

# Fundamentals of Engineering Sample Examination

## Morning Section

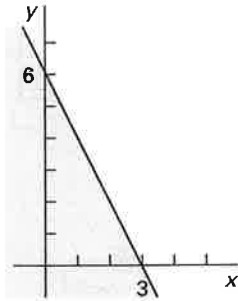
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1. What is the slope of the line tangent to the parabola  $y = 12x^2 + 3$  at a point where  $x = 5$ ?

- (A) 24
- (B) 120
- (C) 303
- (D) 515

2. Which of the following equations correctly describes the shaded area of the  $x$ - $y$  plane?



- (A)  $2x - y \leq 6$
- (B)  $2x + y \leq 6$
- (C)  $2x - y \geq 6$
- (D)  $x + 2y \geq 6$

3. What is the  $(x, y)$  solution for the following system of two simultaneous equations?

$$3x - 6y = 7$$

$$2x - 11y = -5$$

- (A)  $\left(\frac{107}{21}, \frac{29}{21}\right)$
- (B)  $\left(-\frac{17}{45}, \frac{1}{45}\right)$
- (C)  $\left(-\frac{107}{21}, \frac{29}{21}\right)$
- (D)  $\left(\frac{107}{45}, -\frac{106}{45}\right)$

4. What is the simplified equivalent expression of

$$(\cot^2 \theta)(\sin^2 \theta) + \frac{1}{\csc^2 \theta}$$

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

5. What is the derivative with respect to  $x$  of  $\sqrt{2x + 9x^2}$ ?

- (A)  $\frac{1 + 9x}{\sqrt{2x + 9x^2}}$
- (B)  $9x + 1$
- (C)  $\sqrt{2 + 18x}$
- (D)  $(9x + 1)\sqrt{2x + 9x^2}$

6. What is the limit?

$$\lim_{x \rightarrow \infty} \left( \frac{10x^2 - 5x + 1}{(5x - 3)(2x)} \right)$$

- (A)  $-1/3$
- (B) 0
- (C)  $5/6$
- (D) 1

7. What is the integral  $\int x(x + 1)dx$ ?

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

8. How many significant digits are there in the number 023059.11005?

- (A) 5
- (B) 9
- (C) 10
- (D) 11

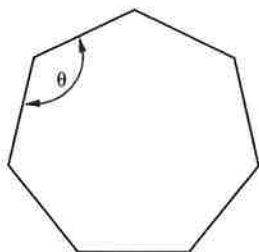
9. The horizontal angle from the ground to the top of a palm tree some unknown distance away is  $46.18^\circ$ . At a point 40 m directly behind the first point, the horizontal angle to the top of the tree is  $29.23^\circ$ . What is most nearly the distance from the palm tree to the first point?

- (A) 42 m
- (B) 46 m
- (C) 51 m
- (D) 61 m

10. What is most nearly the acute angle between vectors  $\mathbf{V}_1 = (3, 2, 1)$  and  $\mathbf{V}_2 = (2, 3, 2)$  based at the origin?

- (A)  $25^\circ$   
 (B)  $33^\circ$   
 (C)  $35^\circ$   
 (D)  $59^\circ$

11. What is most nearly the interior angle,  $\theta$ , of a regular polygon with seven sides?



- (A)  $51^\circ$   
 (B)  $64^\circ$   
 (C)  $116^\circ$   
 (D)  $129^\circ$

12. Which of the following statements is true concerning the Taylor series expansion for  $\cos x$ ?

- (A) The series contains only odd powers of  $x$ .  
 (B) The series contains only even powers of  $x$ .  
 (C) The series contains only negative odd powers of  $x$ .  
 (D) The series contains only every other odd power of  $x$ .

13.  $A$  and  $B$  are subsets of  $Q$ .

$$\begin{aligned} A &= \{4, 7, 9\} \\ B &= \{4, 5, 9, 10\} \\ Q &= \{4, 5, 6, 7, 8, 9, 10\} \end{aligned}$$

What is  $\overline{A} \cup B$ ?

- (A)  $\{4, 5, 6, 7, 8, 9, 10\}$   
 (B)  $\{4, 5, 7, 9, 10\}$   
 (C)  $\{4, 5, 6, 8, 9, 10\}$   
 (D)  $\{5, 10\}$

14. What is the total area inside the cardioid,  $r$ ?

$$r = a(1 + \cos \theta)$$

- (A)  $\frac{3\pi a^2}{2}$   
 (B)  $\frac{2\pi a^2}{3}$   
 (C)  $\frac{3\pi a^2}{4}$   
 (D)  $\frac{4\pi a^2}{3}$

15. What are the values of  $B_1$  and  $B_2$ ?

$$\begin{bmatrix} 9 & 7 \\ 1 & 3 \end{bmatrix} \begin{bmatrix} B_1 \\ B_2 \end{bmatrix} = \begin{bmatrix} 2 \\ 1 \end{bmatrix}$$

- (A)  $B_1 = -\frac{1}{20}$ ;  $B_2 = \frac{7}{20}$   
 (B)  $B_1 = \frac{7}{20}$ ;  $B_2 = -\frac{1}{20}$   
 (C)  $B_1 = -\frac{1}{20}$ ;  $B_2 = -\frac{7}{20}$   
 (D)  $B_1 = 10$ ;  $B_2 = 20$

Problems 16 and 17 are based on the following equation.

$$xy' + 3x - 1 = 0$$

16. What type of differential equation is this?

- (A) homogeneous  
 (B) second-order linear  
 (C) non-linear  
 (D) first-order separable

17. The solution for this equation is

- (A)  $y = \ln(1 - 3x) + C$   
 (B)  $y = \frac{1}{x} - 3 + C$   
 (C)  $y = \ln x - 3x + C$   
 (D)  $y = \ln x - \frac{3x^2}{2} + C$

18. Consider three vectors,  $\overline{A}$ ,  $\overline{B}$ , and  $\overline{C}$ , with the following two properties.

$$\begin{aligned} \overline{A} \cdot (\overline{B} \times \overline{C}) &= 0 \\ \overline{B} &\perp \overline{C} \end{aligned}$$

Which of the following must be true?

- (A)  $\overline{A} \parallel \overline{B}$
- (B)  $\overline{A}$ ,  $\overline{B}$ , and  $\overline{C}$  are coplanar
- (C)  $\overline{A} \parallel \overline{C}$
- (D)  $\overline{A} \perp$  to  $\overline{B}$  or  $\overline{C}$

19. Seven measurements are taken: 4.31, 4.39, 4.38, 4.33, 4.36, 4.32, and 4.37. What is most nearly the sample standard deviation?

- (A) 0.0155
- (B) 0.0167
- (C) 0.0291
- (D) 0.0313

20. Six design engineers are eligible for promotion to pay grade G8, but only four spots are available. How many different combinations of promoted engineers are possible?

- (A) 4
- (B) 6
- (C) 15
- (D) 20

21. A coin is tossed three times. What is the approximate probability of heads appearing at least one time?

- (A) 0.67
- (B) 0.75
- (C) 0.80
- (D) 0.88

22. Six board members of an engineering firm meet in the conference room. The conference table is round and has six identical seats. How many unique seating combinations exist? (Do not count rotations. Shifting each person one seat to the left would not result in a new combination.)

- (A) 24
- (B) 120
- (C) 240
- (D) 720

23. A deck of ten children's cards contains three fish cards, two dog cards, and five cat cards. What is the probability of drawing either a cat card or a dog card from a full deck?

- (A) 1 in 10
- (B) 2 in 10
- (C) 5 in 10
- (D) 7 in 10

24. What is approximately the sample standard deviation of the data set {17, 18, 24, and 33}?

- (A) 5.8
- (B) 6.5
- (C) 7.3
- (D) 8.0

25. On average, a furniture store sells four card tables in a week. Assuming a Poisson distribution for the weekly sales, the probability that the store will sell exactly seven card tables in a given week is most nearly

- (A) 0.060
- (B) 0.075
- (C) 0.11
- (D) 0.15

26. The least squares method is used to plot a straight line through the data points (2,10), (4,9), (6,6), and (7,4). The slope of the line is most nearly

- (A) 1.1
- (B) 1.2
- (C) 1.5
- (D) 1.7

Problems 27–31 are based on the following formulas.

- I.  $C_2H_2$
- II.  $(CH_3)_2O$
- III.  $C_2H_5Br$
- IV.  $C_2H_5COOH$
- V.  $C_2H_4$

27. Which formula(s) describe a carboxylic acid?

- (A) III and IV
- (B) IV only
- (C) II and IV
- (D) III only

28. Which formula(s) describe an alkane?

- (A) III only
- (B) V only
- (C) I and V
- (D) none of the above

29. Which formula(s) describe an alkene?

- (A) I only
- (B) V only
- (C) I and V
- (D) III only

30. Which formula(s) describe an ether?

- (A) IV only
- (B) II only
- (C) II and IV
- (D) III only

31. Which formula(s) describe an alkyl halide?

- (A) II only
- (B) III only
- (C) II and III
- (D) I only

32. A hydrate is a

- (A) buffer solution of water
- (B) compound in which hydrogen is combined with an element less electronegative than itself
- (C) compound containing a definite number of water molecules in its chemical composition
- (D) salt containing the hydroxyl radical

33. Two moles of hydrogen react with 1 mole of oxygen to produce which of the following?

- (A) 1 mole of water
- (B) 2 moles of water
- (C) 3 moles of water
- (D) 2 moles of water with 1 mole of hydrogen left over

34. Ten kilograms of hydrogen gas ( $H_2$ ) are mixed with 355 kg of chlorine ( $Cl_2$ ) in a  $0.50\text{ m}^3$  drum. The two gases react to produce hydrogen chloride. What is the final pressure in the drum if the final temperature is  $60^\circ\text{C}$ ?

- (A) 0.055 MPa
- (B) 2.0 MPa
- (C) 10 MPa
- (D) 55 MPa

Problems 35 and 36 are based on the following statement.

Ten kilograms of oxygen and 2 kg of hydrogen are mixed in a  $1\text{ m}^3$  vessel. The mixture is at  $300\text{K}$ , and initially no reaction takes place.

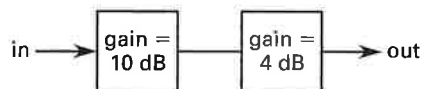
35. What is most nearly the partial pressure of the hydrogen?

- (A) 2.5 MPa
- (B) 3.4 MPa
- (C) 5.0 MPa
- (D) 12 MPa

36. A spark causes the hydrogen and oxygen to react to form water. Assuming complete combustion, approximately how much water is produced?

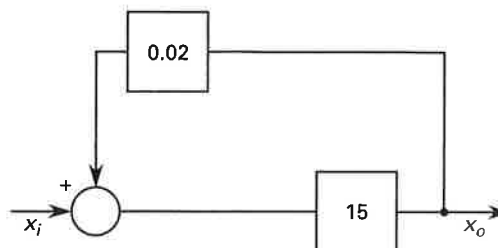
- (A) 5.6 kg
- (B) 11 kg
- (C) 12 kg
- (D) 18 kg

37. What is most nearly the overall gain of the cascaded system?



- (A) 1.6 dB
- (B) 12 dB
- (C) 14 dB
- (D) 40 dB

38. What is most nearly the overall gain,  $x_o/x_i$ , of the following positive feedback system?



- (A) 12
- (B) 15
- (C) 18
- (D) 21

39. Which of the following systems is controllable?

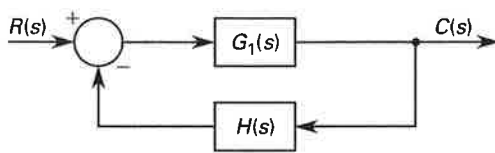
- (A)  $\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 1 & 4 \\ 2 & 8 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u(t)$
- (B)  $\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 1 & -5 \\ -2 & 10 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 10 \\ 2 \end{bmatrix} u(t)$
- (C)  $\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 1 & 3 \\ -2 & 6 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 10 \\ 10 \end{bmatrix} u(t)$
- (D)  $\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 0 & 3 \\ 0 & 4 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 4 \end{bmatrix} u(t)$

Problems 40–42 are based on the following statement and illustration.

The system whose block diagram is shown is governed by the following differential equation.

$$\dot{C}(t) = 10r(t) - 16C(t)$$

$$C(0) = 0$$



40. What is the transfer function,  $G(s) = C(s)/R(s)$ , for the system?

- (A)  $\frac{16}{s - 10}$
- (B)  $\frac{10}{s + 16}$
- (C)  $10s + 16$
- (D)  $\frac{s + 16}{10}$

41. Which of the following is an expression for  $H(s)$ ?

- (A)  $s + 15$
- (B)  $\frac{s}{10} + \frac{3}{2}$
- (C)  $8/5$
- (D)  $8s$

42. What value does  $C(t)$  approach as  $t$  approaches infinity if  $r(t)$  is given by  $2u(t)$ ? ( $u(t)$  is the unit step function.)

- (A)  $-5/4$
- (B)  $0$
- (C)  $8/5$
- (D)  $5/4$

43. A system has a transfer function of

$$H(s) = \frac{s - B}{s^2 + 6s + A}$$

What value of  $A$  will create an unstable system?

- (A)  $-3$
- (B)  $0$
- (C)  $3$
- (D)  $9$

44. A system has a transfer function of

$$H(s) = \frac{s - B}{s^2 + 6s + A}$$

What frequency,  $j\omega$ , corresponds to a zero on the pole-zero diagram?

- (A)  $-A$
- (B)  $-B$
- (C)  $B$
- (D)  $\sqrt{9 - A} - 3$

45. A system has a transfer function of

$$H(s) = \frac{s}{s^2 + 6s}$$

How many poles does the system have?

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

46. In the case of an ethical conflict, which entity takes precedence?

- (A) society
- (B) the client
- (C) the employer
- (D) society and the client are equal and take precedence

47. Who owns the rights to inventions that arise during work for a client if no prior specifications regarding inventions is made?

- (A) the inventor
- (B) the inventor's company
- (C) the client
- (D) the state

48. Which of the following is an ethics violation specifically included in the NCEES sample code of ethics?

- (A) an engineering professor "moonlighting" as a private contractor
- (B) an engineer investing money in the stock of the company for which he/she works
- (C) a civil engineer with little electrical experience signing the plans for an electric generator
- (D) none of the above

49. When may registrants coordinate entire projects?

- (A) if each segment is signed and sealed by registrants responsible for the specific segments
- (B) at no time
- (C) with a special certification
- (D) if all aspects of the project lie within the registrant's area of expertise

50. Which of the following is not an ethics violation?

- (A) designing a product to fail in a specified number of years
- (B) charging a premium for a superior product
- (C) using proceeds from one product in order to sell another product below fair market price
- (D) all of the above

51. When is it ethical to issue statements on technical issues inspired by interested parties?

- (A) at no time
- (B) if no compensation is received
- (C) if there is no personal interest in the issue
- (D) if the interested parties and their interests are explicitly revealed

52. To whom does a professional have ethical responsibilities?

- (A) the employer
- (B) consumers
- (C) competitors
- (D) all of the above

53. Criticism of another professional's work is

- (A) never ethical
- (B) ethical only if it directly relates to public safety and welfare
- (C) ethical if truthful
- (D) none of the above

54. Which entity passes engineering registration laws establishing the minimum criteria required to protect the public?

- (A) state legislature
- (B) professional societies
- (C) national board of registration
- (D) international registering councils

55. The cost of producing an item is represented by the following equation.

$$C_1 = \$25,000 + 0.03P$$

$P$  represents the number of items produced. If the items are sold for \$1.50 each, approximately how many must be sold to break even?

- (A) 1100
- (B) 16,700
- (C) 17,000
- (D) 17,500

56. A factory is running at 80% efficiency with a fixed cost of \$3000, a variable cost per unit of \$5, a selling price per unit of \$16, and a production capacity of 5000 units. What is the approximate current profit of the factory if all products manufactured are sold?

- (A) \$41,000
- (B) \$44,000
- (C) \$52,000
- (D) \$55,000

57. A proposal is made to buy a machine for \$150,000. The expected service life is 15 yr with zero salvage value. What is most nearly the capitalized cost if the machine is kept in service indefinitely? The interest rate is 8%.

- (A) \$150,000
- (B) \$175,000
- (C) \$219,000
- (D) \$225,000

58. Approximately how much money should be deposited now in a savings account to yield \$1000 in 6 yr? The annual interest rate is 10%, compounded semiannually.

- (A) \$459
- (B) \$557
- (C) \$565
- (D) \$679

59. A sum of money is deposited now in a savings account. The effective annual interest rate is 12%, and interest is compounded monthly. Approximately how much money must be deposited to yield \$500 at the end of 11 mo?

- (A) \$153
- (B) \$446
- (C) \$451
- (D) \$500

60. A loan of \$5000 is made for 5 yr at a simple interest rate of 8% per yr. How much total interest is paid?

- (A) \$400
- (B) \$2000
- (C) \$5000
- (D) \$7000

61. You decide to save a uniform amount at the end of each month for 12 months so you will have the \$1000 at the end of 1 yr. The bank where you have a savings account pays 6% interest per annum compounded monthly. How much money do you need to deposit each month?

- (A) \$70
- (B) \$78
- (C) \$81
- (D) \$83

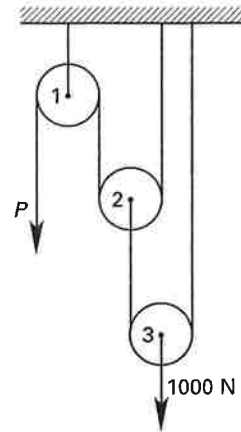
62. \$9000 is to be invested now at 7% effective annual interest. A withdrawal is to be made at the end of each year for 10 yr. The 10 annual withdrawals will be equal, and the tenth will exhaust the fund. The amount of each withdrawal is most nearly

- (A) \$1000
- (B) \$1100
- (C) \$1200
- (D) \$1300

63. A sum of \$60,000 will be needed for building improvements in 5 yr. To generate this amount, a sinking fund is established into which three equal payments will be made, one at the end of each of the first 3 yr. After the third year, no further payments will be made. If an effective annual interest rate of 8% can be expected, the amount that must be paid into the fund each year is most nearly

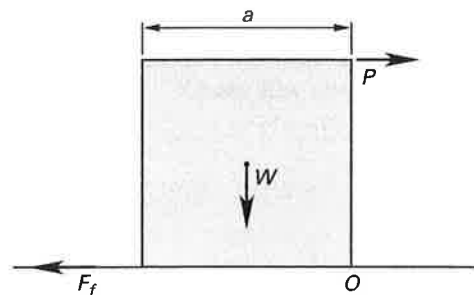
- (A) \$16,000
- (B) \$17,000
- (C) \$19,000
- (D) \$22,000

64. For the system of pulleys shown, most nearly what force,  $P$ , is required to lift the 1000 N load? Assume the pulleys are frictionless and weightless.



- (A) 125 N
- (B) 250 N
- (C) 330 N
- (D) 500 N

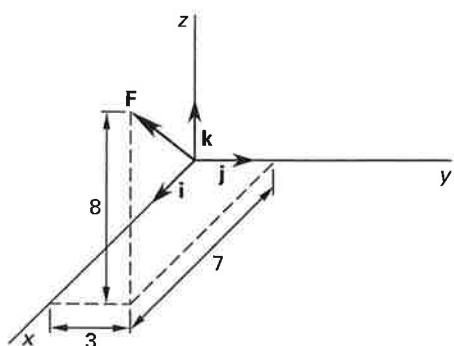
65. A cube of weight  $W$  and side length  $a$  is at rest on a flat surface with a friction coefficient of  $\mu$ . A cord attached to its top edge is pulled in a horizontal direction. The value of  $\mu$  for which it is impossible to predict whether the cube will tip or slide is most nearly



- (A)  $\mu = \frac{P}{W}$
- (B)  $\mu = \frac{W}{P}$
- (C)  $\mu = 0.25$
- (D)  $\mu = 0.5$

66. A 500 N force,  $\mathbf{F}$ , is directed as shown. What is most nearly the component vector representation of the force?





- (A)  $(0.014 \text{ N})\mathbf{i} + (0.006 \text{ N})\mathbf{j} + (0.016 \text{ N})\mathbf{k}$   
 (B)  $(317 \text{ N})\mathbf{i} + (136 \text{ N})\mathbf{j} + (362 \text{ N})\mathbf{k}$   
 (C)  $(194 \text{ N})\mathbf{i} + (83 \text{ N})\mathbf{j} + (222 \text{ N})\mathbf{k}$   
 (D)  $(7 \text{ N})\mathbf{i} + (3 \text{ N})\mathbf{j} + (8 \text{ N})\mathbf{k}$

67. The change in the linear momentum of a particle is equivalent to which of the following?

- (A) the change in the particle's kinetic energy  
 (B) the work performed on the particle  
 (C) the impulse applied to the particle  
 (D) the particle's mass times the distance the particle traveled

Problems 68 and 69 are based on the following statement.

A projectile is launched from a level plane at  $30^\circ$  from horizontal with an initial velocity of 1250 m/s.

68. What is most nearly the maximum height above the plane the projectile will reach?

- (A) 20 km  
 (B) 40 km  
 (C) 60 km  
 (D) 80 km

69. What is most nearly the maximum range of the projectile?

- (A) 40 km  
 (B) 70 km  
 (C) 140 km  
 (D) 160 km

Problems 70 and 71 are based on the following statement.

A 60 kg ball is dropped from a height of 48 m above a table.

70. What is most nearly the velocity of the ball just before impact?

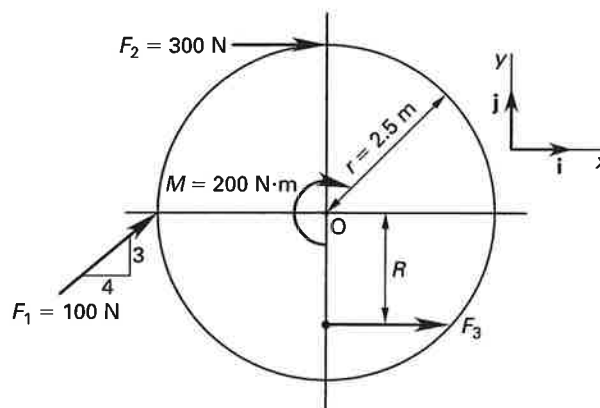
- (A) 11 m/s  
 (B) 15 m/s  
 (C) 22 m/s  
 (D) 31 m/s

71. If the coefficient of restitution between the ground and the ball is 0.9, what is most nearly the kinetic energy of the ball immediately after impact?

- (A) 12 kJ  
 (B) 16 kJ  
 (C) 23 kJ  
 (D) 34 kJ

Problems 72 and 73 are based on the following statement and illustration.

A wheel with a radius of 2.5 m is pinned at point O, has two forces applied at its rim, and has a third force applied at a distance  $R$  from the center. Additionally, a moment,  $M$ , of 200 N·m is applied at the center of the wheel.



72. For equilibrium conditions, what is most nearly the distance  $R$  if  $F_3 = 500 \text{ N}$ ?

- (A) 1.4 m  
 (B) 1.6 m  
 (C) 1.8 m  
 (D) 2.2 m

73. The 200 N·m moment is removed and distance  $R$  is 1.0 m. In order for the system to be in equilibrium,  $F_3$  is most nearly

- (A) -500 N  
 (B) -380 N  
 (C) 600 N  
 (D) 900 N

Problems 74 and 75 are based on the following statement.

At  $t = 0$ , a car traveling south is 10 km directly north of an eastbound bus. The car is traveling at 55 kph, and the bus is traveling at 25 kph. Visibility in all directions is 6 km.

74. Which equation gives the distance,  $d$ , in kilometers, between the car and the bus as a function of time,  $t$ , in hours?

- (A)  $d = 10 - 30t$
- (B)  $d = \sqrt{(10 + 55t)^2 + (25t)^2}$
- (C)  $d = \sqrt{100 - (60.4t)^2}$
- (D)  $d = \sqrt{3650t^2 - 1100t + 100}$

75. What is most nearly the velocity of the bus relative to the car at  $t = 0$ ?

- (A) 25 kph
- (B) 49 kph
- (C) 55 kph
- (D) 60 kph

76. A rectangular beam 4 cm wide and 6 cm high is subjected to a shear of 7000 N at a particular location. The beam is constructed of 2014-T3 aluminum. What is most nearly the maximum shear stress at that location?

- (A) 290 N/cm<sup>2</sup>
- (B) 440 N/cm<sup>2</sup>
- (C) 520 N/cm<sup>2</sup>
- (D) 660 N/cm<sup>2</sup>

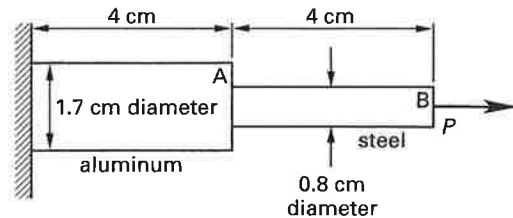
77. A 1020 carbon steel rod is  $\frac{1}{4}$  cm in diameter and 6 cm long. The shear modulus is  $11.5 \times 10^6$  N/cm<sup>2</sup>. Most nearly what torque must be applied to twist the rod 8°?

- (A) 100 N·cm
- (B) 120 N·cm
- (C) 270 N·cm
- (D) 420 N·cm

78. Two cantilever beams of equal length have dimensions of the beams are 0.5 cm  $\times$  0.5 cm and 0.25 cm  $\times$  0.25 cm, respectively. (Assume all other factors are equal.) The ratio of the end deflections,  $y_{0.5}/y_{0.25}$ , is most nearly

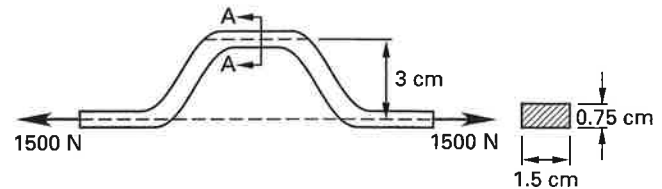
- (A) 0.0625
- (B) 0.125
- (C) 0.500
- (D) 1.25

79. Two rods are securely bonded at a common end and fixed to a wall. Rod A is made of aluminum ( $E = 6.9 \times 10^6$  N/cm<sup>2</sup>) and has a diameter of 1.7 cm. Rod B is made of steel ( $E = 20.7 \times 10^6$  N/cm<sup>2</sup>) and has a diameter of 0.8 cm. Both rods are initially 4 cm long. When a force,  $P$ , of magnitude 40 000 N is applied axially at the end of rod B, what is most nearly the total elongation experienced by the rods?



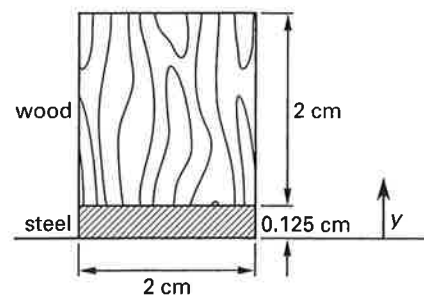
- (A) 0.0063 cm
- (B) 0.014 cm
- (C) 0.026 cm
- (D) 0.050 cm

80. A 1.5 cm  $\times$  0.75 cm steel bar is bent into the configuration shown. An axial load of 1500 N is applied to the ends. What is most nearly the maximum tensile stress of an element at section A-A?



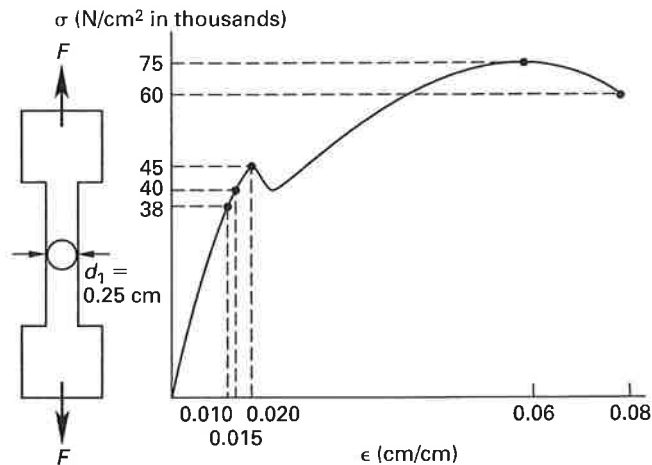
- (A) 1.33 kN/cm<sup>2</sup>
- (B) 9.33 kN/cm<sup>2</sup>
- (C) 32.0 kN/cm<sup>2</sup>
- (D) 33.3 kN/cm<sup>2</sup>

81. A steel plate ( $E_s = 20 \times 10^6$  N/cm<sup>2</sup>) is securely bonded to a wooden beam ( $E_w = 1 \times 10^6$  N/cm<sup>2</sup>). Most nearly where is the neutral axis with respect to the bottom of the composite beam base?



- (A) 0.48 cm
- (B) 0.54 cm
- (C) 0.78 cm
- (D) 0.96 cm

82. A cylindrical metal specimen with properties described by the following graph has a Poisson ratio of 0.3. What is the approximate change in diameter of the specimen if it is loaded axially to the elastic limit?

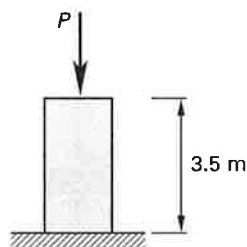


- (A) 11  $\mu\text{m}$
- (B) 15  $\mu\text{m}$
- (C) 45  $\mu\text{m}$
- (D) 60  $\mu\text{m}$

83. For a transversely loaded beam, the second derivative of the transverse deflection with respect to the axial distance along the beam is proportional to which of the following?

- (A) shear
- (B) moment
- (C) load per unit length
- (D) normal stress

84. What is the largest allowable axial load,  $P$ , that the fixed end column shown can bear without buckling, assuming a factor of safety for buckling of 3.0? The modulus of elasticity is  $E = 200 \times 10^9$  Pa, and the centroidal moment of inertia is  $I = 1.0 \times 10^{-4}$  m<sup>4</sup>



- (A) 1100 kN
- (B) 1209 kN
- (C) 1343 kN
- (D) 1390 kN

85. Which of the following is a synonym for electrovalent bonding?

- (A) ionic bonding
- (B) covalent bonding
- (C) double bonding
- (D) critical bonding

86. Which of the following factors will affect the hardenability of steel?

- I. composition
- II. grain size
- III. lattice structure
- IV. cooling rate

- (A) I only
- (B) I and II
- (C) II and III
- (D) I, II, III, and IV

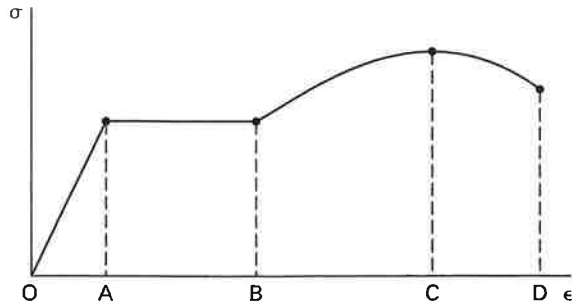
87. The yield strength of common yellow brass (70% Cu, 30% Zn) can be increased by which of the following?

- (A) heat treatment
- (B) annealing
- (C) chill casting
- (D) cold working

88. The elastic modulus, yield strength, ultimate tensile strength, and ductility of a metal can all be determined from

- (A) an endurance test
- (B) an impact test
- (C) a quenching test
- (D) a standard tensile test

89. Consider the stress-strain diagram for a carbon steel in tension. Determine the region where strain hardening occurs.



- (A) O to A
- (B) A to B
- (C) B to C
- (D) C to D

90. For alloys of two or more elements, Gibb's phase rule relates the number of degrees of freedom,  $F$ , to the number of phases,  $P$ , and the number of elements,  $C$ , in an equilibrium mixture. The rule is generally expressed as

- (A)  $P + C = F + 2$
- (B)  $P + C = 2F$
- (C)  $P + F = C + 2$
- (D)  $P = F + C + 2$

91. A 3 m long aluminum bar with a modulus of elasticity of 70 GPa is subjected to a tensile stress of 120 MPa. The elongation is most nearly

- (A) 3.5 mm
- (B) 5.1 mm
- (C) 7.5 mm
- (D) 9.0 mm

92. Which of the following may be the Poisson ratio of a material?

- (A)  $-0.37$
- (B)  $0.25$
- (C)  $0.55$
- (D)  $1.5$

93. When a liquid flows under pressure through a pipe, the head loss due to surface friction with the pipe is  $h_L = f(L/D)(v^2/2g)$ . Which of the following statements is false?

- (A) The equation is valid for laminar as well as turbulent flow.
- (B) The variable  $D$  is the depth of flow in the pipe.
- (C) The friction factor,  $f$ , is a function of a Reynolds number.
- (D) The head loss,  $h_L$ , is expressed in units of distance.

94. What is most nearly the height of a column of carbon tetrachloride (specific gravity 1.56) that supports a pressure of 1 kPa?

- (A) 0.0065 cm
- (B) 6.5 cm
- (C) 10 cm
- (D) 64 cm

95. The velocity at a point on a model of a spillway for a dam is 5 m/s. If the length-to-scale ratio is 15:1, what is most nearly the velocity at the corresponding point on the actual dam? (Assume similar conditions.)

- (A) 6.7 m/s
- (B) 7.5 m/s
- (C) 15 m/s
- (D) 19 m/s

96. The transition between laminar and turbulent flow usually occurs at a Reynolds number of approximately

- (A) 900
- (B) 1200
- (C) 1500
- (D) 2100

97. A floating object is stable when the center of

- (A) gravity is above the center of buoyancy
- (B) buoyancy is above the center of gravity
- (C) buoyancy is at the center of gravity
- (D) gravity is above the metacenter

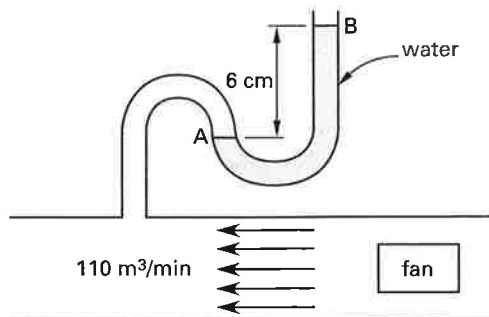
98. The theoretical fluid velocity through a nozzle generated by a 10 m hydraulic head is most nearly

- (A) 4.5 m/s
- (B) 9.9 m/s
- (C) 14 m/s
- (D) 200 m/s

99. Where does the vena contracta caused by a sharp-edged hydraulic orifice usually occur?

- (A) at the centerline of the orifice
- (B) at a distance of about 10% of the orifice diameter upstream from the plane of the orifice
- (C) at a distance within 10% of the orifice diameter downstream from the plane of the orifice
- (D) at a distance equal to about one-half the orifice diameter downstream from the plane of the orifice

100. A blower-type fan delivers air at the rate of  $110 \text{ m}^3/\text{min}$  against a static gage pressure of 6 cm of water. Most nearly what net power is being delivered by the fan if the air has a density of  $1.2 \text{ kg}/\text{m}^3$ ? (Neglect velocity pressure.)

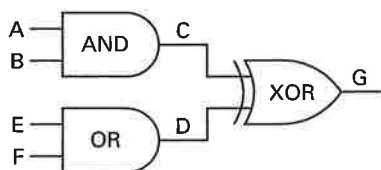


- (A) 0.0016 W
- (B) 110 W
- (C) 1.1 kW
- (D) 110 kW

101. The hydraulic radius of a 5 m deep triangular channel with a 1:1 side slope is most nearly

- (A) 1.0 m
- (B) 1.8 m
- (C) 2.0 m
- (D) 2.8 m

102. For  $A = 1$ ,  $B = 0$ ,  $E = 1$ , and  $F = 0$ , choose the following correct outputs.



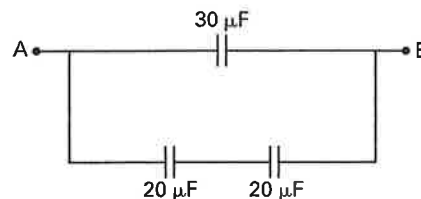
- (A)  $C = 1$ ,  $D = 1$ , and  $G = 0$
- (B)  $C = 1$ ,  $D = 0$ , and  $G = 1$
- (C)  $C = 0$ ,  $D = 1$ , and  $G = 1$
- (D)  $C = 0$ ,  $D = 1$ , and  $G = 0$

103. What is most nearly the current in the  $6 \Omega$  resistor?



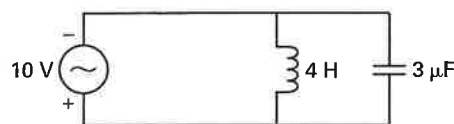
- (A) 1.5 A
- (B) 2 A
- (C) 4 A
- (D) 4.5 A

104. What is most nearly the equivalent capacitance between terminals A and B for the following circuit?



- (A)  $7.5 \mu\text{F}$
- (B)  $32 \mu\text{F}$
- (C)  $40 \mu\text{F}$
- (D)  $70 \mu\text{F}$

105. What is most nearly the resonant frequency of the circuit?

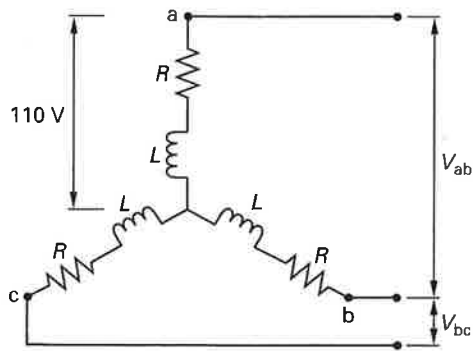


- (A) 1.9 Hz
- (B) 4.6 Hz
- (C) 46 Hz
- (D) 75 Hz

106. The power factor of a single-phase alternating-current circuit is defined as which of the following?

- (A) the ratio of apparent power (kVA) to real power (kW)
- (B) the ratio of real power (kW) to apparent power (kVA)
- (C) the ratio of real power to imaginary power
- (D) the ratio of reactive power to real power

107. What is most nearly the line-to-line voltage,  $V_{ab}$ , of the balanced wye connection?



- (A) 37 V
- (B) 110 V
- (C) 190 V
- (D) 220 V

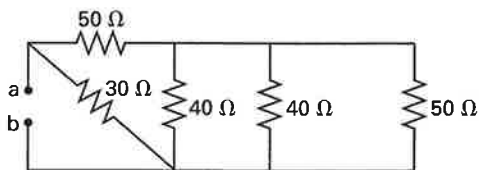
108. What is most nearly the work required to move a charge of 10 C for a distance of 5 m in the same direction as a field of 50 V/m?

- (A) 20 J
- (B) 100 J
- (C) 2.5 kJ
- (D) 13 kJ

109. If a passive parallel  $RLC$  circuit is underdamped, the circuit's condition be changed to overdamped by

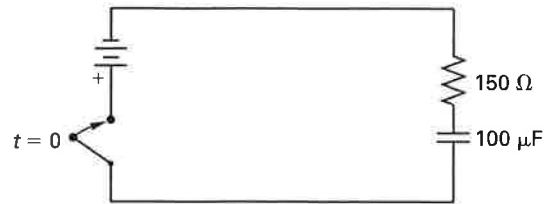
- (A) decreasing inductance ( $L$ )
- (B) decreasing the capacitance ( $C$ ) and inductance ( $L$ )
- (C) increasing the resistance ( $R$ )
- (D) decreasing the resistance ( $R$ )

110. For the circuit shown, what is the equivalent resistance between points a and b?



- (A) 7  $\Omega$
- (B) 20  $\Omega$
- (C) 29  $\Omega$
- (D) 50  $\Omega$

111. Most nearly, how long would it take to charge the capacitor shown to 80% of the battery voltage in the circuit below, if the capacitor initially has no charge?



- (A) 10 ms
- (B) 15 ms
- (C) 20 ms
- (D) 24 ms

112. A unit mass of steam is expanded in a cylinder in such a manner that no energy is added or lost as heat. What is this process called?

- (A) a constant enthalpy process
- (B) an isothermal process
- (C) an adiabatic process
- (D) a constant volume process

113. Which of the following statements is true for a vapor dome drawn on a  $T$ - $s$  (temperature-entropy) diagram?

- (A) The bell-shaped curve indicates the saturation points for a constant temperature.
- (B) The region under the bell-shaped curve indicates superheating.
- (C) The bell-shaped curve indicates the saturation points for various pressures.
- (D) The left side of the bell-shaped curve indicates saturated vapor.

114. One kg of air is stirred at a constant pressure of 1 atm so that the temperature increases from 500K to 600K. The stirring work is most nearly

- (A) 3.4 kJ
- (B) 28 kJ
- (C) 41 kJ
- (D) 100 kJ

115. Use the information provided to determine the specific volume of ammonia at 278K and 10% quality.

$$v_{\text{saturated 278K liquid}} = 0.00158 \text{ m}^3/\text{kg}$$

$$v_{\text{saturated 278K vapor}} = 0.2479 \text{ m}^3/\text{kg}$$

- (A) 0.0016  $\text{m}^3/\text{kg}$
- (B) 0.026  $\text{m}^3/\text{kg}$
- (C) 0.028  $\text{m}^3/\text{kg}$
- (D) 0.25  $\text{m}^3/\text{kg}$

116. What is the approximate total heat transfer necessary to evaporate and superheat 1 kg of saturated liquid water in a boiler? The water is initially at 1 atm and remains so throughout the evaporation process. The final temperature of the vapor is 600°C.

- (A) 3.3 MJ
- (B) 6.2 MJ
- (C) 7.2 MJ
- (D) 8.1 MJ

117. Which group contains processes that are always part of any physically realizable vapor power cycle?

- (A) isentropic compression and isentropic expansion
- (B) isentropic compression
- (C) adiabatic heat addition and adiabatic heat extraction
- (D) isobaric vaporization and isobaric condensation

118. 210 m<sup>3</sup> of water passes through a heat exchanger and absorbs 26 400 MJ of heat energy. The exit temperature is 48°C. The water density is 1000 kg/m<sup>3</sup>. Calculate the entrance temperature.

- (A) 12°C
- (B) 18°C
- (C) 30°C
- (D) 48°C

119. Which of the following is an extensive property?

- (A) pressure
- (B) specific enthalpy
- (C) temperature
- (D) internal energy

120. Which of the following statements is true?

- (A) Equal volumes of different gases have equal weights.
- (B) High-density gases diffuse faster than low-density gases.
- (C) Equal volumes of different gases at the same temperature and pressure have an equal number of molecules.
- (D) Equal volumes of different gases at the same temperature and pressure have equal densities.