroke cycle requires intake, compression, power, and exhaust strokes, completed during two crankshaft revolutions per cylinder. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

68. C — Hydraulic input power is ρgQH. Multiplying by efficiency gives 0.90(1,000)(9.81)(20)(50) = 8.829 MW, approximately 8.83 MW. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

69. C — The kinetic-energy flux through rotor area is proportional to one-half density times area times wind speed cubed. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

70. B — The actuator-disk analysis requires air to retain downstream velocity, limiting the maximum power coefficient to 16/27, approximately 59.3 percent. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

71. D — Turbine power is mass flow multiplied by specific enthalpy drop. Thus 10×500 = 5,000 kW, or 5.0 MW. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

72. A — Turbine isentropic efficiency is actual work divided by isentropic work. The ratio is 480/600 = 0.80, or 80 percent. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

73. C — The feedwater pump raises condensed liquid from condenser pressure to boiler pressure. Because liquid specific volume is small, pump work is modest. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Physical direction also agrees with the governing mechanism.

74. A — Higher average heat-addition temperature generally improves Rankine efficiency, although turbine-exit moisture and practical material limits must also be considered. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

75. D — Superheat increases turbine inlet enthalpy and usually raises specific turbine work while producing drier steam at the turbine exhaust. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

76. B — Absorption systems replace much of the mechanical compression function with absorber, pump, generator, and thermal input, enabling use of waste heat. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

77. B — Thermal storage produces and stores cooling during lower-demand periods, then discharges it during peak loads to reduce peak electrical demand. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

78. C — More tube passes reduce the parallel flow area per pass, increasing velocity, heat-transfer coefficient, and tube-side pressure drop. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

79. A — Using $Q = UA\Delta T_lm$, area is $A = 500/[1.0(25)] = 20\ m^2$. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism. Boundary conditions must be confirmed before applying the relation.

80. D — Effectiveness compares actual exchanger duty with the thermodynamic maximum possible duty based on the smaller heat-capacity rate and inlet temperature difference. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

81. A — Deposits add thermal resistance and often restrict flow. Because total resistance increases, the overall heat-transfer coefficient decreases. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

82. C — The LMTD is $(60-20)/\ln(60/20) = 40/\ln 3$ = approximately 36.4 K. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism. Boundary conditions must be confirmed before applying the relation.

83. B — Cooling-tower approach measures how closely cooled water approaches the entering-air wet-bulb temperature, the relevant evaporative-cooling limit. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

84. D — Cooling-tower range is the reduction in circulating-water temperature across the tower, equal to hot-water inlet temperature minus cold-water outlet temperature. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

85. D — With negligible drift, cycles $C = (E+B)/B$, so $B = E/(C-1) = 2/(3-1) = 1.0$ kg/s. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

86. C — The compressor should receive low-pressure vapor, commonly slightly superheated, to avoid liquid slugging and raise refrigerant pressure and temperature. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

87. A — An expansion valve performs throttling with negligible heat, work, and energy changes, so inlet and outlet specific enthalpies are approximately equal. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

88. B — Refrigerator COP equals cooling effect divided by work input. Therefore $COP_R = 30/10 = 3.0$. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

89. D — Heating COP equals heat delivered to the warm space divided by work input. Thus $COP_{HP} = 40/10 = 4.0$. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

90. A — Energy conservation gives $Q_H = Q_L + W$. Dividing by W yields $COP_{HP} = COP_R + 1$. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

91. C — Subcooling lowers liquid enthalpy before throttling. With evaporator outlet conditions otherwise fixed, the refrigerating effect per unit mass increases. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

92. B — Controlled superheat confirms evaporation is complete before refrigerant reaches the compressor, protecting it from damaging liquid carryover. Units and signs remain consistent with the

stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

93. C — Motor efficiency is mechanical output divided by electrical input. The ratio 15/18 = 0.833, or approximately 83.3 percent. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

94. D — Thin-wall equations give hoop stress pr/t and longitudinal stress pr/(2t). Therefore hoop stress is twice longitudinal stress under closed-end internal pressure. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. Boundary conditions must be confirmed before applying the relation.

95. B — Factor of safety against yielding is yield strength divided by working stress. Thus 240/80 = 3.0. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

96. A — Simple payback divides initial cost by uniform annual savings. Thus $100,000/$25,000 per year = 4 years. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

97. A — One-year compound future value is P(1+i). Therefore $10,000(1.05) = $10,500. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism. Boundary conditions must be confirmed before applying the relation.

98. D — The critical path determines project duration. Under the standard schedule calculation, its activities have zero total float, so delay extends completion unless recovery occurs. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result.

99. B — Durations along a single sequential path add. Therefore the path takes 4 + 6 = 10 days. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.

100. C — Three-phase real power is √3 V I PF. Substitution gives 1.732(480)(20)(0.80) = approximately 13.3 kW. Units and signs remain consistent with the stated assumptions. The distractors reflect omitted efficiency factors, inverted ratios, or confused properties. An order-of-magnitude check supports the selected result. Physical direction also agrees with the governing mechanism.