

Fundamentals of Engineering Sample Examination

Morning Section

Name: _____

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|---------------------|---------------------|---------------------|----------------------|
| 1. (A) (B) (C) (D) | 31. (A) (B) (C) (D) | 61. (A) (B) (C) (D) | 91. (A) (B) (C) (D) |
| 2. (A) (B) (C) (D) | 32. (A) (B) (C) (D) | 62. (A) (B) (C) (D) | 92. (A) (B) (C) (D) |
| 3. (A) (B) (C) (D) | 33. (A) (B) (C) (D) | 63. (A) (B) (C) (D) | 93. (A) (B) (C) (D) |
| 4. (A) (B) (C) (D) | 34. (A) (B) (C) (D) | 64. (A) (B) (C) (D) | 94. (A) (B) (C) (D) |
| 5. (A) (B) (C) (D) | 35. (A) (B) (C) (D) | 65. (A) (B) (C) (D) | 95. (A) (B) (C) (D) |
| 6. (A) (B) (C) (D) | 36. (A) (B) (C) (D) | 66. (A) (B) (C) (D) | 96. (A) (B) (C) (D) |
| 7. (A) (B) (C) (D) | 37. (A) (B) (C) (D) | 67. (A) (B) (C) (D) | 97. (A) (B) (C) (D) |
| 8. (A) (B) (C) (D) | 38. (A) (B) (C) (D) | 68. (A) (B) (C) (D) | 98. (A) (B) (C) (D) |
| 9. (A) (B) (C) (D) | 39. (A) (B) (C) (D) | 69. (A) (B) (C) (D) | 99. (A) (B) (C) (D) |
| 10. (A) (B) (C) (D) | 40. (A) (B) (C) (D) | 70. (A) (B) (C) (D) | 100. (A) (B) (C) (D) |
| 11. (A) (B) (C) (D) | 41. (A) (B) (C) (D) | 71. (A) (B) (C) (D) | 101. (A) (B) (C) (D) |
| 12. (A) (B) (C) (D) | 42. (A) (B) (C) (D) | 72. (A) (B) (C) (D) | 102. (A) (B) (C) (D) |
| 13. (A) (B) (C) (D) | 43. (A) (B) (C) (D) | 73. (A) (B) (C) (D) | 103. (A) (B) (C) (D) |
| 14. (A) (B) (C) (D) | 44. (A) (B) (C) (D) | 74. (A) (B) (C) (D) | 104. (A) (B) (C) (D) |
| 15. (A) (B) (C) (D) | 45. (A) (B) (C) (D) | 75. (A) (B) (C) (D) | 105. (A) (B) (C) (D) |
| 16. (A) (B) (C) (D) | 46. (A) (B) (C) (D) | 76. (A) (B) (C) (D) | 106. (A) (B) (C) (D) |
| 17. (A) (B) (C) (D) | 47. (A) (B) (C) (D) | 77. (A) (B) (C) (D) | 107. (A) (B) (C) (D) |
| 18. (A) (B) (C) (D) | 48. (A) (B) (C) (D) | 78. (A) (B) (C) (D) | 108. (A) (B) (C) (D) |
| 19. (A) (B) (C) (D) | 49. (A) (B) (C) (D) | 79. (A) (B) (C) (D) | 109. (A) (B) (C) (D) |
| 20. (A) (B) (C) (D) | 50. (A) (B) (C) (D) | 80. (A) (B) (C) (D) | 110. (A) (B) (C) (D) |
| 21. (A) (B) (C) (D) | 51. (A) (B) (C) (D) | 81. (A) (B) (C) (D) | 111. (A) (B) (C) (D) |
| 22. (A) (B) (C) (D) | 52. (A) (B) (C) (D) | 82. (A) (B) (C) (D) | 112. (A) (B) (C) (D) |
| 23. (A) (B) (C) (D) | 53. (A) (B) (C) (D) | 83. (A) (B) (C) (D) | 113. (A) (B) (C) (D) |
| 24. (A) (B) (C) (D) | 54. (A) (B) (C) (D) | 84. (A) (B) (C) (D) | 114. (A) (B) (C) (D) |
| 25. (A) (B) (C) (D) | 55. (A) (B) (C) (D) | 85. (A) (B) (C) (D) | 115. (A) (B) (C) (D) |
| 26. (A) (B) (C) (D) | 56. (A) (B) (C) (D) | 86. (A) (B) (C) (D) | 116. (A) (B) (C) (D) |
| 27. (A) (B) (C) (D) | 57. (A) (B) (C) (D) | 87. (A) (B) (C) (D) | 117. (A) (B) (C) (D) |
| 28. (A) (B) (C) (D) | 58. (A) (B) (C) (D) | 88. (A) (B) (C) (D) | 118. (A) (B) (C) (D) |
| 29. (A) (B) (C) (D) | 59. (A) (B) (C) (D) | 89. (A) (B) (C) (D) | 119. (A) (B) (C) (D) |
| 30. (A) (B) (C) (D) | 60. (A) (B) (C) (D) | 90. (A) (B) (C) (D) | 120. (A) (B) (C) (D) |

1. The half-life of a radioactive isotope is 4.3 days. Most nearly, how long will it take to reduce the original amount to 1%?

- (A) 3.2 days
- (B) 16 days
- (C) 29 days
- (D) 40 days

2. What is the determinant of the following 2×2 matrix?

$$\begin{bmatrix} 1 & 4 \\ 3 & 2 \end{bmatrix}$$

- (A) -10
- (B) -5
- (C) 9
- (D) 10

3. What is most nearly the value of the following limit?

$$\lim_{x \rightarrow 3} \frac{x^2 - 9}{x - 3}$$

- (A) -6
- (B) 1
- (C) 6
- (D) ∞

4. Given the vector $\mathbf{V} = \mathbf{i} + 2\mathbf{j} + \mathbf{k}$, what is most nearly the angle between \mathbf{V} and the x -axis?

- (A) 22°
- (B) 24°
- (C) 66°
- (D) 80°

5. Evaluate the following definite integral.

$$\int_2^\infty \frac{1}{x^2} dx$$

- (A) $1/24$
- (B) $1/8$
- (C) $1/2$
- (D) 2

6. Which is a true statement about the two vectors?

$$\mathbf{V}_1 = \mathbf{i} + 2\mathbf{j} + \mathbf{k}$$

$$\mathbf{V}_2 = \mathbf{i} + 3\mathbf{j} - 7\mathbf{k}$$

- (A) Both vectors pass through $(0, -1, 6)$.
- (B) The vectors are parallel.
- (C) The vectors are orthogonal.
- (D) The angle between the vectors is 17.4° .

7. What is most nearly the area bounded by $y = 0$, $y = e^x$, $x = 0$, and $x = 1$?

- (A) 1.4
- (B) 1.7
- (C) 2.7
- (D) 3.4

8. A function of x is given below. Which (x, y) point is a relative maximum or minimum?

$$y = \frac{1}{4}x^4 - 1.5x^2 + 2x + 5$$

- (A) $(-2, -1)$
- (B) $(-2, -2)$
- (C) $(2, -2)$
- (D) $(-1, -1.75)$

9. The slope of a line is $1/2$. The slope of a second line is $-2/3$. The lines intersect at the point $(3, 1)$. What is most nearly the acute angle between the lines?

- (A) 27°
- (B) 50°
- (C) 60°
- (D) 80°

10. A function is given. What value of x maximizes y ?

$$y^2 + y + x^2 - 2x = 5$$

- (A) -1
- (B) $1/2$
- (C) 1
- (D) 5

11. An elephant is chained to a corner of a 30 m \times 35 m building. If the chain is 40 m long and the elephant can reach 1 m farther than the chain length, what is the maximum area the elephant can cover?

- (A) 3870 m^2
- (B) 3960 m^2
- (C) 3970 m^2
- (D) 4080 m^2

12. What is a point of inflection for the following equation?

$$y = 9x^3 + x^2 - 15x + 32$$

- (A) $(-27, -176,000)$
- (B) $(-21.2, -84,400)$
- (C) $(-0.037, 32.6)$
- (D) $(19.2, 63,300)$

13. Assume that three force vectors are applied at a single point.

$$\mathbf{F}_1 = \mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$$

$$\mathbf{F}_2 = 2\mathbf{i} + 7\mathbf{j} - \mathbf{k}$$

$$\mathbf{F}_3 = -\mathbf{i} + 4\mathbf{j} + 2\mathbf{k}$$

What is most nearly the magnitude of the resultant force vector, \mathbf{R} ?

- (A) 13
- (B) 14
- (C) 15
- (D) 16

14. What is the solution to the differential equation if $x = 1$ at $t = 0$, and $dx/dt = 0$ at $t = 0$?

$$\frac{1}{2} \frac{d^2x}{dt^2} + 4 \frac{dx}{dt} + 8x = 5$$

- (A) $e^{-4t} + 4te^{-4t}$
- (B) $\frac{3}{8}e^{-2t}(\cos 2t + \sin 2t) + \frac{5}{8}$
- (C) $e^{-4t} + 4te^{-4t} + \frac{5}{8}$
- (D) $\frac{3}{8}e^{-4t} + \frac{3}{2}te^{-4t} + \frac{5}{8}$

15. What is the smallest positive value of y on the curve $y = 7x^2 - 3x + 8$?

- (A) 3/14
- (B) 3/7
- (C) 14/3
- (D) 215/28

16. Which of the following is equivalent to $\sin 2\theta$?

- (A) $2 \sin \theta \cos \theta$
- (B) $\cos^2 \theta - \sin^2 \theta$
- (C) $\sin \theta \cos \theta$
- (D) $\frac{1 - \cos 2\theta}{2}$

17. If $i \equiv \sqrt{-1}$, what is the value of $(i)^i$?

- (A) i^2
- (B) e^{2i}
- (C) -1
- (D) $e^{-\frac{\pi}{2}}$

18. What is most nearly the volume of the object created when the area bounded by $y = 0$, $x = 0$, and $y = \sqrt{4 - x^2}$ is rotated about the y -axis?

- (A) 3.1
- (B) 8.4
- (C) 17
- (D) 34

19. Five fair coins are each flipped once. What is the probability that at least two of the coins will show heads?

- (A) 0.19
- (B) 0.80
- (C) 0.81
- (D) 0.84

20. What is most nearly the standard deviation of 1, 4, and 7?

- (A) 2.5
- (B) 3.0
- (C) 5.7
- (D) 6.0

21. What is most nearly the probability of picking an orange ball out of a bag containing seven orange balls, eight green balls, and two white balls?

- (A) 0.059
- (B) 0.15
- (C) 0.24
- (D) 0.41

22. Five dice are thrown. The probability of rolling at least one six is most nearly

- (A) 0.50
- (B) 0.52
- (C) 0.60
- (D) 0.67

23. What is most nearly the sample standard deviation for the data set {2.0, 7.0, 9.0, 12, 34}?

- (A) 11
- (B) 12
- (C) 13
- (D) 17

24. On average, a piece of machinery jams five times a week. Assuming a Poisson distribution for the jams, the probability that the machine will jam exactly three times in a given week is most nearly

- (A) 0.0033
- (B) 0.14
- (C) 0.33
- (D) 1.40

25. The least-squares method is used to plot a straight line through the data points (2,2), (4,7), (1,11), and (5,9). The slope of the line is most nearly

- (A) -8
- (B) -4
- (C) 0
- (D) 3.5

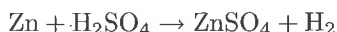
26. The method of determining the graph of a curve that best approximates a given collection of points is called

- (A) integration by parts
- (B) curve fitting
- (C) nonlinear interpolation
- (D) hypothesis testing

27. Which of the following is the formula for acetic acid?

- (A) COOH
- (B) CH₂COOH
- (C) CH₃CH₂COOH
- (D) CH₃COOH

28. What is oxidized and what is reduced in the following reaction?



- (A) Zinc is oxidized only.
- (B) Zinc is reduced only.
- (C) Zinc is oxidized and hydrogen is reduced.
- (D) Zinc is reduced and hydrogen is oxidized.

29. How many moles of NaOH will be neutralized by 1 mole of H₃PO₄?

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

30. An anode is

- (A) the endpoint of a directed network
- (B) an electrode at which oxidation occurs
- (C) an electrode at which reduction occurs
- (D) the electrode to which the cation would be attracted during an electrolytic reaction

31. Beryllium, magnesium, and calcium all belong to which elemental grouping?

- (A) noble elements
- (B) halogens
- (C) alkali metals
- (D) alkaline earth metals

32. If 1 mol of gaseous chlorine combines with 1 mol of calcium to form calcium chloride (CaCl₂), which of the following statements is true?

- (A) Calcium has a valence of +1.
- (B) 1 lbm of chlorine will combine with 1 lbm of calcium.
- (C) Chlorine has a valence of -2.
- (D) Calcium has a valence of +2.

33. Balance the following equation.



- (A) $3\text{PbO}_2 + 6\text{H}_2\text{SO}_4 + 3\text{Pb} \rightleftharpoons 6\text{H}_2\text{O} + 5\text{PbSO}_4$
- (B) $3\text{PbO}_2 + 6\text{H}_2\text{SO}_4 + \text{Pb} \rightleftharpoons 6\text{H}_2\text{O} + 4\text{PbSO}_4$
- (C) $2\text{PbO}_2 + \text{H}_2\text{SO}_4 + 2\text{Pb} \rightleftharpoons 4\text{H}_2\text{O} + 4\text{PbSO}_4$
- (D) $\text{PbO}_2 + 2\text{H}_2\text{SO}_4 + \text{Pb} \rightleftharpoons 2\text{H}_2\text{O} + 2\text{PbSO}_4$

34. What is the most likely formula of a compound with the following gravimetric analysis?

oxygen: 13.7%
carbon: 20.5%
hydrogen: 5.1%
chlorine: 60.7%

- (A) CH₃OCl
- (B) C₂H₆OCl
- (C) C₂H₆OCl₂
- (D) CH₆O₂Cl

35. How many moles of hydrochloric acid will be required to neutralize 1 mol of sodium hydroxide?

- (A) 0.3 mol
- (B) 0.5 mol
- (C) 1.0 mol
- (D) 1.5 mol

36. What is most nearly the mass of 1 atom of carbon-12?

- (A) 5.0×10^{-24} g
- (B) 2.0×10^{-23} g
- (C) 4.0×10^{-23} g
- (D) 7.6×10^{-23} g

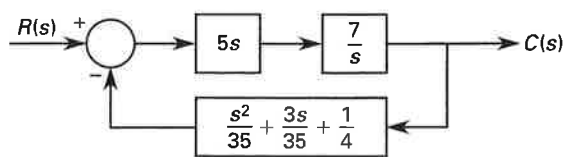
37. A system is found to have the following transfer function.

$$H(s) = \frac{7 + s}{2s^2 + 14s - 36}$$

s is the frequency in Hz. What frequency defines the system as inherently unstable?

- (A) -7 Hz
- (B) 2 Hz
- (C) 4 Hz
- (D) 9 Hz

Problems 38–43 are based on the following illustration. All values are in non-dimensionalized units.



38. What is most nearly the natural frequency of the control system?

- (A) 0.707
- (B) 3.12
- (C) 5.92
- (D) 9.75

Problems 39–42 assume that the natural frequency of the control system shown in Prob. 38 is $5q$ Hz, where q is some scalar.

39. What is most nearly the steady-state gain of the control system?

- (A) $1.4/q^2$
- (B) $7.0/q^2$
- (C) $16/q^2$
- (D) $180/q^2$

40. What is most nearly the damping ratio of the control system?

- (A) $0.06/q$
- (B) $0.3/q$
- (C) $0.6/q$
- (D) $0.8/q$

Problems 41 and 42 assume a damping ratio of 0.5.

41. What is most nearly the damped natural frequency (in Hz) of the control system?

- (A) $0.866q$
- (B) $3.54q$
- (C) $3.75q$
- (D) $4.33q$

42. What is most nearly the damped resonant frequency (in Hz) of the control system?

- (A) $0.866q$
- (B) $3.54q$
- (C) $3.75q$
- (D) $4.33q$

43. If the control system is given a unit step input, how will the response be characterized?

- (A) underdamped
- (B) overdamped
- (C) critically damped
- (D) unstable

44. A baud is

- (A) a measure of the intervals between transmitted digital data
- (B) a device used to demodulate audio data signals
- (C) a unit of magnitude of electronically transmitted audio signals
- (D) a unit of speed in digital data transmission measuring number of signals per second

45. The following code is an example of what programming technique?

```
b = cube(a)
cube(a)
{
  b = a * a * a
  return b
}
```

- (A) branching
- (B) function call
- (C) looping
- (D) subroutine

46. When can a professional provide services if conflicts of interest are involved?

- (A) if no compensation is received
- (B) if doing so does not personally benefit the professional
- (C) if full disclosure of potential conflicts are provided
- (D) never

47. When is the receipt of compensation from more than one party for the same project ethical?
- (A) never
 - (B) when the total of all compensation received does not exceed "reasonable" compensation for the type of work performed
 - (C) always
 - (D) when all parties involved know about and agree to the arrangement
48. When may professionals make political donations?
- (A) at no time
 - (B) if it is not for current, past, or future influence or favors
 - (C) if all donations are made as an individual and do not represent a firm or entity
 - (D) only below specified amounts
49. Which of the following is not always an ethics violation?
- (A) signing plans or blueprints without having first designed and/or checked the plans
 - (B) revealing confidential information about a product without first obtaining permission
 - (C) granting a contract to a company for which the professional is an officer while concurrently serving on the board issuing the grants
 - (D) any individual accepting fees from contractors hired for a project
50. In the event of an ethical conflict, to whom does the professional hold the least ethical responsibility?
- (A) the employer
 - (B) the client
 - (C) the consumer
 - (D) society
51. Ethical behavior is officially regulated by whom?
- (A) individual employers
 - (B) registered engineers
 - (C) professional societies
 - (D) state enforcement agencies
52. Whistle blowing is
- (A) an ethical practice
 - (B) an illegal practice
 - (C) an unethical practice
 - (D) a career-enhancing practice
53. Which of the following is not a reason professionals must adhere to a code of ethics?
- (A) Professions are self-regulating.
 - (B) Professionals receive above-average compensation.
 - (C) Professionals have autonomy.
 - (D) Professions are responsible for training other professionals.
54. The National Society of Professional Engineers' (NSPE) Code of Ethics addresses competitive bidding. Which of the following is NOT stipulated?
- (A) Engineers and their firms may refuse to bid competitively on engineering services.
 - (B) Clients are required to seek competitive bids for design services.
 - (C) Federal laws governing procedures for procuring engineering services (e.g., competitive bidding) remain in full force.
 - (D) Engineers and their societies may actively lobby for legislation that would prohibit competitive bidding for design services.
55. A credit card offers 1.2% effective monthly interest. What is most nearly the effective annual rate with monthly compounding?
- (A) 7.9%
 - (B) 8.9%
 - (C) 14%
 - (D) 15%
56. A bank charges 12% simple interest on a \$300 loan. Most nearly, how much will be repaid if the loan is paid back in one lump sum after three years?
- (A) \$108
 - (B) \$408
 - (C) \$415
 - (D) \$421
57. Most nearly, how long will it take a sum of money to double at a 5% annual percentage rate?
- (A) 6 years
 - (B) 10 years
 - (C) 11 years
 - (D) 14 years
58. A piece of machinery has an initial cost of \$40,000 and results in an increase in annual maintenance costs of \$2000. If the machinery saves the company \$10,000

per year, in approximately how many years will the machine pay for itself if compounding is considered? The effective annual interest rate is 6%.

- (A) 5.2 years
- (B) 6.1 years
- (C) 7 years
- (D) 8 years

59. Funds are deposited in a savings account at an interest rate of 8% per annum. If the interest is compounded semi-annually, what is most nearly the initial amount that must be deposited to yield a total of \$10,000 in 10 years?

- (A) \$4530
- (B) \$4560
- (C) \$6730
- (D) \$8200

60. \$500 is deposited into a bank savings account with 6% interest compounded annually. Most nearly how much is in the account at the end of three years?

- (A) \$550
- (B) \$600
- (C) \$650
- (D) \$700

61. At the end of each year for five years, \$500 is deposited into a credit union account. The credit union pays 5% interest compounded annually. At the end of five years (immediately following the fifth deposit) most nearly how much will be in the account?

- (A) \$640
- (B) \$1750
- (C) \$2760
- (D) \$3550

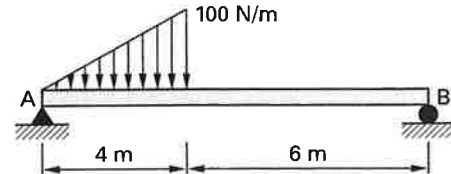
62. On January 1, \$5000 is deposited into a high-interest savings account that pays 8% interest compounded annually. If all of the money is withdrawn in five equal end-of-year sums beginning December 31 of the first year, most nearly how much will each withdrawal be?

- (A) \$1008
- (B) \$1150
- (C) \$1210
- (D) \$1250

63. If you needed to have \$800 in savings at the end of four years and your savings account yielded 5% interest paid annually, most nearly how much would you need to deposit today?

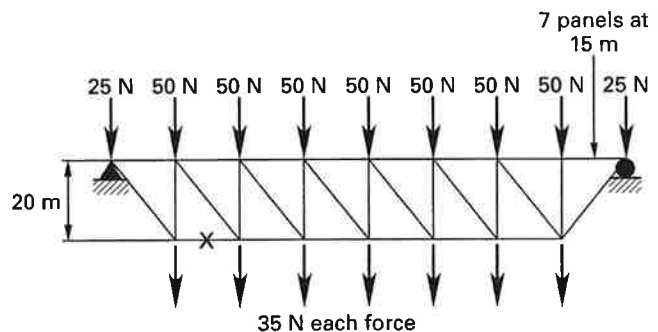
- (A) \$570
- (B) \$600
- (C) \$660
- (D) \$770

64. What is most nearly the reaction at A?



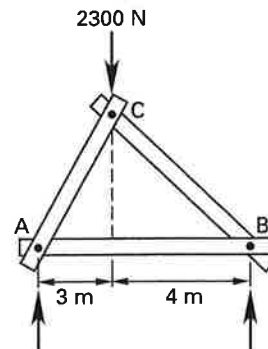
- (A) 50 N
- (B) 100 N
- (C) 130 N
- (D) 150 N

65. Find the magnitude of the force in the member marked with an "X." All members are pin-connected.



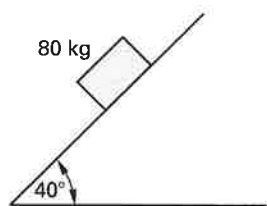
- (A) 9.70 N
- (B) 27.3 N
- (C) 85.0 N
- (D) 223 N

66. The approximate vertical force component in member BC is



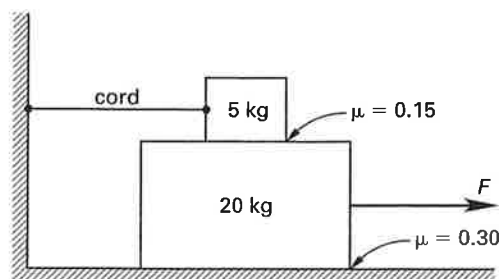
- (A) 990 N
 (B) 1300 N
 (C) 2300 N
 (D) 3600 N

67. What is most nearly the frictional force between the 80 kg block and the ramp? The coefficient of static friction is 0.2, and the coefficient of dynamic friction is 0.15.



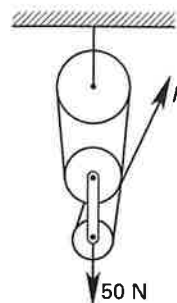
- (A) 60 N
 (B) 80 N
 (C) 90 N
 (D) 120 N

68. Force F is gradually increased until the 20 kg block begins moving to the right. The 5 kg block is prevented from moving by a cord. What is most nearly the minimum force F for which movement is possible?



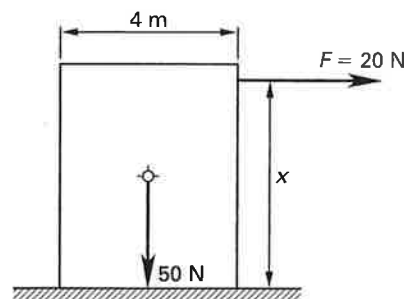
- (A) 7.4 N
 (B) 59 N
 (C) 74 N
 (D) 81 N

69. Most nearly, what force, F , is required to lift a 50 N load? All pulleys are frictionless. Assume all strands are parallel.



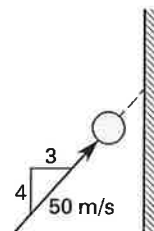
- (A) 8.3 N
 (B) 13 N
 (C) 17 N
 (D) 25 N

70. What is most nearly the maximum value of x such that F can be applied without tipping the block? ($\mu = 0.4$.)



- (A) 1.5 m
 (B) 3.5 m
 (C) 4.4 m
 (D) 5.0 m

71. What is most nearly the component of velocity perpendicular to the wall after impact if the coefficient of restitution is 0.8?



- (A) 24 m/s
 (B) 30 m/s
 (C) 32 m/s
 (D) 40 m/s

72. The velocity of a particle at time t is

$$v(t) = 12t^4 + \frac{7}{t}$$

Most nearly, what total distance is traveled between $t = 0.2$ and $t = 0.3$?

- (A) 0.98
- (B) 1.8
- (C) 2.8
- (D) 8.4

73. A spring has a spring constant of 10 N/cm. It is compressed 5 cm. The spring is released and pushes against a free projectile with a mass of 1 kg. The projectile velocity immediately after losing contact with the spring is most nearly

- (A) 0.32 m/s
- (B) 1.6 m/s
- (C) 32 m/s
- (D) 50 m/s

74. A rocket is moving through a vacuum. It changes its velocity from 9020 m/s to 5100 m/s in 48 s. The power required to accomplish this if the rocket's mass is 213 000 kg is most nearly

- (A) 34 GW
- (B) 120 GW
- (C) 170 GW
- (D) 250 GW

75. A projectile is launched at 52 degrees from horizontal with an initial velocity of 3600 m/s. If the mass of the projectile is 32 kg, what is most nearly the total kinetic and potential energy possessed by the projectile at $t = 13$ s? Neglect all forms of friction.

- (A) 5.9 kJ
- (B) 0.58 MJ
- (C) 210 MJ
- (D) 420 MJ

Problems 76 and 77 are based on the following statement.

A 30 cm long rod ($E = 3 \times 10^7$ N/cm², $\alpha = 6 \times 10^{-6}$ cm/cm $^\circ$ C) with a 2 cm² cross section is fixed at both ends.

76. If the rod is heated to 60 $^\circ$ C above the neutral temperature, what is most nearly the stress?

- (A) 110 N/cm²
- (B) 11 000 N/cm²
- (C) 36 000 N/cm²
- (D) 57 000 N/cm²

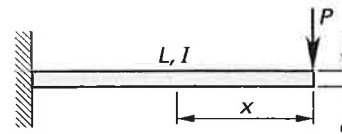
77. If one end of the rod is free to expand the elongation is most nearly

- (A) 5.4×10^{-4} cm
- (B) 3.6×10^{-4} cm
- (C) 0.01 cm
- (D) 0.03 cm

78. Vickers, Knoop, and Brinell are all names of

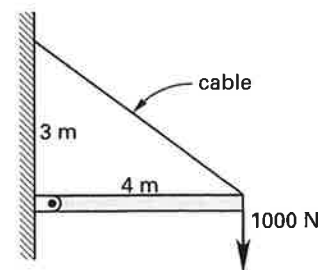
- (A) Nobel prize winners in metallurgy
- (B) thermodynamic constants
- (C) hardness tests
- (D) chi-squared statistics

79. What is the maximum flexural stress at a distance x from the free end of a cantilever beam supporting a tip load, P ?



- (A) $\frac{Pxc}{2I}$
- (B) $\frac{Pc}{2I}$
- (C) $\frac{PcL}{2I}$
- (D) $\frac{Pxc}{2EI}$

80. What is most nearly the elongation in the cable if $F = 1000$ N? The cable's effective cross-sectional area is 2 cm². Its modulus of elasticity is 1.5×10^6 N/cm².



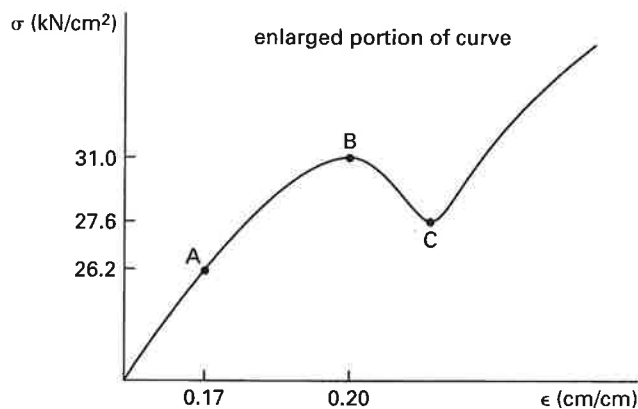
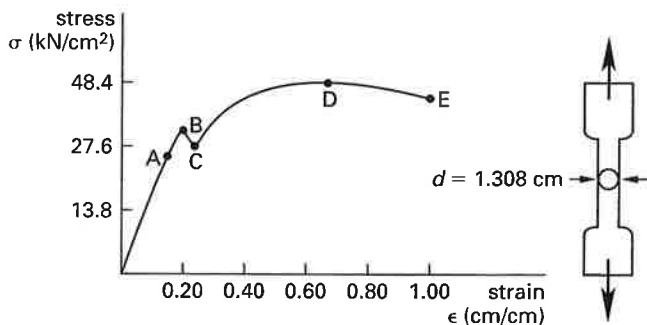
- (A) 0.0028 cm
- (B) 0.14 cm
- (C) 0.28 cm
- (D) 0.56 cm

81. A simply-supported beam carries a single concentrated load at its center. If its slenderness ratio is 150, it is most likely to fail

- (A) where the moment is zero
- (B) where the shear is maximum
- (C) at a support
- (D) where the slope of the deflection curve is zero

Problems 82 and 83 are based on the following statement and illustrations.

The results of a tensile test on a round specimen of a given material are shown.



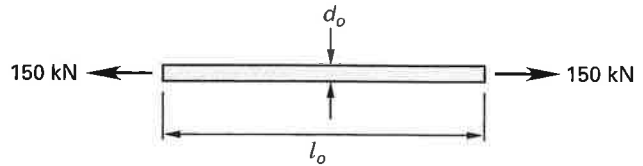
82. What is most nearly the yield stress?

- (A) 26 kN/cm²
- (B) 28 kN/cm²
- (C) 29 kN/cm²
- (D) 31 kN/cm²

83. What is most nearly the elastic limit of the material?

- (A) 26 kN/cm²
- (B) 28 kN/cm²
- (C) 31 kN/cm²
- (D) 34 kN/cm²

84. The aluminum rod shown in the following illustration has an initial diameter, d_o , of 30 mm and an initial gauge length, ℓ_o , of 200 mm. The yield strength is 420 MPa. What is the modulus of elasticity if a force of 150 kN elongates the rod by 1.0 mm?



- (A) 21 GPa
- (B) 31 GPa
- (C) 42 GPa
- (D) 53 GPa

85. Which type of hardening will work to some extent in all metals?

- (A) work-hardening
- (B) annealing
- (C) martempering
- (D) austenitizing

86. What do impact tests determine?

- (A) hardness
- (B) yield strength
- (C) toughness
- (D) creep strength

87. What is one of the main differences between cast iron and steel?

- (A) Steel has a lower carbon content.
- (B) Steel always contains alloying metals such as nickel, chromium, manganese, and vanadium.
- (C) Steel cannot be annealed, whereas cast iron can.
- (D) Steel contains a large amount of uncombined carbon.

88. For a fixed curing time, the ultimate strength of concrete

- (A) increases with a decrease in water content
- (B) decreases with a decrease in water content
- (C) is independent of water content if cured for a sufficiently long time
- (D) is independent of curing pressure

89. The radius of a hypothetical electron orbit is known to be 0.75 \AA . What is most nearly the de Broglie wavelength of the electron if four complete cycles constitute a stable pattern around the nucleus?

- (A) 0.19 \AA
- (B) 1.2 \AA
- (C) 2.4 \AA
- (D) 4.7 \AA

90. An orbital

- (A) may have 2, 8, 18, or 32 electrons
- (B) may have 2 electrons with the same spin direction
- (C) may be photographed with an electron microscope
- (D) may be unoccupied

91. For corrosion to occur, which of the following items must be present?

- I. anode
 - II. cathode
 - III. electrolyte
- (A) I and II
 - (B) I and III
 - (C) II and III
 - (D) I, II, and III

92. A system consisting of an open bucket containing a mixture of ice and water is to be warmed from 0°C to 20°C . How many degrees of freedom does the system have?

- (A) 0
- (B) 1
- (C) 2
- (D) 3

93. A venturi meter is used to measure air velocity. A one-fifth scale model of the venturi meter is built, and water is used as the test fluid. Viscosity of the air is $1.82 \times 10^{-5} \text{ N}\cdot\text{s}/\text{m}^2$. Viscosity of the water is $9.82 \times 10^{-4} \text{ N}\cdot\text{s}/\text{m}^2$. What will be the approximate ratio of the model to the actual velocities observed?

- (A) 0.32
- (B) 3.1
- (C) 11
- (D) 54

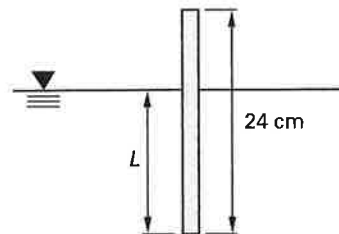
94. A 150 m long surface vessel is modeled at 1:50. Most nearly, what speed must the model travel if a 40 kph similarity is desired?

- (A) 0.22 m/s
- (B) 1.5 m/s
- (C) 1.6 m/s
- (D) 2.2 m/s

95. What is most nearly the hydraulic radius of an equilateral triangle (vertex down) open channel flowing at full capacity with a maximum depth of 3 m?

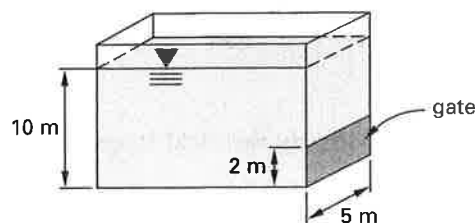
- (A) 0.60 m
- (B) 0.65 m
- (C) 0.70 m
- (D) 0.75 m

96. A 24 cm long rod floats vertically in water. It has a 1 cm^2 cross section and a specific gravity of 0.6. Most nearly, what length, L , is submerged?



- (A) 9.6 cm
- (B) 14 cm
- (C) 18 cm
- (D) 19 cm

97. A tank is filled with water to a depth of 10 m. The total force on the gate is most nearly



- (A) 90 kN
- (B) 440 kN
- (C) 880 kN
- (D) 980 kN

98. When a thin-bore, hollow glass tube is inserted into a container of mercury, the surface of the mercury in the tube

- (A) is level with the surface of the mercury in the container
- (B) is below the container surface due to cohesion
- (C) is below the container surface due to adhesion
- (D) is above the container surface due to cohesion

99. The fluid in a manometer tube is 60% water and 40% alcohol (specific gravity = 0.8). What is most nearly the manometer fluid height difference if a 42.7 kPa pressure difference is applied across the two ends of the manometer?

- (A) 23 cm
- (B) 47 cm
- (C) 470 cm
- (D) 550 cm

100. Carbon dioxide (CO_2) gas has a molecular weight of 44. The density of STP air is 1.29 kg/m^3 . The specific gravity of CO_2 gas at 66°C and 138 kPa, using STP air as reference, is most nearly

- (A) 0.67
- (B) 1.1
- (C) 1.7
- (D) 2.1

101. A vacuum pump is used to drain a basement of 20°C water. The vapor pressure of water at this temperature is 2.34 kPa. The pump is incapable of lifting water higher than 10.5 m. The atmospheric pressure is most nearly

- (A) 100 kPa
- (B) 150 kPa
- (C) 210 kPa
- (D) 270 kPa

102. Six coulombs of charge pass through a wire in 2 s. What is most nearly the average current flowing?

- (A) 1.6 A
- (B) 3 A
- (C) 4.8 A
- (D) 6 A

103. An ideal transformer has 200 primary turns and 20 secondary turns. What is most nearly the secondary voltage if the primary voltage is 120 V?

- (A) 1.2 V
- (B) 12 V
- (C) 120 V
- (D) 1200 V

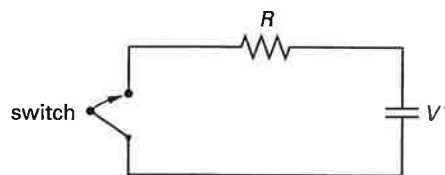
104. If 0.3 A flows in the secondary and 30 A flows in the primary of a perfectly matched, ideal transformer, what is most nearly the primary to secondary turns ratio?

- (A) 1:100
- (B) 1:10
- (C) 10:1
- (D) 100:1

105. Five watts are dissipated in a primary (input) circuit that includes a perfectly matched, ideal transformer with a primary-to-secondary turns ratio of 15:1. If the input resistance is 2000Ω , what is most nearly the load resistance?

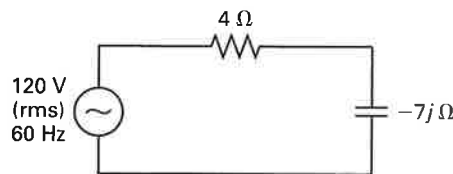
- (A) 8.9Ω
- (B) 130Ω
- (C) $6.2 \text{ k}\Omega$
- (D) $30 \text{ k}\Omega$

106. What is the total energy dissipated in the resistor when the capacitor discharges?



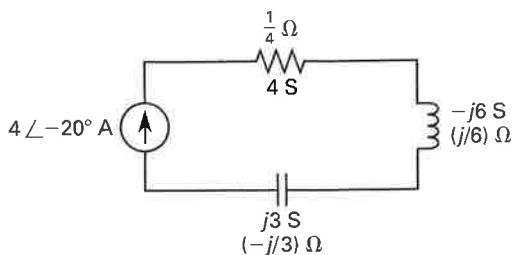
- (A) $V^2 R$
- (B) $\frac{1}{2} CV$
- (C) CV
- (D) $\frac{1}{2} CV^2$

107. What is most nearly the phase angle difference between the current and the voltage? Take the voltage as the reference.



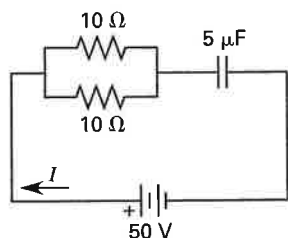
- (A) -60°
- (B) -35°
- (C) -30°
- (D) $+30^\circ$

108. What is most nearly the phasor voltage drop across the current source?



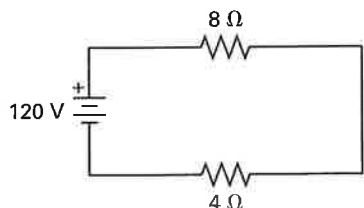
- (A) $0.80\angle 16.8^\circ$ V
 (B) $1.2\angle -53.7^\circ$ V
 (C) $5.0\angle 36.8^\circ$ V
 (D) $6.0\angle -20.0^\circ$ V

109. Two $10\ \Omega$ resistances are connected in parallel. This combination is connected in series with a capacitor of $5\ \mu\text{F}$. The circuit is connected across a DC source voltage of 50 V. What is most nearly the maximum steady-state current through the battery?



- (A) 0
 (B) 1 A
 (C) 5 A
 (D) 7 A

110. The voltage appearing across the $4\ \Omega$ resistor is most nearly



- (A) 27 V
 (B) 40 V
 (C) 80 V
 (D) 120 V

111. A series RLC circuit driven by an AC voltage contains reactances $X_L = 20\ \Omega$ and $X_C = 14\ \Omega$ and resistance $R = 10\ \Omega$. What is most nearly the impedance at resonant frequency?

- (A) $10\ \Omega$
 (B) $14\ \Omega$
 (C) $20\ \Omega$
 (D) $24\ \Omega$

112. What are the changes in internal energy for reversible adiabatic and isothermal processes, respectively?

- (A) $C_p\Delta T$ and 0
 (B) 0 and $C_v\Delta T$
 (C) $C_v\Delta T$ and $C_p\Delta T$
 (D) $C_v\Delta T$ and 0

113. A steam engine operates between 150°C and 550°C . What is most nearly its theoretical maximum thermal efficiency?

- (A) 27%
 (B) 49%
 (C) 73%
 (D) 95%

114. Regardless of the process, the change in enthalpy (ΔH) for n moles of an ideal gas is

- (A) $\frac{nRT}{V}$
 (B) 0
 (C) $nC_v\Delta T$
 (D) $nC_p\Delta T$

115. Which of the following statements is true?

- (A) Entropy always decreases.
 (B) Entropy increases up to the critical temperature, and then it decreases.
 (C) Theoretically, entropy approaches zero as the temperature approaches zero.
 (D) None of the above statements are true.

116. When is the equation $TdS = pdV + dU$ valid?

- (A) only in constant temperature processes
 (B) only in constant pressure processes
 (C) only in reversible processes
 (D) always

117. Which of the following statements is true for a perfect gas flowing through an insulated valve?

- (A) Enthalpy is essentially unchanged.
 (B) Entropy decreases.
 (C) Temperature increases greatly.
 (D) Flow is isentropic.

118. If an initial volume of an ideal gas is compressed to one-half its original volume and to twice its original temperature, the pressure

- (A) remains constant
- (B) doubles
- (C) quadruples
- (D) halves

119. If an initial volume of saturated steam is expanded isothermally to twice the initial volume, the pressure

- (A) decreases
- (B) increases
- (C) halves
- (D) doubles

120. Which of the following is true of an adiabatic process?

- (A) It allows heat transfer into the system but not out of the system.
- (B) It may be reversible.
- (C) It is one in which enthalpy remains unchanged.
- (D) It is one in which the equation $W = Q$ is valid.