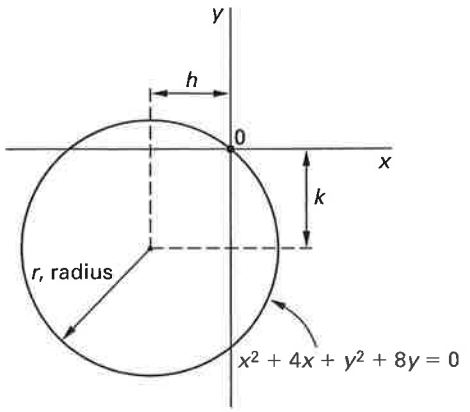
Fundamentals of Engineering Sample Examination

Afternoon Section

Name: _____

1.	(A)	(B)	(C)	(D)	16.	(A)	(B)	(C)	(D)	31.	(A)	(B)	(C)	(D)	46.	(A)	(B)	(C)	(D)
2.	(A)	(B)	(C)	(D)	17.	(A)	(B)	(C)	(D)	32.	(A)	(B)	(C)	(D)	47.	(A)	(B)	(C)	(D)
3.	(A)	(B)	(C)	(D)	18.	(A)	(B)	(C)	(D)	33.	(A)	(B)	(C)	(D)	48.	(A)	(B)	(C)	(D)
4.	(A)	(B)	(C)	(D)	19.	(A)	(B)	(C)	(D)	34.	(A)	(B)	(C)	(D)	49.	(A)	(B)	(C)	(D)
5.	(A)	(B)	(C)	(D)	20.	(A)	(B)	(C)	(D)	35.	(A)	(B)	(C)	(D)	50.	(A)	(B)	(C)	(D)
6.	(A)	(B)	(C)	(D)	21.	(A)	(B)	(C)	(D)	36.	(A)	(B)	(C)	(D)	51.	(A)	(B)	(C)	(D)
7.	(A)	(B)	(C)	(D)	22.	(A)	(B)	(C)	(D)	37.	(A)	(B)	(C)	(D)	52.	(A)	(B)	(C)	(D)
8.	(A)	(B)	(C)	(D)	23.	(A)	(B)	(C)	(D)	38.	(A)	(B)	(C)	(D)	53.	(A)	(B)	(C)	(D)
9.	(A)	(B)	(C)	(D)	24.	(A)	(B)	(C)	(D)	39.	(A)	(B)	(C)	(D)	54.	(A)	(B)	(C)	(D)
10.	(A)	(B)	(C)	(D)	25.	(A)	(B)	(C)	(D)	40.	(A)	(B)	(C)	(D)	55.	(A)	(B)	(C)	(D)
11.	(A)	(B)	(C)	(D)	26.	(A)	(B)	(C)	(D)	41.	(A)	(B)	(C)	(D)	56.	(A)	(B)	(C)	(D)
12.	(A)	(B)	(C)	(D)	27.	(A)	(B)	(C)	(D)	42.	(A)	(B)	(C)	(D)	57.	(A)	(B)	(C)	(D)
13.	(A)	(B)	(C)	(D)	28.	(A)	(B)	(C)	(D)	43.	(A)	(B)	(C)	(D)	58.	(A)	(B)	(C)	(D)
14.	(A)	(B)	(C)	(D)	29.	(A)	(B)	(C)	(D)	44.	(A)	(B)	(C)	(D)	59.	(A)	(B)	(C)	(D)
15.	(A)	(B)	(C)	(D)	30.	(A)	(B)	(C)	(D)	45.	(A)	(B)	(C)	(D)	60.	(A)	(B)	(C)	(D)

Problems 1–3 are based on the following illustration.



1. What are the coordinates of the circle's center?

(A) $(-4,-8)$
(B) $(2,-4)$
(C) $(-4,-2)$
(D) $(-2,-4)$

2. What is the radius of the circle?

(A) $\sqrt{8}$
(B) $2\sqrt{5}$
(C) $4\sqrt{5}$
(D) 10

3. What is the slope of the line that is tangent to the circle and passes through the origin?

(A) -2
(B) $-3/4$
(C) $-1/2$
(D) $1/2$

Problems 4–6 are based on the following equation.

$$2y' = 3xy + 1$$

4. The equation is a

(A) second-order polynomial of two variables
(B) first-order, homogeneous equation
(C) linear first-order differential equation
(D) second-order differential equation

5. What is the integrating factor?

(A) $3x$
(B) $3/2x$
(C) $e^{-\frac{3}{2}x^2}$
(D) $e^{-\frac{3}{4}x^2}$

6. What is the solution?

(A) $y = \ln\left(\frac{3}{2}x^2\right) + C$
(B) $y = \frac{3}{2}x + C$
(C) $y = Ce^{\frac{3}{4}x^2} - \frac{1}{3}$
(D) $y = \left(e^{\frac{3}{4}x^2}\right)\left(\frac{1}{2}\int e^{-\frac{3}{4}x^2}dx + C\right)$

7. The least-squares method is used to plot a straight line through the data points (3,−5), (3,−2), (4,3), and (−1,6). The correlation coefficient is most nearly

(A) −0.97
(B) −0.91
(C) −0.59
(D) −0.36

8. Testing has shown that, on average, 2% of the bearings produced at a factory are defective. 20 bearings are chosen at random. The probability that exactly three of them are defective is most nearly

(A) 0.0037
(B) 0.0044
(C) 0.0059
(D) 0.0065

9. The number of different permutations of n distinct objects taken r at a time is

(A) $\dfrac{n!}{(n-r)!}$
(B) $\dfrac{n!}{r!(n-r)!}$
(C) $\dfrac{n!}{n_1!n_2!\ldots n_r!}$
(D) $\left(\dfrac{n+1}{2}\right)^r$

10. The equation $y = ax^3 + bx^2 + cx + d$ will fit how many constraints on a curve?

(A) one
(B) two
(C) three
(D) four

11. 100 random samples were taken from a large population. A particular numerical characteristic of sampled items was measured. The results of the measurements were as follows.

- 45 measurements were between 85.9 and 90.0
- 90.1 was observed once
- 90.2 was observed three times
- 90.3 was observed twice
- 90.4 was observed four times
- 45 measurements were between 90.5 and 95.8

The smallest value was 85.9 and the largest value was 95.8. The sum of all 100 measurements was 9117.0. Except those noted, no measurements occurred more than twice.

What is the mean of the measurements?

(A) 90.3
(B) 90.5
(C) 90.6
(D) 91.2

12. Protists are part of which biological group?

(A) seed plants
(B) eucaryotes
(C) eubacteria
(D) archaebacteria

13. What is the specific growth rate of an organismal growth batch culture that exhibits a constant change in cell concentration from 10^3 mg/L to 10^5 mg/L during the 15 h log growth phase?

(A) 0.07 h^{-1}
(B) 0.13 h^{-1}
(C) 0.3 h^{-1}
(D) 6.6 h^{-1}

14. A village with a stable population has a water supply that has been contaminated with benzene (C_6H_6) from a leaking underground storage tank. The leak occurred during the 20 yr prior to the tank being removed. The estimated average concentration of benzene during this period of leaking was 50 μg/L. The slope factor for benzene by the oral route is 2.0×10^{-2} $(mg/kg \cdot day)^{-1}$. Assume a 70 yr lifespan, 10 kg children, and 1 L/day child water consumption. What are the probable risks of additional cancers for the village's children who drank the water?

(A) children 0.71×10^{-1}
(B) children 1.4×10^{-3}
(C) children 2.9×10^{-5}
(D) children 5.7×10^{-7}

Problems 15–17 are based on the following statement.

A company must purchase a machine that will be used over the next 8 years. The purchase price is \$10,000, and the salvage value after 8 years is \$1000. The annual insurance is 2% of the purchase price, the electricity cost is \$300 per year, and maintenance and replacement parts cost \$100 per year. The effective annual interest rate for economic analysis is 6%. Neglect taxes.

15. What is most nearly the effective uniform annual cost of ownership?

(A) \$1200
(B) \$2100
(C) \$2200
(D) \$2300

16. What is most nearly the minimum acceptable average annual return on the machine?

(A) \$2050
(B) \$2110
(C) \$2210
(D) \$2330

17. What is the present worth of the machine if its return is \$3000 per year for 8 years?

(A) \$5530
(B) \$8630
(C) \$9260
(D) \$24,000

18. A machine has an initial cost of \$10,000 and an annual maintenance cost of \$450. The life of the machine is 15 years, and its salvage value is \$2500. Assuming an annual effective interest rate of 4%, the equivalent uniform annual cost of the machine is most nearly

(A) \$1200
(B) \$1400
(C) \$1500
(D) \$1800

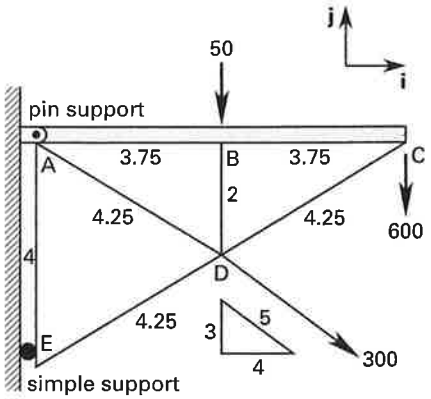
19. A machine has an initial cost of \$14,000, a life of 15 years, and a straight line depreciation value of \$850. The salvage value is most nearly

(A) \$850
(B) \$1250
(C) \$2400
(D) \$3700

20. The salary range for a particular employee's job has six levels, each one 4% greater than the one below it. Circumstances dictate that the employee's salary must be reduced from the top (sixth) level to the second level. That results in a reduction of \$140 per month. What is most nearly the employee's salary per month at level six?

(A) \$840
(B) \$960
(C) \$980
(D) \$3600

Problems 21–23 are based on the following statement and illustration. A simple truss mechanism is loaded as shown. All joints are pin-connected.



21. What is most nearly the reaction at pin A?

(A) $\mathbf{A} = 1461\mathbf{i} + 830\mathbf{j}$
(B) $\mathbf{A} = -1461\mathbf{i} + 830\mathbf{j}$
(C) $\mathbf{A} = -980\mathbf{i} - 730\mathbf{j}$
(D) $\mathbf{A} = +1400\mathbf{i} - 370\mathbf{j}$

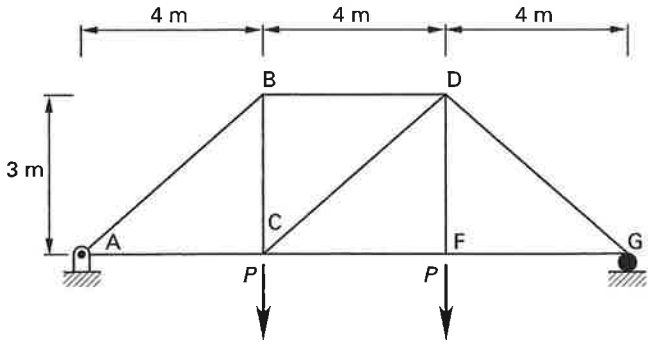
22. What are most nearly the forces in members AD and ED?

(A) $F_{AD} = 676$ (tension)
$F_{ED} = 346$ (tension)
(B) $F_{AD} = 676$ (compression)
$F_{ED} = 346$ (compression)
(C) $F_{AD} = 380$ (tension)
$F_{ED} = 1383$ (compression)
(D) $F_{AD} = 380$ (compression)
$F_{ED} = 1383$ (tension)

23. Most nearly, what additional horizontal force applied at D will reduce the value of the reaction at roller E to zero?

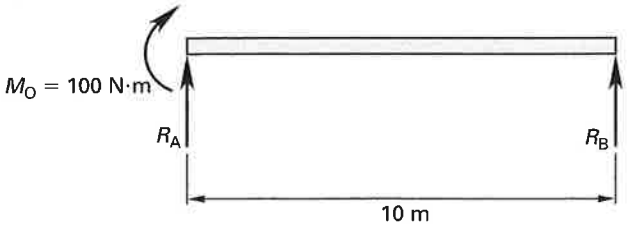
(A) 1221 to the right
(B) 1461 to the right
(C) 2344 to the right
(D) 2441 to the right

24. The truss members are pin connected. If member BD is a round steel rod of radius 1.25 cm, what is most nearly the maximum load, P, that can be supported by the truss without causing the member to buckle? The rod's modulus of elasticity is 42.0 GPa.



(A) 130 N
(B) 370 N
(C) 500 N
(D) 820 N

25. Determine the vertical deflection at the center of the beam. EI is constant.



(A) $\dfrac{625}{EI}$ m downward

(B) $\dfrac{400}{EI}$ m downward

(C) $\dfrac{350}{EI}$ m downward

(D) $\dfrac{700}{EI}$ m upward

26. For an elastic, isotropic material, the modulus of elasticity, shear modulus, and Poisson's ratio are related by which of the following equations?

(A) $G = \dfrac{E}{2(1+v)}$

(B) $G = 2E(1+v)$

(C) $G = \dfrac{2E}{1+v}$

(D) $\dfrac{G}{2} = \dfrac{E}{1+v}$

27. A hollow, cylindrical copper column has an outer diameter of 5 cm and a wall thickness of 2 cm. A concentric load of 14.4 N is applied to one end. The axial stress is most nearly

(A) 0.76 Pa
(B) 19 Pa
(C) 76 Pa
(D) 190 Pa

28. Given a shear stress, τ_{xy}, of 12 000 kPa and a shear modulus, G, of 87 GPa, the shear strain is most nearly

(A) 0.7×10^{-5} rad
(B) 1.4×10^{-4} rad
(C) 2.5×10^{-4} rad
(D) 5.5×10^{-4} rad

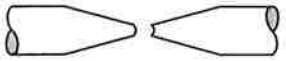
29. The hardness of steel may be increased by heating to approximately 1500°F and quenching in oil or water if

(A) the carbon content is from 0.2% to 2.0%
(B) the carbon content is above 3.0%
(C) the carbon content is below 0.2%
(D) all carbon is removed and the steel contains only chromium, nickel, manganese, or a combination of these

30. Plastically deforming a metal generally results in

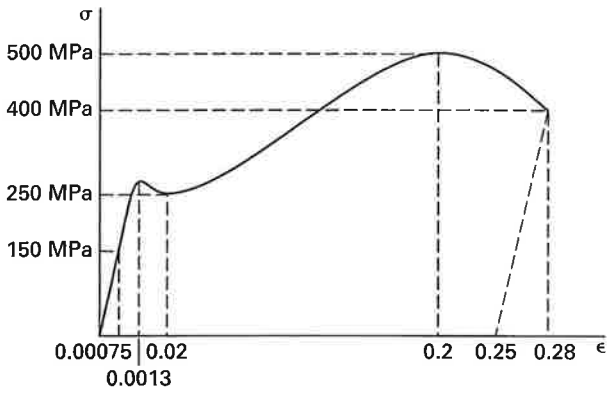
(A) increased strength and ductility
(B) increased strength and decreased ductility
(C) decreased strength and ductility
(D) decreased strength and increased ductility

31. The following illustration depicts what type of metal after a tensile failure?



(A) very ductile metal
(B) moderately ductile metal
(C) brittle metal
(D) indeterminate

32. A ductile metal was submitted to a tensile test, resulting in the following stress-strain (σ-ϵ) curve.



What is the percent elongation at failure?

(A) 2%
(B) 13%
(C) 25%
(D) 28%

33. The continuous yielding of a material under constant stress is known as

(A) failure
(B) strain
(C) creep
(D) ductility

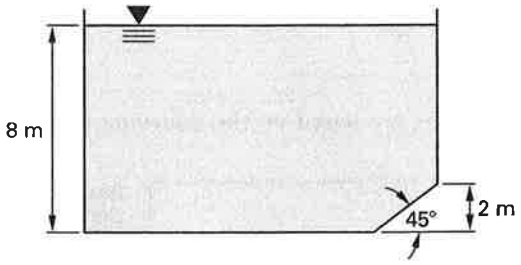
34. The mass of an atom of nickel is most nearly

(A) 2.1×10^{-23} g/atom
(B) 9.7×10^{-23} g/atom
(C) 28×10^{-23} g/atom
(D) 59×10^{-23} g/atom

35. A 2 m long cylindrical bar is suspended vertically from one end. The bar material has a density of 2500 kg/m^3 and modulus of elasticity of 210 GPa. The bar's cross-sectional area is 150 cm^2. What is the elongation of the bar due to its own mass?

(A) 1.17×10^{-10} m
(B) 2.34×10^{-9} m
(C) 1.17×10^{-8} m
(D) 2.34×10^{-7} m

36. Most nearly, what total resultant force is acting on the inclined section of the water tank? Express your answer in kilonewtons per meter width of tank.



(A) 150 kN/m
(B) 190 kN/m
(C) 280 kN/m
(D) 310 kN/m

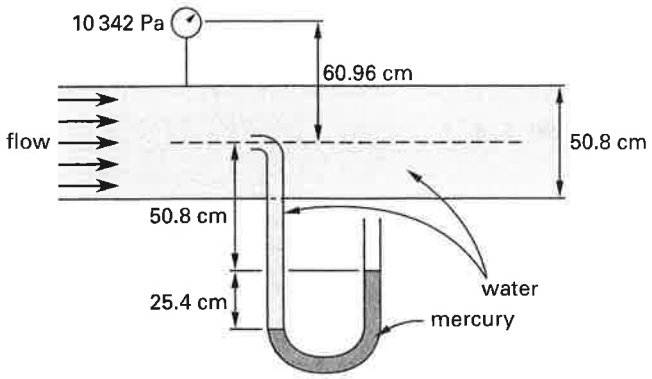
37. What is most nearly the expected head loss per kilometer of closed circular pipe (17 cm inside diameter, friction factor of 0.03) when 3300 L/min of water flow under pressure?

(A) 0.053 m
(B) 22 m
(C) 53 m
(D) 4300 m

38. A perfect venturi with a throat diameter of 1.8 cm is placed horizontally in a pipe with a 5 cm inside diameter. Eight kg of water flow through the pipe each second. What is most nearly the difference between the pipe and venturi throat static pressures?

(A) 30 kPa
(B) 490 kPa
(C) 640 kPa
(D) 970 kPa

39. A static pressure gauge and mercury manometer are connected to a 50.8 cm diameter pipeline flowing full of water. One cubic centimeter of mercury has a weight of 0.1336 N. What is most nearly the velocity at the center of the pipeline?



(A) 0.66 m/s
(B) 0.79 m/s
(C) 4.5 m/s
(D) 5.7 m/s

40. Water is pumped up a hill into a reservoir by a pump at the bottom of the hill. The pump discharges water at a rate of 2 m/s and a pressure of 1000 kPa. Disregarding friction, the highest possible elevation of the reservoir's water surface is most nearly

(A) 100 m
(B) 1000 m
(C) 1020 m
(D) 10200 m

41. Water flows in a 0.5 m (inside diameter) sewer line ($n = 0.015$, geometric slope = 0.001). The Manning coefficient, n, varies with depth. Flow is full, uniform, and steady. The flow rate is most nearly

(A) 0.10 m^3/s
(B) 0.21 m^3/s
(C) 0.53 m^3/s
(D) 0.70 m^3/s

42. The velocities upstream and downstream, v_1 and v_2 respectively, of a 4.0 m wide sluice gate are unknown. The upstream depth is 2.0 m, and the downstream depth is 0.6 m. Flow is uniform and steady. The geometric slope across the sluice gate is zero. The downstream velocity, v_2, is most nearly

(A) 0.3 m/s
(B) 3 m/s
(C) 4.7 m/s
(D) 5.5 m/s

43. A rectangular channel ($n = 0.013$, $s = 0.004$) has a depth of 3 m. The width of the channel is 5 m. The velocity of water in the channel is most nearly

(A) 1 m/s
(B) 6 m/s
(C) 15 m/s
(D) 90 m/s

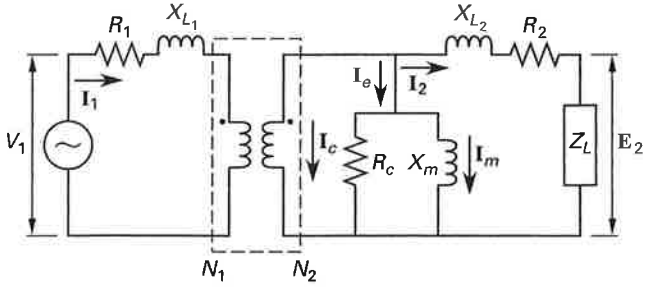
44. A rectangular channel on a 0.002 slope is constructed of finished concrete ($n = 0.012$). The channel is 2.4 m wide with a depth of 1.5 m. The flow rate is most nearly

(A) 0.67 m^3/s
(B) 2.9 m^3/s
(C) 10 m^3/s
(D) 41 m^3/s

Problems 45–48 are based on the following information and illustration.

single-phase transformer
90 kVA
10,000 V primary: 2000 V secondary
60 Hz
power factor: 0.8 leading

$R_1 = 6\ \Omega$ $\quad R'_2 = 7\ \Omega$
$X_{L_1} = 31\ \Omega$ $\quad X'_{L_2} = 31\ \Omega$
$X'_m = 55\ \text{k}\Omega$ $\quad R'_c = 120\ \text{k}\Omega$
$|Z_L| = 55\ \Omega$



45. What is $\mathbf{I}_2$ referred to the secondary side if the secondary voltage is 2000 V?

(A) $36.36\angle -36.87°$ A
(B) $36.87\angle -36.36°$ A
(C) $33.10\angle 36.87°$ A
(D) $36.36\angle 36.87°$ A

46. What is $\mathbf{E}_2$ referred to the secondary side?

(A) $2.0\angle 0°$ kV
(B) $5.0\angle 0°$ kV
(C) $2.0\angle 90°$ kV
(D) $110\angle 90°$ kV

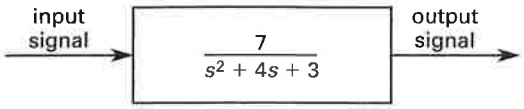
47. What is $\mathbf{I}_2$ referred to the primary side?

(A) $36.97\angle -36.36°$ A
(B) $7.27\angle -36.87°$ A
(C) $7.27\angle 36.87°$ A
(D) $181\angle 36.87°$ A

48. What is $\mathbf{E}_2$ referred to the primary side?

(A) $0.80\angle 0°$ kV
(B) $5.0\angle 0°$ kV
(C) $10\angle 0°$ kV
(D) $50\angle 0°$ kV

Problems 49–51 are based on the following illustration.



49. What is the output signal as a function of time if a unit impulse function is the input signal?

(A) $\left(\frac{7}{2}\right)\left(e^{t} + e^{-3t}\right)$
(B) $\left(\frac{7}{2}\right)\left(e^{-t} + e^{-3t}\right)$
(C) $\left(\frac{7}{2}\right)\left(e^{-3t} - e^{-t}\right)$
(D) $\left(\frac{7}{2}\right)\left(e^{-t} - e^{-3t}\right)$

50. What is the steady-state output if the unit step function of height 5 at $t = 0$ is the input signal?

(A) 3/35
(B) 35/6
(C) 35/3
(D) 7/3

51. What is the steady-state response if the sinusoid $7\sin(2t + \pi/3)$ is the input signal?

(A) $6.08\angle -157°$
(B) $6.08\angle -37°$
(C) $6.08\angle 52.9°$
(D) $6.08\angle 142.9°$

52. What is most nearly the coefficient of performance of a Carnot refrigeration cycle operating between $-23.3°$C and $-123.3°$C?

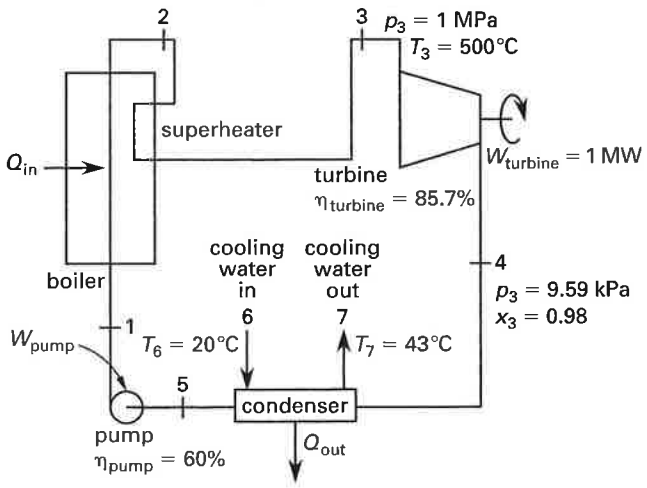
(A) −0.50
(B) 0.50
(C) 1.1
(D) 1.5

53. Most nearly, what work is done in compressing 1 kg of air originally at standard temperature and pressure (0°C, 1 atm) to one-half of its original volume in an isothermal process?

(A) 38 kJ
(B) 53 kJ
(C) 76 kJ
(D) 150 kJ

Problems 54–59 are based on the following statement and illustration.

A 1 MW power plant operates on the simple turbine cycle illustrated above. The isentropic efficiencies of the pump and turbine are 60% and 85.7%, respectively.



54. Superheated steam enters the turbine at 1 MPa and 500°C. Steam leaves the turbine at 9.59 kPa and with a quality of 98%. The ideal turbine work per unit mass of steam is most nearly

(A) 650 kJ/kg
(B) 810 kJ/kg
(C) 940 kJ/kg
(D) 1100 kJ/kg

55. Most nearly, what mass of steam passing through the turbine each hour would be required to generate 1 MW of power?

(A) 1900 kg/h
(B) 3100 kg/h
(C) 3800 kg/h
(D) 4500 kg/h

56. The enthalpy of the liquid leaving the condenser is most nearly

(A) 170 kJ/kg
(B) 180 kJ/kg
(C) 190 kJ/kg
(D) 200 kJ/kg

57. Cooling water enters the condenser at 20°C and leaves at 43°C. What is most nearly the flow rate of the cooling water?

(A) 8.7×10^3 kg/h
(B) 2.9×10^4 kg/h
(C) 1.1×10^5 kg/h
(D) 1.2×10^5 kg/h

58. The energy per unit mass of condensate added by the boiler feed pump is most nearly

(A) 800 J/kg
(B) 1000 J/kg
(C) 1700 J/kg
(D) 2400 J/kg

59. What is the approximate temperature of the water leaving the boiler feed pump?

(A) 45.2°C
(B) 45.4°C
(C) 46.1°C
(D) 47.0°C

60. In an isentropic process, $p_1 = 7.25$ N/cm^2, $p_2 = 10.73$ N/cm^2, and $T_1 = 355$K. The ratio of specific heats is 1.4. What is most nearly the value of T_2?

(A) 330K
(B) 360K
(C) 400K
(D) 440K