

# PRACTICE EXAM 14 : FE CIVIL SIMULATION (110 QUESTIONS)

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**110 questions. Recommended time: 5 hours 20 minutes.**

1. Water flows in a 0.3 m diameter pipe at 1.5 m/s. What is the volumetric flow rate?

- A. 0.045 m<sup>3</sup>/s
- B. 0.212 m<sup>3</sup>/s
- C. 0.071 m<sup>3</sup>/s
- D. 0.106 m<sup>3</sup>/s

2. How much must be deposited now to accumulate \$20,000 in 10 years at 7% compounded annually?

- A. \$14,000
- B. \$10,167
- C. \$8,000
- D. \$18,700

3. A force of 80 N acts at 25° above the horizontal. What is its horizontal component?

- A. 33.8 N
- B. 80 N
- C. 45 N
- D. 72.5 N

4. A sand has  $e_{\max} = 0.8$ ,  $e_{\min} = 0.4$ , and an in-situ void ratio of 0.6. What is its relative density?

- A. 25%
- B. 75%
- C. 50%
- D. 60%

5. A traffic signal has a 60 s cycle with 4 phases, each carrying 3 s of lost time. What is the total lost time per cycle?

- A. 12 s
- B. 4 s
- C. 8 s
- D. 3 s

6. A cantilever beam 3 m long carries a uniformly distributed load of 6 kN/m. What is the maximum bending moment?

- A. 9 kN·m
- B. 18 kN·m
- C. 54 kN·m
- D. 27 kN·m

7. What is the determinant of the matrix  $\begin{bmatrix} 3 & 2 \\ 1 & 4 \end{bmatrix}$ ?

- A. 14
- B. 12
- C. 10
- D. 5

8. The yield strength of common A36 structural steel is approximately:

- A. 36 MPa
- B. 250 MPa
- C. 400 MPa
- D. 500 MPa

9. A rectangular channel is 4 m wide and flows at a depth of 2 m. What is the wetted perimeter?

- A. 4 m
- B. 6 m
- C. 8 m
- D. 12 m

10. A car traveling at 25 m/s decelerates uniformly to rest in 5 s. What is the deceleration?

- A. 125 m/s<sup>2</sup>
- B. 0.2 m/s<sup>2</sup>
- C. 2.5 m/s<sup>2</sup>
- D. 5 m/s<sup>2</sup>

11. The standard biochemical oxygen demand (BOD) test is conducted over a period of:

- A. 5 days at 20°C
- B. 30 minutes
- C. 24 hours
- D. 28 days

12. A foresight reading of 1.85 m is taken from an instrument with a height of instrument of 102.45 m. What is the elevation of the foresight point?

- A. 104.30 m
- B. 100.60 m
- C. 1.85 m
- D. 102.45 m

13. The compression index of a normally consolidated clay is used to estimate:

- A. Bearing capacity
- B. Permeability
- C. Friction angle
- D. Consolidation settlement

14. The sinking fund factor ( $A/F$ ) is used to find the:

- A. Uniform deposit needed to reach a future sum
- B. Present worth of a future amount
- C. Annual payment to repay a present loan
- D. Future value of a present amount

15. A 500 N load hangs at the midpoint of a horizontal beam supported at both ends. What is each support reaction?

- A. 250 N
- B. 500 N
- C. 125 N
- D. 1,000 N

16. In Bernoulli's equation, the velocity head term is expressed as:

- A.  $P/\gamma$
- B.  $z$
- C.  $\gamma h$
- D.  $V^2/2g$

17. A horizontal sight-distance restriction on a curve may require:

- A. Reducing the superelevation
- B. Adding more travel lanes
- C. Increasing the speed limit
- D. Clearing obstructions on the inside of the curve

18. A doubly symmetric W-section is most efficient at resisting:

- A. Pure torsion
- B. Axial tension only
- C. Bending about its strong axis
- D. Direct shear only

19. A right triangle has legs of length 9 and 12. What is the length of the hypotenuse?

- A. 15
- B. 21
- C. 7.9
- D. 18

20. The total vertical stress at a point in a soil deposit increases with:

- A. Depth and soil unit weight
- B. Decreasing depth
- C. Pore water pressure only
- D. The soil friction angle

21. A bond is purchased at a discount when its purchase price is:

- A. Above its face value
- B. Below its face value
- C. Equal to its coupon
- D. Equal to its face value

22. A 1,500 kg car travels at 30 m/s. What is its kinetic energy?

- A. 45 kJ
- B. 675 kJ
- C. 1,350 kJ
- D. 22.5 kJ

23. For flow over a sharp-crested rectangular weir, the discharge depends primarily on the:

- A. Downstream depth only
- B. Channel longitudinal slope
- C. Head over the crest
- D. Pipe diameter upstream

24. A  $1^\circ$  angular error over a 100 m sight introduces a transverse displacement of about:

- A. 0.1 m
- B. 1.75 m
- C. 10 m
- D. 0.5 m

25. A steel cable 5 m long stretches 2 mm under load. What is its axial strain?

- A.  $4 \times 10^{-3}$
- B.  $4 \times 10^{-4}$
- C. 0.4
- D.  $4 \times 10^{-5}$

26. Camber is built into a beam during fabrication mainly to:

- A. Offset anticipated dead-load deflection
- B. Increase the shear capacity
- C. Reduce the beam's weight
- D. Resist applied torsion

27. The unit weight of soil submerged below the water table is the:

- A. Dry unit weight
- B. Buoyant (effective) unit weight
- C. Total unit weight
- D. Saturated unit weight plus water

28. The annual worth method gives the same recommendation as the present worth method because they:

- A. Use different interest rates
- B. Ignore the time value of money
- C. Are equivalent transformations of the same cash flows
- D. Apply only to perpetual series

29. What is the first derivative of  $x^3 - 4x$ ?

- A.  $3x^3 - 4$
- B.  $x^2 - 4$
- C.  $3x - 4$
- D.  $3x^2 - 4$

30. A manometer is an instrument used to measure:

- A. Flow velocity
- B. Fluid temperature
- C. Pressure difference
- D. Fluid viscosity

31. A reduction in following headway between successive vehicles indicates:

- A. Lower traffic density
- B. Increased free-flow speed
- C. Greater vehicle spacing
- D. Higher density and a reduced safety margin

32. A connection that permits rotation but transmits shear is modeled as a:

- A. Fixed (moment) connection
- B. Simple (pinned) connection
- C. Roller without shear
- D. Free end

33. A soil classified as GW in the Unified Soil Classification System is a:

- A. Low-plasticity clay
- B. Poorly graded sand
- C. Well-graded gravel
- D. High-plasticity silt

34. A construction cost index is used to:

- A. Compute depreciation rates
- B. Adjust historical costs to current prices
- C. Set the interest rate
- D. Estimate salvage value

35. A ball rolls horizontally off a table 1.96 m high. How long does it take to reach the floor ( $g = 9.81 \text{ m/s}^2$ )?

- A. 0.63 s
- B. 0.20 s
- C. 1.26 s
- D. 0.40 s

36. A straight line passes through the points (0, 2) and (4, 10). What is its slope?

- A. 0.5
- B. 4
- C. 2
- D. 8

37. The absolute (dynamic) viscosity of a fluid has SI units of:

- A. Pa·s
- B. m<sup>2</sup>/s
- C. kg/m<sup>3</sup>
- D. N/m<sup>2</sup>

38. In Allowable Stress Design, the factor of safety is applied to the:

- A. Applied loads only
- B. Deflection limit
- C. Modulus of elasticity
- D. Material strength to set an allowable stress

39. A clay's sensitivity is defined as the ratio of its:

- A. Undisturbed to remolded shear strength
- B. Liquid limit to plastic limit
- C. Dry to wet unit weight
- D. Cohesion to friction angle

40. An incremental benefit-cost analysis compares alternatives by examining the:

- A. Cheapest option's ratio alone
- B. Average of all the ratios
- C. Salvage values by themselves
- D. Added benefits and costs of the more expensive option

41. What is the value of  $e^0$ ?

- A. 0
- B. e
- C. 2.718
- D. 1

42. A traffic signal's effective green time equals the displayed green plus yellow minus the:

- A. Pedestrian interval
- B. Cycle length
- C. Lost time
- D. All-red interval only

43. Three concurrent coplanar forces in equilibrium can be represented graphically as a:

- A. Single resultant force
- B. Couple moment
- C. Closed force triangle
- D. Straight line of forces

44. Shear flow in a built-up beam cross-section is computed using the relation:

A.  $\sigma = Mc/I$

B.  $\tau = Tr/J$

C.  $\delta = PL/AE$

D.  $q = VQ/I$

45. A pump must lift water 15 m and overcome 5 m of friction loss. What total head must it supply (neglecting velocity head)?

A. 10 m

B. 20 m

C. 5 m

D. 75 m

46. The bearing capacity factor  $N_c$  for a strip footing on undrained clay is approximately:

A. 5.14

B. 1.0

C. 0.5

D. 10

47. A profitability index greater than 1.0 indicates that:

A. The present worth of benefits exceeds the investment

B. The payback exceeds the project life

C. The salvage value is negative

D. The interest rate is zero

48. An arithmetic series has a first term of 2, a last term of 20, and 10 terms. What is its sum?

- A. 220
- B. 22
- C. 200
- D. 110

49. On a vertical crest curve, the available sight distance is limited by the:

- A. Headlight beam at night
- B. Curve obstructing the line of sight over the crest
- C. Side friction on the pavement
- D. Drainage gradient

50. A simply supported beam under a uniformly distributed load has its maximum deflection at the:

- A. Midspan
- B. Supports
- C. Quarter points
- D. One-third span

51. Flow at a point that does not change with time is termed:

- A. Uniform
- B. Steady
- C. Turbulent
- D. Laminar

52. Passive earth pressure against a retaining wall is mobilized when the wall:

- A. Stays perfectly still
- B. Moves away from the soil
- C. Rotates about its top
- D. Moves into the soil mass

53. When comparing alternatives, the only cash flows that are relevant are those that:

- A. Occurred in the past
- B. Are identical across the options
- C. Are sunk costs
- D. Differ between the alternatives

54. A 3 kg mass on a spring of stiffness 300 N/m has a natural frequency  $\omega = \sqrt{(k/m)}$  of:

- A. 100 rad/s
- B. 1 rad/s
- C. 10 rad/s
- D. 30 rad/s

55. Two independent events each have a probability of 0.4. What is the probability that both occur?

- A. 0.8
- B. 0.16
- C. 0.4
- D. 0.04

56. A theodolite is used primarily to measure:

- A. Horizontal and vertical angles
- B. Elevations only
- C. Soil density
- D. Water flow rate

57. The slenderness of a compression member is reduced by:

- A. Increasing the applied load
- B. Decreasing the cross-section
- C. Increasing the radius of gyration
- D. Lengthening the member

58. Increasing the interior roughness of a pipe results in:

- A. Lower head loss
- B. A reduced Reynolds number
- C. A higher friction factor and greater head loss
- D. No change in flow

59. A quick condition (boiling sand) develops when upward seepage reduces the effective stress to:

- A. A maximum value
- B. Zero
- C. The total stress
- D. The pore pressure squared

60. Working capital committed to a project is best described as:

- A. Permanently lost spending
- B. Funds tied up in operations and recovered at the end
- C. The same as depreciation
- D. A one-time tax credit

61. What is the natural logarithm of  $e^3$ ?

- A. 3
- B.  $e^3$
- C. 1
- D. 30

62. On level ground and neglecting air resistance, a projectile's range is maximized at a launch angle of:

- A.  $30^\circ$
- B.  $60^\circ$
- C.  $90^\circ$
- D.  $45^\circ$

63. The total energy per unit weight at a point in a flow is the:

- A. Pressure head alone
- B. Velocity head alone
- C. Sum of pressure, velocity, and elevation heads
- D. Elevation head alone

64. A beam's flexural stiffness is represented by the product:

- A. AE
- B. EI
- C. GJ
- D. kL

65. The allowable bearing pressure of a footing is the ultimate capacity divided by the:

- A. Footing area
- B. Factor of safety
- C. Soil unit weight
- D. Depth of embedment

66. The capacity of a signalized approach equals the saturation flow rate multiplied by the:

- A. Cycle length
- B. Number of crashes
- C. Effective green ratio (g/C)
- D. Lost time per phase

67. A future amount discounted to its present value is multiplied by the factor:

- A. (F/A)
- B. (A/P)
- C. (F/P)
- D. (P/F)

68. What is the slope of the line  $2y = 6x + 8$ ?

- A. 6
- B. 8
- C. 3
- D. 2

69. The moment arm of a force is the perpendicular distance from the:

- A. Force tip to its tail
- B. Line of action to the pivot point
- C. Pivot to the nearest support
- D. Force to the centroid

70. Open-channel flow is driven primarily by:

- A. Gravity acting along the channel slope
- B. A mechanical pressure pump
- C. Wind shear alone
- D. Capillary action

71. Differential settlement between footings is more damaging than uniform settlement because it:

- A. Lowers the water table
- B. Increases the soil density
- C. Has no structural effect
- D. Induces distortion and stresses in the structure

72. The study period in an economic analysis is the:

- A. Time horizon over which cash flows are evaluated
- B. Interest rate per period
- C. Number of compounding periods per year
- D. Salvage value timing only

73. What is the value of  $\sin 90^\circ$ ?

- A. 1
- B. 0
- C. 0.5
- D. 0.707

74. Concrete attains most of its design compressive strength within:

- A. 1 hour
- B. 7 years
- C. 28 days
- D. 1 day

75. The hydraulic grade line lies below the energy grade line by an amount equal to the:

- A. Velocity head
- B. Pressure head
- C. Elevation head
- D. Friction slope

76. A 5 kg object falls freely from rest for 3 s. What is its velocity ( $g = 9.81 \text{ m/s}^2$ )?

- A. 15 m/s
- B. 49 m/s
- C. 9.8 m/s
- D. 29.4 m/s

77. A flow line in a flow net represents:

- A. A line of equal total head
- B. A path followed by a water particle through the soil
- C. A contour of equal ground elevation
- D. The outer boundary of the dam

78. A nominal annual rate of 12% compounded quarterly has an interest rate per period of:

- A. 3%
- B. 12%
- C. 1%
- D. 4%

79. What is the probability of NOT rolling a 6 on a single fair die?

- A.  $1/6$
- B.  $1/2$
- C.  $5/6$
- D.  $1/3$

80. A simply supported beam under a uniformly distributed load has zero bending moment at the:

- A. Supports
- B. Midspan
- C. Quarter points
- D. Centroid of the load

81. The fluid property that resists shear deformation is:

- A. Density
- B. Surface tension
- C. Viscosity
- D. Specific gravity

82. The design vehicle chosen for an intersection's geometry should be:

- A. The smallest passenger car
- B. The average of all vehicles
- C. A motorcycle
- D. The largest vehicle expected to use it regularly

83. The optimum moisture content of a soil is the water content at which:

- A. Maximum dry density is achieved for a given compaction effort
- B. The soil becomes a liquid
- C. Permeability reaches its highest value
- D. Shear strength drops to zero

84. A uniform annual cost is converted to present worth using the factor:

- A.  $(A/F)$
- B.  $(F/P)$
- C.  $(P/A)$
- D.  $(A/P)$

85. How many independent equilibrium equations are available for a two-dimensional rigid body?

- A. One
- B. Two
- C. Four
- D. Three

86. A beam deflects the most when its flexural rigidity  $EI$  is:

- A. Large
- B. Infinite
- C. Small
- D. Equal to the load

87. In a connected body of static fluid, the pressure at points of equal elevation is:

- A. Greater near the walls
- B. Equal to zero
- C. Equal at equal elevation
- D. Dependent on the container shape

88. A pile group's capacity may be less than the sum of the individual pile capacities due to:

- A. Increased end bearing
- B. Group efficiency from overlapping stress zones
- C. Reduced pile length
- D. A higher water table alone

89. The equivalent annual cost method is especially useful for comparing alternatives with:

- A. Unequal service lives
- B. Identical first costs only
- C. Zero salvage value
- D. Equal annual benefits only

90. The area of a circle is doubled when its radius is multiplied by:

- A. 2
- B.  $\sqrt{2}$
- C. 4
- D. 1.5

91. A 2 kg ball moving at 4 m/s strikes a wall and rebounds at 4 m/s. What is the magnitude of the change in momentum?

- A. 0 kg·m/s
- B. 16 kg·m/s
- C. 8 kg·m/s
- D. 4 kg·m/s

92. Web crippling in a steel beam occurs primarily because of:

- A. Excessive span length
- B. Lateral wind load
- C. Thermal expansion
- D. Concentrated loads or reactions applied to the web

93. A weaving section on a highway is a location where:

- A. Merging and diverging traffic streams cross over a length of roadway
- B. Two traffic signals are placed close together
- C. A travel lane is permanently closed
- D. A curve meets a tangent section

94. A cofferdam is constructed primarily to:

- A. Compact subgrade soil
- B. Measure groundwater flow
- C. Create a dry working area within a body of water
- D. Test the capacity of piles

95. For a given discharge in an open channel, the depth at which specific energy is minimum is the:

- A. Critical depth
- B. Normal depth
- C. Maximum depth
- D. Conjugate depth

96. What is the indefinite integral of  $x \, dx$ ?

- A.  $x + C$
- B.  $1 + C$
- C.  $x^2/2 + C$
- D.  $2x + C$

97. A cash flow diagram graphically represents the:

- A. Timing and magnitude of cash inflows and outflows
- B. Depreciation method only
- C. Interest rate schedule
- D. Tax bracket of the firm

98. The allowable deflection of a typical floor beam is often limited to a span fraction such as:

- A.  $L/10$
- B.  $L/360$
- C.  $L/2$
- D.  $L/50$

99. A soil's coefficient of consolidation governs the:

- A. Total settlement amount
- B. Ultimate bearing capacity
- C. Rate of consolidation settlement
- D. Friction angle

100. A diamond interchange is a type of:

- A. At-grade roundabout
- B. Signalized four-way stop
- C. Pedestrian crossing
- D. Grade-separated interchange

101. A body's angular momentum is conserved when the net external:

- A. Torque is zero
- B. Force is at a maximum
- C. Velocity is constant
- D. Mass is changing

102. Evaluate  $8^{2/3}$ .

- A. 4
- B. 16
- C. 2
- D. 64

103. The momentum equation in fluid mechanics is used primarily to determine:

- A. The fluid temperature
- B. The fluid viscosity
- C. Forces exerted by flowing fluid on structures
- D. The chemical composition

104. A column's buckling capacity increases when its:

- A. Cross-section is reduced
- B. Applied load is increased
- C. Material is removed
- D. Effective length is reduced

105. The stable angle of a cut slope in a dry cohesionless soil is limited by the soil's:

- A. Plasticity index
- B. Angle of internal friction
- C. Specific gravity
- D. Liquid limit

106. Two cash flows are said to be equivalent when they:

- A. Occur at the same time only
- B. Have equal magnitudes only
- C. Both ignore interest
- D. Have the same value at a given interest rate

107. An "angle to the right" in traverse work is turned:

- A. Counterclockwise from north
- B. Vertically upward
- C. Along the plumb line
- D. Clockwise from the back line to the forward line

108. The mean of a data set increases by 5 when every value in the set is:

- A. Multiplied by 5
- B. Divided by 5
- C. Increased by 5
- D. Squared

109. A 1,200 kg car accelerates from rest to 20 m/s in 8 s. What is the approximate average power output?

- A. 10 kW
- B. 30 kW
- C. 60 kW
- D. 5 kW

110. When an engineer signs and seals a drawing, they are certifying that:

- A. The contractor accepts all liability
- B. The work was prepared by or under their responsible charge
- C. The client approved the budget
- D. The permit fee has been paid

## Answer Key and Explanations

1. D —  $Q = AV = (\pi/4 \times 0.3^2) \times 1.5 = 0.0707 \times 1.5 = 0.106 \text{ m}^3/\text{s}$ . Flow rate equals cross-sectional area times velocity. The  $\pi d^2/4$  area calculation is the decisive step.
2. B —  $P = F/(1 + i)^n = 20,000/1.07^{10} = 20,000/1.9672 = \$10,167$ . The present-worth factor discounts a future amount to today. The required deposit is about half the target because of a decade of compounding.
3. D —  $F_x = F \cos\theta = 80 \times \cos 25^\circ = 80 \times 0.906 = 72.5 \text{ N}$ . The horizontal component uses the cosine of the angle from horizontal. The vertical component would use the sine.

4. C —  $Dr = (e_{\max} - e)/(e_{\max} - e_{\min}) = (0.8 - 0.6)/(0.8 - 0.4) = 0.2/0.4 = 0.50 = 50\%$ . Relative density places the in-situ state between the loosest and densest conditions. A value of 50% indicates a medium-dense sand.
5. A — Total lost time =  $3 \text{ s} \times 4 \text{ phases} = 12 \text{ s}$ . Lost time accrues once per phase from startup and clearance. It reduces the green time usable for vehicle movement.
6. D —  $M_{\max} = wL^2/2 = 6 \times 3^2/2 = 27 \text{ kN}\cdot\text{m}$  at the fixed support. For a cantilever under uniform load, the maximum moment is at the wall. The span-squared term makes length dominant.
7. C — Determinant =  $(3)(4) - (2)(1) = 12 - 2 = 10$ . The  $2 \times 2$  determinant is the difference of the diagonal products. A nonzero value confirms the matrix is invertible.
8. B — A36 steel has a specified minimum yield strength of about 250 MPa (36 ksi). This value sets the basis for allowable and factored design strengths. Higher-grade steels such as A992 yield at about 345 MPa.
9. C — Wetted perimeter = width +  $2 \times$  depth =  $4 + 2(2) = 8 \text{ m}$ . Only the channel surfaces in contact with water are counted. The open top is excluded.
10. D —  $a = \Delta v/t = 25/5 = 5 \text{ m/s}^2$ . Uniform deceleration is the velocity change divided by time. The negative sign indicates slowing, with magnitude  $5 \text{ m/s}^2$ .
11. A — The standard BOD test runs for 5 days at  $20^\circ\text{C}$ , giving the widely reported  $\text{BOD}_5$  value. This period captures a consistent fraction of the ultimate oxygen demand. It indexes the biodegradable organic load.
12. B — Elevation = HI - foresight =  $102.45 - 1.85 = 100.60 \text{ m}$ . Foresight readings are subtracted from the height of instrument to find point elevations. This is the core leveling computation.
13. D — The compression index  $C_c$  of a normally consolidated clay is used to estimate consolidation settlement. It quantifies compression per log cycle of effective stress. It feeds directly into settlement calculations.
14. A — The sinking fund factor ( $A/F$ ) gives the uniform deposit needed to accumulate a specified future sum. It is the reciprocal of the uniform-series compound-amount factor. It is used for replacement and reserve funding.
15. A — Each reaction =  $500/2 = 250 \text{ N}$  by symmetry. A centered load on equal spans splits evenly between the supports. Vertical equilibrium requires the reactions to sum to the load.
16. D — The velocity head in Bernoulli's equation is  $V^2/2g$ , the kinetic energy per unit weight. It represents the energy associated with the fluid's motion. The other terms are pressure and elevation heads.
17. D — A horizontal sight-distance restriction is corrected by clearing obstructions on the inside of the curve. Removing the sight obstruction restores the required line of sight. The middle ordinate defines the needed clearance.
18. C — A doubly symmetric W-section is most efficient in strong-axis bending, where most of its material is far from the neutral axis. This maximizes the section modulus. It is the standard orientation for beams.
19. A — Hypotenuse =  $\sqrt{(9^2 + 12^2)} = \sqrt{225} = 15$ . The Pythagorean theorem combines the two legs. This is the 9-12-15 triangle, a scaled 3-4-5.
20. A — Total vertical stress increases with depth and soil unit weight, since  $\sigma = \gamma z$ . Greater depth or heavier soil produces higher geostatic stress. Pore pressure is subtracted separately to find effective stress.
21. B — A bond bought at a discount has a purchase price below its face value, typically because its coupon is below market rates. The investor's yield then exceeds the coupon rate. The face value is repaid at maturity.

22. B —  $KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 1,500 \times 30^2 = 675,000 \text{ J} = 675 \text{ kJ}$ . Kinetic energy scales with the square of speed. Distractor A omits the square, and C double-counts it.
23. C — Discharge over a sharp-crested rectangular weir depends on the head over the crest, with  $Q$  proportional to  $H^{1.5}$ . The head-discharge relationship makes the weir a flow-measuring device. Downstream depth does not control free flow.
24. B — Transverse offset =  $100 \times \tan 1^\circ = 100 \times 0.01746 = 1.75 \text{ m}$ . A one-degree pointing error grows linearly with sight distance. This illustrates why precise angular measurement matters over long sights.
25. B — Strain =  $\Delta L/L = 2 \text{ mm}/5,000 \text{ mm} = 4 \times 10^{-4}$ . Strain is the dimensionless ratio of elongation to original length. Consistent units are essential to avoid order-of-magnitude errors.
26. A — Camber is an upward curvature built into a beam to offset anticipated dead-load deflection, so the loaded beam appears level. It improves appearance and serviceability. It does not change strength or shear capacity.
27. B — Submerged soil has a buoyant (effective) unit weight equal to the saturated unit weight minus that of water. Buoyancy reduces the effective stress that the grains carry. This value is used for stresses below the water table.
28. C — Present worth and annual worth are equivalent transformations of the same cash flows at the same interest rate, so they yield identical recommendations. One can be converted to the other with a single factor. The choice is a matter of convenience.
29. D — The derivative of  $x^3 - 4x$  is  $3x^2 - 4$ . The power rule gives  $3x^2$  for  $x^3$  and  $-4$  for  $-4x$ . The constant multiple is preserved.
30. C — A manometer measures pressure difference by the height difference of a liquid column. The fluid's specific weight converts the height to pressure. It is a simple, accurate instrument for moderate pressures.
31. D — A reduced following headway means vehicles are closer together, indicating higher density and a smaller safety margin. Shorter gaps leave less time to react. This raises rear-end collision risk.
32. B — A connection that allows rotation but transmits shear is idealized as a simple (pinned) connection. It carries no moment. This assumption underlies the analysis of simply supported beams.
33. C — In USCS, GW denotes well-graded gravel, with a wide range of particle sizes and few fines. Good gradation gives dense packing and high strength. The W distinguishes it from poorly graded gravel (GP).
34. B — A construction cost index adjusts historical project costs to current price levels. It accounts for inflation in materials and labor. This allows fair comparison of costs across different years.
35. A —  $t = \sqrt{2h/g} = \sqrt{2 \times 1.96/9.81} = \sqrt{0.40} = 0.63 \text{ s}$ . Horizontal launch means initial vertical velocity is zero. Fall time depends only on height and gravity.
36. C — Slope =  $(10 - 2)/(4 - 0) = 8/4 = 2$ . The slope is the change in  $y$  divided by the change in  $x$ . The line rises two units for each unit of horizontal travel.
37. A — Dynamic (absolute) viscosity has SI units of pascal-seconds (Pa·s). It relates shear stress to velocity gradient. Kinematic viscosity, in contrast, has units of  $\text{m}^2/\text{s}$ .
38. D — In Allowable Stress Design, the factor of safety divides the material strength to set a lower allowable stress. Loads are kept at service levels. This contrasts with LRFD, which factors the loads.

39. A — Sensitivity is the ratio of undisturbed to remolded undrained shear strength. It measures how much strength a clay loses when disturbed. Highly sensitive clays can lose most of their strength when remolded.
40. D — Incremental benefit-cost analysis examines the added benefits and costs of moving to a more expensive alternative. The increment is justified if its B/C ratio exceeds 1.0. Comparing increments avoids ranking errors from individual ratios.
41. D — Any nonzero base raised to the zero power equals 1, so  $e^0 = 1$ . This follows from the laws of exponents. It is a standard reference value.
42. C — Effective green time equals the displayed green plus yellow minus the lost time. Lost time accounts for startup delay and the unused portion of clearance. It represents the time genuinely available for movement.
43. C — Three concurrent coplanar forces in equilibrium form a closed force triangle when drawn head to tail. The closure reflects a zero resultant. This is the graphical statement of equilibrium.
44. D — Shear flow is computed as  $q = VQ/I$ , where  $Q$  is the first moment of the connected area. It gives the force per unit length that fasteners or welds must transfer. This sizes connectors in built-up sections.
45. B — Total head = static lift + friction =  $15 + 5 = 20$  m. The pump must supply enough head to raise the water and overcome losses. Velocity head is usually small and neglected here.
46. A — For a strip footing on undrained clay, the bearing capacity factor  $N_c$  is approximately  $5.14(\pi + 2)$ . It multiplies the undrained shear strength in the capacity equation. This is a standard  $\phi = 0$  result.
47. A — A profitability index above 1.0 means the present worth of benefits exceeds the initial investment, indicating an economically favorable project. It normalizes net benefit by cost. Values below 1.0 signal rejection.
48. D — Sum =  $n(a + l)/2 = 10(2 + 20)/2 = 10 \times 11 = 110$ . The arithmetic series sum averages the first and last terms and multiplies by the count. This formula applies to any evenly spaced series.
49. B — On a crest curve, the roadway itself blocks the line of sight over the top, limiting sight distance. The curve length is set so the required sight distance clears the crest. Sag curves, by contrast, are governed by headlight distance.
50. A — Maximum deflection of a uniformly loaded simple beam occurs at midspan, equal to  $5wL^4/384EI$ . Symmetry places the peak deflection at the center. The supports have zero deflection.
51. B — Steady flow is flow whose properties at a given point do not change with time. Uniform flow, by contrast, refers to no change with position. The distinction is fundamental in fluid mechanics.
52. D — Passive earth pressure is mobilized when a wall moves into the soil, compressing it. This generates the maximum soil resistance. Active pressure develops when the wall moves away from the soil.
53. D — Only cash flows that differ between alternatives are relevant to the comparison. Identical and sunk cash flows cancel or are ignored. Focusing on differences simplifies and clarifies the decision.
54. C —  $\omega = \sqrt{(k/m)} = \sqrt{(300/3)} = \sqrt{100} = 10$  rad/s. The natural frequency rises with stiffness and falls with mass. This governs the system's free vibration.
55. B —  $P(\text{both}) = 0.4 \times 0.4 = 0.16$  for independent events. Independence allows multiplying the individual probabilities. The joint probability is smaller than either alone.
56. A — A theodolite measures horizontal and vertical angles with precision. These angles support traversing and triangulation. Distances are obtained separately by taping or EDM.

57. C — Increasing the radius of gyration lowers the slenderness ratio  $KL/r$ , improving buckling resistance. Reducing effective length has the same effect. A stockier section is less prone to buckling.
58. C — Greater pipe roughness raises the friction factor and therefore the head loss. The rougher boundary increases turbulence and resistance. Smoother pipes reduce friction loss.
59. B — A quick (boiling) condition occurs when upward seepage reduces effective stress to zero, leaving the sand with no shear strength. The grains lose intergranular contact. This causes piping and instability in excavations.
60. B — Working capital is funds tied up to support operations and is recovered at the project's end. It is an investment, not an expense. Its recovery is included as a cash inflow in the final period.
61. A —  $\ln(e^3) = 3$ , since the natural logarithm and exponential are inverse functions. The logarithm returns the exponent of  $e$ . This identity simplifies many calculations.
62. D — On level ground without air resistance, range is maximized at a  $45^\circ$  launch angle. This balances horizontal velocity against flight time. Angles equally above and below  $45^\circ$  give equal, shorter ranges.
63. C — Total head per unit weight is the sum of pressure head, velocity head, and elevation head. This is the Bernoulli energy expression. Each term represents a form of mechanical energy.
64. B — Flexural stiffness is the product  $EI$ , combining the material modulus and the section's moment of inertia. It governs beam deflection. A larger  $EI$  produces a stiffer, less deflecting beam.
65. B — Allowable bearing pressure = ultimate capacity / factor of safety. The factor of safety provides a margin against bearing failure. A typical value for foundations is about 3.
66. C — Approach capacity = saturation flow rate  $\times$  (g/C), the effective green ratio. The green ratio is the fraction of the cycle available to that movement. More green provides greater capacity.
67. D — A future amount is discounted to the present by the (P/F) single-payment present-worth factor. It is the reciprocal of the (F/P) factor. It applies to one lump sum, not a series.
68. C — Rewriting  $2y = 6x + 8$  as  $y = 3x + 4$  shows the slope is 3. Dividing through by 2 puts it in slope-intercept form. The coefficient of  $x$  is the slope.
69. B — The moment arm is the perpendicular distance from the force's line of action to the pivot. It is multiplied by the force to compute the moment. Only the perpendicular component contributes.
70. A — Open-channel flow is driven by gravity acting along the channel slope, since the surface is open to the atmosphere. The water moves downhill under its own weight. Pressure flow, by contrast, fills the conduit.
71. D — Differential settlement induces distortion and additional stresses in a structure, which can cause cracking or tilting. Uniform settlement moves the whole structure equally and is less harmful. Limiting differential movement is a key design goal.
72. A — The study period is the time horizon over which a project's cash flows are evaluated. It frames the analysis for comparison. Alternatives are often compared over a common study period.
73. A —  $\sin 90^\circ = 1$ , its maximum value. The sine of a right angle corresponds to full vertical projection. This is a standard reference value.
74. C — Concrete attains most of its specified compressive strength by 28 days, the standard age for testing  $f'_c$ . Strength gain is rapid early and then levels off. Earlier tests track curing progress.
75. A — The hydraulic grade line lies below the energy grade line by the velocity head,  $V^2/2g$ . The HGL represents pressure plus elevation head. Subtracting the kinetic term gives the HGL from the EGL.
76. D —  $v = gt = 9.81 \times 3 = 29.4$  m/s. In free fall from rest, velocity increases linearly with time. Mass does not affect the result.

77. B — A flow line traces the path a water particle follows as it seeps through soil. Equipotential lines, by contrast, connect points of equal head. Together they form the flow net used for seepage analysis.
78. A — Rate per period = nominal/periods =  $12\%/4 = 3\%$  per quarter. Dividing the nominal annual rate by the compounding frequency gives the periodic rate. The effective annual rate would be slightly higher.
79. C —  $P(\text{not } 6) = 5/6$ , since five of the six equally likely faces are not a six. The complement of rolling a six gives the answer. Probabilities of complementary events sum to one.
80. A — A simply supported beam has zero bending moment at its supports, where only reactions act. The moment builds to a maximum within the span. Pinned and roller ends cannot resist moment.
81. C — Viscosity is the fluid property that resists shear deformation, relating shear stress to the rate of strain. Higher viscosity means greater internal friction. It distinguishes thick fluids from thin ones.
82. D — The design vehicle should be the largest vehicle expected to use the facility regularly, so the geometry accommodates its turning needs. Designing for a smaller vehicle would cause encroachment. This sets curb radii and lane widths.
83. A — Optimum moisture content is the water content at which a given compaction effort produces maximum dry density. Too little or too much water lowers the achievable density. It is identified from the Proctor compaction curve.
84. C — A uniform annual cost is converted to present worth using the (P/A) factor. This series present-worth factor sums the discounted annual amounts. It is fundamental to life-cycle cost analysis.
85. D — A two-dimensional rigid body has three independent equilibrium equations: sum of forces in two directions and sum of moments. These solve for up to three unknown reactions. More unknowns make the structure indeterminate.
86. C — Deflection is inversely proportional to flexural rigidity EI, so a small EI produces large deflection. A flexible (low-stiffness) member sags more under load. Increasing EI stiffens the member.
87. C — In a connected static fluid, pressure is equal at all points of equal elevation. This follows from hydrostatic equilibrium. It is the basis for manometer and hydraulic-system analysis.
88. B — Group efficiency can make a pile group's capacity less than the sum of individual piles because their stress zones overlap in the soil. Closely spaced piles share and intensify stresses. Spacing and soil type govern the reduction.
89. A — The equivalent annual cost method is well suited to comparing alternatives with unequal service lives, since it expresses each on a per-year basis. This implicitly assumes repeating cycles. It avoids the need for a common multiple study period.
90. B — Since area is proportional to  $r^2$ , doubling the area requires multiplying the radius by  $\sqrt{2}$ . Squaring  $\sqrt{2}$  yields the factor of two in area. This reflects the quadratic area-radius relationship.
91. B —  $\Delta p = m(v_f - v_i) = 2[4 - (-4)] = 16 \text{ kg}\cdot\text{m/s}$ . The rebound reverses the velocity sign, so the momentum change is the sum of the magnitudes. This larger change reflects the reversal of direction.
92. D — Web crippling results from high concentrated loads or reactions bearing on a thin beam web. The localized compression can buckle or crush the web. Bearing stiffeners are added to prevent it.
93. A — A weaving section is where merging and diverging traffic streams cross paths over a length of roadway, such as between an on-ramp and a nearby off-ramp. The crossing maneuvers reduce capacity and speed. Adequate length is needed to complete them safely.

94. C — A cofferdam is a temporary enclosure built to create a dry working area within a body of water. Water is pumped out so construction can proceed in the dry. It is common for bridge piers and foundations.
95. A — Critical depth is the depth at which specific energy is minimum for a given discharge. At this depth the Froude number equals one. It marks the transition between subcritical and supercritical flow.
96. C — The integral of  $x \, dx$  is  $x^2/2 + C$ . Raising the exponent and dividing reverses the power rule. The constant of integration is required.
97. A — A cash flow diagram graphically represents the timing and magnitude of inflows and outflows over the analysis period. Arrows show direction and size at each time. It organizes the data for economic analysis.
98. B — Floor beam deflection under live load is commonly limited to about  $L/360$  for serviceability. This controls perceptible sag and protects finishes. Stricter limits apply where sensitive elements are supported.
99. C — The coefficient of consolidation governs the rate at which consolidation settlement occurs over time. It combines permeability and compressibility. The total settlement magnitude depends on other parameters.
100. D — A diamond interchange is a grade-separated interchange, with one road passing over the other and ramps connecting them. The separation eliminates the at-grade crossing conflict. It is common at freeway-arterial junctions.
101. A — Angular momentum is conserved when the net external torque on a system is zero. With no torque, the rotational state remains unchanged. This parallels linear momentum conservation under zero net force.
102. A —  $8^{(2/3)} = (8^{(1/3)})^2 = 2^2 = 4$ . The denominator of the exponent takes the cube root, and the numerator squares the result. Evaluating roots first keeps the numbers small.
103. C — The momentum equation determines the forces that flowing fluid exerts on structures such as bends, nozzles, and vanes. It applies Newton's second law to the control volume. It is essential for thrust and reaction force analysis.
104. D — Reducing a column's effective length raises its buckling capacity, since the Euler load varies inversely with the square of effective length. Added bracing or fixity shortens the effective length. This is the most direct way to improve stability.
105. B — The stable angle of a dry cohesionless slope is limited by the soil's angle of internal friction, which equals its angle of repose. Slopes steeper than this fail by sliding. Cohesion would allow steeper temporary cuts.
106. D — Two cash flows are equivalent when they have the same value at a specified interest rate, even if their timing or magnitude differs. The interest rate is what makes the comparison possible. Equivalence is the foundation of engineering economics.
107. D — An angle to the right is measured clockwise from the rear (back) line to the forward line at a traverse station. This convention standardizes traverse angle recording. It enables consistent computation of directions.
108. C — Adding 5 to every value in a data set shifts the mean up by exactly 5. A uniform shift moves the average by the same amount. Multiplying or squaring would change the mean differently.
109. B —  $P = KE/t = (1/2 \times 1,200 \times 20^2)/8 = 240,000/8 = 30,000 \text{ W} = 30 \text{ kW}$ . Average power is the energy delivered divided by the time. This is the work-energy approach to power.

110. B — Signing and sealing a drawing certifies that the work was prepared by or under the engineer's responsible charge. It is a legal attestation of professional responsibility. It does not transfer liability to others or address fees.