

# PRACTICE EXAM 11 : FE CIVIL SIMULATION (110 QUESTIONS)

---

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

1. A simply supported beam of span 8 m carries a uniform load of 15 kN/m. What total load is transferred to the two supports combined?

- A. 60 kN
- B. 240 kN
- C. 120 kN
- D. 15 kN

2. In a uniform gradient cash-flow series analyzed with the (P/G, i, n) factor, the gradient G represents:

- A. The first-year cash flow
- B. The total over all years
- C. The interest rate applied
- D. The constant annual increase

3. A project has an actual cost of \$120,000 and an earned value of \$100,000. What is the cost variance (EV – AC)?

- A. +\$10,000
- B. -\$10,000

- C. -\$20,000
- D. +\$20,000

4. A steel column has a yield strength of 250 MPa and a gross area of 5,000 mm<sup>2</sup>. Using  $F_y \cdot A_g$ , what is its yielding axial capacity?

- A. 50 kN
- B. 250 kN
- C. 5,000 kN
- D. 1,250 kN

5. A vehicle travels 90 km in 1.5 hours. What is its average speed?

- A. 60 km/hr
- B. 135 km/hr
- C. 45 km/hr
- D. 90 km/hr

6. A cantilever beam carries a point load  $P$  at its free end. The bending moment diagram along the beam is:

- A. Constant at  $PL$  throughout
- B. Zero everywhere
- C. Maximum at the free end
- D. Linearly increasing from zero at the free end to  $PL$  at the fixed end

7. A loader moves 60 m<sup>3</sup> of soil per hour and works 7 hours per day. What is its daily production?

- A. 420 m<sup>3</sup>

- B. 67 m<sup>3</sup>
- C. 8.6 m<sup>3</sup>
- D. 60 m<sup>3</sup>

8. A 4-phase signal has a lost time of 4 s per phase. What is the total lost time per cycle?

- A. 4 s
- B. 60 s
- C. 16 s
- D. 240 s

9. The loss of concrete workability between mixing and placement over time is called:

- A. Bleeding
- B. Slump loss
- C. Segregation
- D. Efflorescence

10. An engineer's obligation to hold paramount the safety of the public is found in:

- A. The contractor's bid documents
- B. Engineering codes of ethics
- C. The project's construction schedule
- D. The material supplier's warranty

11. A ball falls freely from rest for 2 s. Using  $g = 9.81 \text{ m/s}^2$ , what is its velocity?

- A. 19.62 m/s

- B. 4.905 m/s
- C. 39.24 m/s
- D. 9.81 m/s

12. A design speed of 100 km/hr converts to how many m/s?

- A. 27.8 m/s
- B. 360 m/s
- C. 100 m/s
- D. 16.7 m/s

13. A circular pipe 0.4 m in diameter flows full. What is its cross-sectional area?

- A. 0.50 m<sup>2</sup>
- B. 0.126 m<sup>2</sup>
- C. 1.26 m<sup>2</sup>
- D. 0.04 m<sup>2</sup>

14. A \$12,000 loan is repaid in equal annual installments over 4 years at 0% interest. What is each payment?

- A. \$4,000
- B. \$3,000
- C. \$12,000
- D. \$1,500

15. A 500 m distance is taped in five 100 m segments, each with a random error of  $\pm 0.01$  m. What is the estimated total error?

- A. 0.05 m
- B. 0.01 m
- C. 0.022 m
- D. 0.10 m

16. What is the value of 5! (5 factorial)?

- A. 25
- B. 5
- C. 15
- D. 120

17. An investment doubles in 12 years. Using the Rule of 72, what is the approximate annual interest rate?

- A. 6%
- B. 12%
- C. 2%
- D. 24%

18. A 2 m bar stretches 1 mm under load. What is its axial strain?

- A. 0.001
- B. 0.002
- C. 0.0001
- D. 0.0005

19. A retaining wall's resistance to sliding along its base is primarily provided by:

- A. The weight of the backfill alone
- B. The passive pressure on the stem
- C. The active earth pressure
- D. The friction between the base and the foundation soil

20. A line 60 m long has an azimuth of  $90^\circ$ . What is its departure (east component)?

- A. 60 m
- B. 0 m
- C. 30 m
- D. 42.4 m

21. An hourly volume is 1,800 veh/hr and the peak 15-minute count is 500. Using  $PHF = V / (4 \times \text{peak 15-min})$ , what is the peak-hour factor?

- A. 0.45
- B. 3.6
- C. 1.11
- D. 0.90

22. A wheelbarrow of capacity  $0.08 \text{ m}^3$  is used to place  $4 \text{ m}^3$  of concrete. How many loads are required?

- A. 32 loads
- B. 0.32 loads
- C. 50 loads
- D. 0.02 loads

23. A plant achieves 90% BOD removal on an influent BOD of 250 mg/L. What is the effluent BOD?

- A. 225 mg/L
- B. 90 mg/L
- C. 25 mg/L
- D. 2.5 mg/L

24. A project has a first cost of \$100,000 and annual net benefits of \$20,000. Ignoring interest, what is the simple payback period?

- A. 5 years
- B. 2 years
- C. 0.2 year
- D. 20 years

25. A soil has a void ratio of 0.6. Using  $n = e/(1 + e)$ , what is its porosity?

- A. 0.375
- B. 0.60
- C. 1.60
- D. 0.40

26. Discharge over a sharp-crested rectangular weir depends most strongly on the:

- A. Pipe roughness upstream
- B. Water temperature
- C. Head of water above the crest
- D. Color of the channel lining

27. Eutrophication of a lake is caused primarily by an excess of:

- A. Dissolved oxygen
- B. Heavy metals
- C. Suspended sand
- D. Nutrients such as nitrogen and phosphorus

28. Adding excess water to a concrete mix to improve workability will:

- A. Increase the compressive strength
- B. Decrease the compressive strength
- C. Have no effect on strength
- D. Eliminate the need for cement

29. A 10 kg object accelerates at  $3 \text{ m/s}^2$ . What is the net force on it?

- A. 30 N
- B. 3.33 N
- C. 13 N
- D. 90 N

30. What is the equation of a circle of radius 4 centered at the origin?

- A.  $x + y = 4$
- B.  $x^2 + y^2 = 8$
- C.  $x^2 - y^2 = 16$
- D.  $x^2 + y^2 = 16$

31. In a bolt group resisting an eccentric load, the bolt carrying the largest force is generally the one:

- A. Farthest from the centroid of the group
- B. Closest to the centroid of the group
- C. At the exact centroid
- D. Located at the load application point

32. A pressure of 200 kPa acts on a hydraulic piston of area 0.05 m<sup>2</sup>. What force is produced?

- A. 4,000 N
- B. 10,000 N
- C. 1,000 N
- D. 40 N

33. A wheel rotates at 300 rpm. What is its angular velocity in rad/s?

- A. 31.4 rad/s
- B. 300 rad/s
- C. 5 rad/s
- D. 1,885 rad/s

34. A truck slows on a steep grade on a two-lane highway. This is commonly mitigated by providing a:

- A. Wider shoulder
- B. Reduced speed limit only
- C. Climbing lane
- D. Additional traffic signal

35. An engineer is asked to certify work they did not review and have no knowledge of. The engineer should:

- A. Certify it to maintain the client relationship
- B. Certify it for an additional fee
- C. Decline to certify work outside their knowledge
- D. Certify it and assign blame to others later

36. What does the expression  $\sin^2\theta + \cos^2\theta$  equal?

- A. 0
- B. 2
- C.  $\sin\theta \cdot \cos\theta$
- D. 1

37. A roadway carries 1,500 veh/hr at a space-mean speed of 50 km/hr. Using  $k = q/v$ , what is the traffic density?

- A. 75,000 veh/km
- B. 0.033 veh/km
- C. 30 veh/km
- D. 50 veh/km

38. A simply supported beam with a central point load has its maximum bending moment at:

- A. The left support
- B. The right support
- C. The midspan under the load
- D. The quarter point

39. The principal binding agent that hardens and gives concrete its strength is:

- A. Coarse aggregate
- B. Fine sand
- C. Entrained air
- D. Hydrated cement paste

40. Two forces of 6 N and 8 N act at right angles. What is the magnitude of their resultant?

- A. 14 N
- B. 2 N
- C. 10 N
- D. 48 N

41. A 5-hectare site has  $C = 0.6$  and  $i = 30$  mm/hr. Using the metric rational method  $Q = CiA/360$  ( $Q$  in  $m^3/s$ ), what is the peak runoff?

- A.  $0.25 m^3/s$
- B.  $90 m^3/s$
- C.  $2.5 m^3/s$
- D.  $0.025 m^3/s$

42. A direct shear test on sand determines the soil's:

- A. Permeability
- B. Water content
- C. Specific gravity
- D. Angle of internal friction

43. A fluid at rest exerts pressure on a submerged surface that acts:

- A. Only horizontally
- B. Only at the centroid
- C. Tangent to the surface
- D. Perpendicular to the surface

44. A masonry wall requires 1,200 bricks and a mason lays 150 per hour. How much labor time is required?

- A. 4 hours
- B. 1,050 hours
- C. 8 hours
- D. 0.125 hour

45. A material with a high modulus of elasticity, under a given stress within the elastic range, will:

- A. Deform less than a material with a lower modulus
- B. Deform more than a material with a lower modulus
- C. Fail immediately
- D. Have no relationship to deformation

46. On the critical path, activity A (3 days) must finish before activity B (5 days) begins. What is the combined duration?

- A. 5 days
- B. 3 days
- C. 8 days
- D. 15 days

47. A 1 m steel rod ( $E = 200 \text{ GPa}$ ) is stressed to 100 MPa. Using  $\delta = \sigma L/E$ , what is its elongation?

- A. 0.5 mm
- B. 1.0 mm
- C. 2.0 mm
- D. 0.25 mm

48. A pressure head of 10 m of water corresponds to what pressure ( $\gamma = 9.81 \text{ kN/m}^3$ )?

- A. 98.1 kPa
- B. 10 kPa
- C. 9.81 kPa
- D. 981 kPa

49. A standard Proctor test is performed to determine the:

- A. Shear strength under load
- B. Maximum dry density and optimum moisture content
- C. Permeability coefficient
- D. Atterberg limits

50. A beam reaction is found by summing moments about a point in order to eliminate:

- A. All applied loads
- B. The beam's self-weight
- C. The distributed load
- D. The other unknown reaction at that point

51. A soil is classified as "well-graded" when it contains:

- A. Particles all of a single size
- B. Only clay-sized particles
- C. Only gravel-sized particles
- D. A wide and continuous range of particle sizes

52. Reinforcing bars are deformed (ribbed) rather than smooth primarily to:

- A. Improve the bond between steel and concrete
- B. Reduce the steel's weight
- C. Increase corrosion resistance
- D. Make the bars easier to cut

53. A 500 N force acts at  $37^\circ$  above horizontal. What is its vertical component?

- A. 400 N
- B. 500 N
- C. 300 N
- D. 250 N

54. A column under pure axial compression shortens. The internal stress in the column is:

- A. Compressive normal stress
- B. Tensile normal stress
- C. Pure torsional shear
- D. Bending stress

55. As water flows from a wide to a narrow section of a horizontal pipe, by Bernoulli's principle the pressure in the narrow section:

- A. Increases
- B. Decreases
- C. Stays the same
- D. Drops to absolute zero

56. Primary treatment in a wastewater plant removes pollutants mainly by:

- A. Chemical disinfection
- B. Biological oxidation
- C. Physical settling of solids
- D. Reverse osmosis

57. A continuous beam over three supports is statically indeterminate because:

- A. It has fewer reactions than equilibrium equations
- B. It is unstable
- C. It has more reactions than equilibrium equations
- D. It carries no load

58. Discharge over a triangular (V-notch) weir varies with head raised to the power of:

- A. 1.0
- B. 2.5
- C. 0.5
- D. 1.5

59. A change order in a construction contract is used to:

- A. Terminate the contract immediately
- B. Set the original bid price
- C. Replace the project engineer
- D. Formally modify the scope, price, or schedule

60. A manometer measures a pressure difference using:

- A. A rotating impeller
- B. An electrical resistance gauge
- C. The speed of sound in the fluid
- D. The height difference of a liquid column

61. A beam deflection limit is specified as  $L/360$ . For a 7,200 mm span, what is the deflection limit?

- A. 36 mm
- B. 20 mm
- C. 360 mm
- D. 7,200 mm

62. An angle is recorded as  $47^{\circ}36'$ . What is this in decimal degrees?

- A.  $47.36^{\circ}$
- B.  $47.60^{\circ}$
- C.  $48.00^{\circ}$
- D.  $47.06^{\circ}$

63. A future amount of \$20,000 is discounted at 10% for 1 year. What is its present worth?

- A. \$18,182
- B. \$22,000
- C. \$20,000
- D. \$2,000

64. A beam fails when its maximum bending stress reaches the material's:

- A. Shear modulus
- B. Poisson's ratio
- C. Density
- D. Flexural strength (rupture stress)

65. A higher cement content in concrete, all else equal, generally produces:

- A. Lower strength
- B. No change in strength
- C. Reduced durability always
- D. Higher strength and greater heat of hydration

66. A soil's coefficient of permeability is measured in units of:

- A. Newtons per square meter
- B. Length per unit time, such as m/s
- C. Kilograms per cubic meter
- D. Degrees

67. A driver's total braking distance increases most rapidly with:

- A. The vehicle's color
- B. The square of the travel speed
- C. The first power of the speed
- D. The road's width

68. A backhoe excavates a trench 1.2 m wide, 2 m deep, and 50 m long. What is the excavation volume?

- A. 120 m<sup>3</sup>
- B. 53.2 m<sup>3</sup>
- C. 100 m<sup>3</sup>
- D. 12 m<sup>3</sup>

69. The phreatic surface in an earth dam represents the:

- A. Top of the impervious core
- B. Crest of the dam
- C. Top boundary of the seepage flow within the dam
- D. Downstream toe drain

70. A stop sign at an intersection:

- A. Assigns the right of way to the stopped driver
- B. Gives right of way to cross traffic, requiring the driver to stop and yield
- C. Mandates a speed increase
- D. Sets a signal phase timing

71. Offering a payment to influence the award of a contract is:

- A. A standard business practice
- B. Required by procurement law
- C. Bribery and an ethics violation
- D. A form of liquidated damages

72. A two-force member in equilibrium carries two forces that are:

- A. Perpendicular to each other
- B. Of different magnitudes
- C. Acting in the same direction
- D. Equal, opposite, and collinear

73. Lateral bracing of a steel beam is provided to prevent:

- A. Axial yielding of the web
- B. Shear failure at the supports
- C. Bearing failure under the load
- D. Lateral-torsional buckling of the compression flange

74. A ladder of weight  $W$  leans against a frictionless wall with no other vertical load. The normal reaction from the horizontal floor on the ladder's base is:

- A. Zero
- B. Equal to the ladder's weight  $W$
- C. Twice the weight
- D. Horizontal in direction

75. A clay layer between two sand layers consolidates by draining water:

- A. Only downward
- B. Only upward
- C. From both top and bottom (double drainage)
- D. Never, since clay is impermeable

76. The hydrostatic force on a vertical rectangular gate increases with depth because:

- A. Pressure increases linearly with depth
- B. The gate area decreases with depth
- C. The fluid density decreases with depth
- D. Pressure is constant at all depths

77. A soil with a liquid limit of 65 and high plasticity is classified in the USCS as:

- A. SP (poorly graded sand)
- B. CH (high-plasticity clay)
- C. GW (well-graded gravel)
- D. ML (low-plasticity silt)

78. A junior engineer, at the firm's request, seals documents for a project where they were not in responsible charge. This is:

- A. Acceptable if the firm approves
- B. An ethics violation regarding responsible charge
- C. Required by the firm's policy
- D. Standard for junior engineers

79. A signalized intersection's delay per vehicle is a key measure used to assign its:

- A. Level of service
- B. Pavement thickness
- C. Structural number
- D. Soil bearing capacity

80. An engineer becomes aware that a colleague is practicing in a way that endangers the public. The ethical duty is to:

- A. Ignore it to avoid conflict
- B. Report the unsafe practice to the appropriate authority
- C. Cover for the colleague
- D. Wait until an accident occurs

81. The ultimate bearing capacity of a footing increases with all of the following EXCEPT:

- A. A higher soil friction angle
- B. A wider footing
- C. The water table rising to the ground surface
- D. A greater footing depth

82. A contour line on a topographic map connects points of equal:

- A. Horizontal distance
- B. Slope angle
- C. Magnetic bearing
- D. Elevation

83. A 50 mm rainfall falls on a 2-hectare impervious lot ( $C = 1.0$ ). What is the total runoff volume?

- A. 100 m<sup>3</sup>
- B. 1,000 m<sup>3</sup>
- C. 10,000 m<sup>3</sup>
- D. 50 m<sup>3</sup>

84. A truss member in compression must be checked for buckling because compression members can fail:

- A. Only by tensile rupture
- B. Only by shear
- C. Only by corrosion
- D. By buckling at a load below the yield strength

85. Aeration of water in treatment is used primarily to:

- A. Add a chlorine residual
- B. Add oxygen and remove dissolved gases or odors
- C. Increase turbidity
- D. Lower the water temperature only

86. A 1,200 kg car travels at 25 m/s. What is its kinetic energy?

- A. 375 kJ
- B. 15 kJ
- C. 750 kJ
- D. 30 kJ

87. What is the probability of rolling a sum of 7 with two fair dice?

- A. 0.083
- B. 0.167
- C. 0.50
- D. 0.028

88. A concrete pour is scheduled, but the forecast shows freezing temperatures. The contractor should:

- A. Take cold-weather concreting precautions
- B. Add extra water to prevent freezing
- C. Pour without any changes
- D. Reduce the cement content

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

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

90. A simply supported beam carries a uniform load. The support reactions are:

- A. Unequal, with the larger at the left
- B. Zero at both supports
- C. Equal, each carrying half the total load
- D. Equal to the full total load each

91. The polar moment of inertia of a solid circular shaft of diameter  $d$  is:

- A.  $\pi d^3/16$
- B.  $\pi d^2/4$
- C.  $bh^3/12$
- D.  $\pi d^4/32$

92. What is the derivative of  $x^5$  with respect to  $x$ ?

- A.  $x^4$
- B.  $5x^6$
- C.  $5x^4$
- D.  $x^5/5$

93. The time of concentration of a watershed is the time for runoff to travel from:

- A. The outlet back to the divide
- B. One side of the channel to the other
- C. The most hydraulically remote point to the outlet
- D. The rain gauge to the lab

94. A total station combines distance and angle measurement and records data:

- A. Electronically for direct download
- B. Only in paper field books
- C. Using a magnetic compass alone
- D. Without any angle capability

95. The energy grade line in a pipe lies above the hydraulic grade line by an amount equal to the:

- A. Elevation head
- B. Pressure head
- C. Pipe diameter
- D. Velocity head

96. A pinned connection in a steel frame is idealized as transferring:

- A. Both force and moment
- B. Force but not moment
- C. Moment but not force
- D. Neither force nor moment

97. Creep in concrete refers to:

- A. Sudden brittle fracture under impact
- B. Gradual time-dependent deformation under sustained load
- C. Rapid strength gain in the first hour
- D. Corrosion of the reinforcement

98. What is the area under the curve  $y = 2x$  from  $x = 0$  to  $x = 3$ ?

- A. 9
- B. 6
- C. 18
- D. 3

99. A geotextile placed between a subgrade and an aggregate base layer functions primarily for:

- A. Increasing the soil's plasticity
- B. Adding chemical stabilization
- C. Separation and filtration
- D. Raising the water table

100. The discharge of a stream is the product of its cross-sectional area and its:

- A. Mean flow velocity
- B. Water temperature
- C. Bank height
- D. Sediment color

101. A simply supported beam of span  $L$  carries a central point load  $P$ . What is the maximum bending moment?

- A.  $PL$
- B.  $PL/4$
- C.  $PL/8$
- D.  $PL/2$

102. Two angles of a triangle are  $50^\circ$  and  $60^\circ$ . What is the third angle?

- A.  $110^\circ$
- B.  $50^\circ$
- C.  $70^\circ$
- D.  $90^\circ$

103. Determining the elevation difference between two points using a level and a graduated rod is called:

- A. Differential leveling
- B. Triangulation
- C. Traversing
- D. Resection

104. The minimum acceptable rate of return used to screen investments is called the:

- A. Internal rate of return
- B. Payback period
- C. Benefit-cost ratio
- D. Minimum attractive rate of return (MARR)

105. A distributed load of 4 kN/m acts over a 5 m length. What is the total equivalent concentrated force?

- A. 0.8 kN
- B. 9 kN
- C. 20 kN
- D. 40 kN

106. A 3 kg mass moves in a circle of radius 2 m at 4 m/s. What is its centripetal acceleration?

- A. 2 m/s<sup>2</sup>
- B. 8 m/s<sup>2</sup>
- C. 32 m/s<sup>2</sup>
- D. 4 m/s<sup>2</sup>

107. A force couple consists of two forces that are:

- A. Equal, parallel, and in the same direction
- B. Equal, parallel, opposite in direction, and separated by a distance
- C. Unequal and concurrent
- D. Acting through the same point

108. If  $f(x) = 3x^2 + 2x$ , what is  $f(2)$ ?

- A. 8
- B. 14
- C. 16
- D. 20

109. A one-way reinforced concrete slab resists bending primarily by placing main reinforcement:

- A. Parallel to the supports
- B. Perpendicular to the supports, spanning the short direction
- C. Diagonally at  $45^\circ$
- D. Only at the slab's center

110. Computing a station's coordinates from a known point using a line's latitude and departure is called:

- A. Resection
- B. Latitudes and departures (coordinate computation)
- C. Stadia tacheometry
- D. Barometric leveling

## PRACTICE EXAM 11 – ANSWER KEY AND EXPLANATIONS

- 1. C** — Total support load =  $wL = 15 \times 8 = 120$  kN. The two reactions together must carry the entire distributed load. Each support takes half, but the combined total equals the full applied load.
- 2. D** — In a gradient series,  $G$  is the constant amount by which the cash flow changes each period, here \$500. The  $(P/G)$  factor converts this uniform increase to a present value. It is distinct from the base annuity amount.
- 3. C** — Cost variance =  $EV - AC = 100,000 - 120,000 = -\$20,000$ . A negative cost variance signals the project is over budget. More was spent than the value of work earned.
- 4. D** — Yielding capacity =  $F_y \cdot A_g = 250 \times 10^6 \times 5,000 \times 10^{-6} = 1,250,000$  N = 1,250 kN. Gross-section yielding is one of the basic axial limit states. The full cross-section resists the load.
- 5. A** — Average speed = distance/time =  $90/1.5 = 60$  km/hr. Speed is total distance divided by total time. The units follow directly.
- 6. D** — For a cantilever with a free-end point load, the moment grows linearly from zero at the free end to  $PL$  at the fixed end. The fixed support resists the largest moment. The diagram is a straight line.
- 7. A** — Daily production = rate  $\times$  hours =  $60 \times 7 = 420$  m<sup>3</sup>. Hourly output multiplied by working hours gives daily volume. This is a basic productivity calculation.
- 8. C** — Total lost time = lost time per phase  $\times$  number of phases =  $4 \times 4 = 16$  s. Each phase incurs start-up and clearance losses. The total reduces the cycle's usable green.
- 9. B** — The loss of workability over time between mixing and placement is slump loss. It results from ongoing hydration and water absorption. It must be managed to ensure proper placement.
- 10. B** — The paramount duty to public safety is established in engineering codes of ethics. These codes govern professional conduct across the discipline. Contract and schedule documents do not set this obligation.
- 11. A** —  $v = gt = 9.81 \times 2 = 19.62$  m/s. A freely falling object gains velocity linearly with time from rest. Mass does not affect the result.
- 12. A** —  $100$  km/hr  $\div 3.6 = 27.8$  m/s. Dividing by 3.6 converts kilometers per hour to meters per second. The factor comes from 1,000 m per 3,600 s.
- 13. B** —  $A = \pi(d/2)^2 = \pi(0.2)^2 = 0.126$  m<sup>2</sup>. The full-flow area of a circular pipe uses its radius. The 0.4 m diameter gives a 0.2 m radius.
- 14. B** — At 0% interest, each payment =  $12,000/4 = \$3,000$ . With no time value of money, the principal divides evenly. No interest is added.

- 15. C** — Combined error =  $\sqrt{5} \times 0.01 = 0.022$  m. Random errors accumulate as the square root of the number of independent segments. Five 100 m segments make up the 500 m line.
- 16. D** —  $5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$ . A factorial multiplies all positive integers up to the number. It counts the orderings of five distinct items.
- 17. A** — Rate  $\approx 72/\text{doubling time} = 72/12 = 6\%$ . The Rule of 72 estimates the compound rate that doubles money in a given time. It approximates exponential growth.
- 18. D** — Strain =  $\Delta L/L = 0.001/2 = 0.0005$ . Axial strain is the elongation divided by the original length. It is a dimensionless ratio.
- 19. D** — Resistance to base sliding is provided chiefly by friction between the wall base and the foundation soil. This frictional force opposes the lateral earth thrust. A base key can add passive resistance.
- 20. A** — Departure =  $L \sin(\text{azimuth}) = 60 \times \sin 90^\circ = 60$  m east. An azimuth of  $90^\circ$  points due east, so the entire length is the east component. The latitude is zero.
- 21. D** — PHF =  $V/(4 \times \text{peak 15-min}) = 1,800/(4 \times 500) = 1,800/2,000 = 0.90$ . The peak-hour factor measures flow uniformity within the hour. A value near 1.0 indicates steady flow.
- 22. C** — Loads = total volume/capacity =  $4/0.08 = 50$  loads. Dividing the required volume by the wheelbarrow capacity gives the count. Each load delivers  $0.08 \text{ m}^3$ .
- 23. C** — Effluent = influent  $\times (1 - \text{removal}) = 250 \times 0.10 = 25$  mg/L. A 90% removal leaves 10% of the influent BOD. The remaining load passes to the effluent.
- 24. A** — Simple payback = first cost/annual benefit =  $100,000/20,000 = 5$  years. Ignoring interest, this is the time to recover the investment. Annual net benefits repay the cost evenly.
- 25. A** — Porosity  $n = e/(1 + e) = 0.6/1.6 = 0.375$ . This converts void ratio (voids to solids) into porosity (voids to total). Porosity is always less than the void ratio.
- 26. C** — Weir discharge depends most strongly on the head above the crest. Discharge rises with head to the 1.5 power for a rectangular weir. Temperature and lining color are negligible.
- 27. D** — Eutrophication is driven by excess nutrients such as nitrogen and phosphorus. These fuel algal blooms that deplete oxygen as they decay. The result is degraded water quality.
- 28. B** — Excess water raises the water-cement ratio, decreasing compressive strength. Added water increases workability but weakens the hardened concrete. This trade-off is fundamental to mix design.
- 29. A** —  $F = ma = 10 \times 3 = 30$  N. Newton's second law relates net force to mass and acceleration. The result is in newtons.

- 30. D** — A circle of radius 4 centered at the origin is  $x^2 + y^2 = 16$ , since  $r^2 = 4^2 = 16$ . The standard form sets the sum of squared coordinates equal to  $r^2$ . The radius is the square root of 16.
- 31. A** — In an eccentrically loaded bolt group, the bolt farthest from the centroid carries the largest force. Force from the moment is proportional to distance from the centroid. The outermost bolt governs the design.
- 32. B** —  $F = pA = 200,000 \times 0.05 = 10,000$  N. Force equals pressure times area. This is the basis of hydraulic force multiplication.
- 33. A** —  $\omega = 300 \times 2\pi/60 = 31.4$  rad/s. Converting rpm to rad/s multiplies by  $2\pi$  and divides by 60. The result expresses angular speed in radians.
- 34. C** — A climbing lane is provided so faster vehicles can pass trucks that slow on steep grades. It restores capacity and reduces platooning. It is a standard two-lane highway treatment.
- 35. C** — The engineer should decline to certify work outside their knowledge. Certifying unreviewed work misrepresents professional responsibility. Honesty and competence require refusal.
- 36. D** — The Pythagorean identity  $\sin^2\theta + \cos^2\theta = 1$  holds for every angle. It follows from the unit circle definition. It is foundational in trigonometry.
- 37. C** — Density  $k = q/v = 1,500/50 = 30$  veh/km. The fundamental traffic relation  $q = k \cdot v$  rearranges to  $k = q/v$ . The units of veh/hr over km/hr give veh/km.
- 38. C** — For a central point load, the maximum bending moment is at midspan under the load. Shear is zero there, where the moment peaks. The reactions are equal by symmetry.
- 39. D** — Hydrated cement paste is the binder that hardens and gives concrete its strength. It forms when cement reacts with water. Aggregates are inert filler bound by this paste.
- 40. C** — Resultant =  $\sqrt{(6^2 + 8^2)} = \sqrt{(36 + 64)} = \sqrt{100} = 10$  N. Perpendicular forces combine by the Pythagorean theorem. This is a 3-4-5 relationship scaled by two.
- 41. A** —  $Q = CiA/360 = 0.6 \times 30 \times 5/360 = 90/360 = 0.25$  m<sup>3</sup>/s. The metric rational method uses the 1/360 factor for these units. Peak flow scales with C, intensity, and area.
- 42. D** — A direct shear test measures the soil's angle of internal friction (and cohesion). It shears the sample along a forced plane under normal load. The strength envelope yields the friction angle.
- 43. D** — A fluid at rest exerts pressure perpendicular to any submerged surface. A static fluid sustains no shear, so the force is normal to the surface. This defines hydrostatic pressure.
- 44. C** — Labor time = bricks/rate =  $1,200/150 = 8$  hours. Dividing the quantity by the production rate gives the time. This is a productivity calculation.

- 45. A** — A higher modulus of elasticity means less deformation under a given stress. Modulus is the ratio of stress to strain, so a higher value yields smaller strain. Stiffer materials deflect less.
- 46. C** — Sequential critical activities add:  $3 + 5 = 8$  days. With a finish-to-start dependency and no overlap, durations sum. Both lie on the critical path.
- 47. A** —  $\delta = \sigma L/E = 100 \times 10^6 \times 1/200 \times 10^9 = 5 \times 10^{-4} \text{ m} = 0.5 \text{ mm}$ . Elongation equals stress times length over the modulus. The area cancels when stress is given.
- 48. A** —  $p = \gamma h = 9.81 \times 10 = 98.1 \text{ kPa}$ . Pressure equals specific weight times head. Ten meters of water produces about one atmosphere.
- 49. B** — The standard Proctor test determines the maximum dry density and the optimum moisture content. It compacts soil at varying water contents to find the peak. These values guide field compaction.
- 50. D** — Summing moments about a support point eliminates that support's unknown reaction, since its moment arm is zero. This isolates the other reaction. It is the standard technique for finding reactions.
- 51. D** — A well-graded soil contains a wide, continuous range of particle sizes. The range lets smaller grains fill the voids between larger ones. This produces dense packing.
- 52. A** — Deformed (ribbed) bars improve the mechanical bond between steel and concrete. The ribs resist slip, allowing stress transfer. Smooth bars bond poorly.
- 53. C** — Vertical component =  $F \sin \theta = 500 \times \sin 37^\circ = 500 \times 0.6018 = 300 \text{ N}$ . The sine resolves the force vertically. The  $37^\circ$  angle gives a 0.6 factor.
- 54. A** — A column under axial compression develops compressive normal stress. The load shortens the member along its axis. Stress equals load over cross-sectional area.
- 55. B** — By Bernoulli's principle, faster flow in the narrow section means lower pressure. Continuity raises velocity where the area shrinks, and energy conservation lowers the pressure. Velocity and pressure trade off.
- 56. C** — Primary treatment removes pollutants mainly by physical settling of solids. Heavy solids sink and are removed as sludge. Biological and chemical processes come later.
- 57. C** — A continuous beam over three supports has more reactions than the three equilibrium equations, making it indeterminate. The extra reaction is a redundant. Compatibility equations are needed to solve it.
- 58. B** — V-notch (triangular) weir discharge varies with head to the 2.5 power. The triangular geometry gives this stronger dependence than a rectangular weir's 1.5. It makes V-notches sensitive at low flows.
- 59. D** — A change order formally modifies the contract scope, price, or schedule. It documents agreed changes during construction. It is not a termination or the original bid.

- 60. D** — A manometer measures pressure difference from the height difference of a liquid column. The column height relates directly to pressure through  $\gamma h$ . It is a simple, direct device.
- 61. B** — Deflection limit = span/360 = 7,200/360 = 20 mm. The L/360 criterion controls serviceability deflection. Dividing the span by 360 gives the allowable value.
- 62. B** —  $47^{\circ}36' = 47 + 36/60 = 47.60^{\circ}$ . Each minute is one-sixtieth of a degree. Converting the minutes gives the decimal fraction.
- 63. A** —  $PW = F/(1 + i) = 20,000/1.10 = \$18,182$ . Discounting one year at 10% divides by 1.10. The present worth is less than the future amount.
- 64. D** — A beam fails in bending when the maximum stress reaches the material's flexural strength (modulus of rupture). This is the stress at which the extreme fiber breaks. It governs the bending capacity.
- 65. D** — More cement, all else equal, raises strength and increases the heat of hydration. The added binder produces more strength-giving paste but releases more heat. Excess heat can cause thermal cracking.
- 66. B** — Permeability (hydraulic conductivity) has units of length per time, such as m/s. It expresses the velocity of flow under a unit gradient. The units reflect Darcy's law.
- 67. B** — Braking distance increases with the square of speed. Kinetic energy to be dissipated grows as  $v^2$ , so stopping distance does too. Doubling speed roughly quadruples the distance.
- 68. A** — Volume = width  $\times$  depth  $\times$  length =  $1.2 \times 2 \times 50 = 120 \text{ m}^3$ . The trench is a rectangular prism. Multiplying the three dimensions gives the volume.
- 69. C** — The phreatic surface is the top boundary of seepage flow (the water table) within the dam. Below it the soil is saturated. Its location governs seepage and stability analysis.
- 70. B** — A stop sign requires the driver to stop and yield, giving right of way to cross traffic. It assigns priority to the uncontrolled movement. The stopped driver proceeds only when clear.
- 71. C** — Offering a payment to influence a contract award is bribery and an ethics violation. It corrupts fair competition and professional integrity. Codes of ethics strictly prohibit it.
- 72. D** — A two-force member in equilibrium carries forces that are equal, opposite, and collinear. Only such a force pair satisfies both force and moment balance. The force acts along the member's axis.
- 73. D** — Lateral bracing prevents lateral-torsional buckling of the compression flange. It restrains sideways movement and twist of the beam. Bracing the compression flange raises the buckling capacity.
- 74. B** — With a frictionless wall and no extra vertical load, the floor's vertical reaction equals the ladder's weight  $W$ . Vertical equilibrium requires the upward reaction to balance the weight. The wall provides only a horizontal reaction.

- 75. C** — A clay layer between two sand layers drains from both top and bottom, a double-drainage condition. The shorter drainage path speeds consolidation. Single drainage would take about four times as long.
- 76. A** — Hydrostatic force on a vertical gate grows with depth because pressure increases linearly with depth. Deeper points carry greater pressure. The resultant acts below the centroid.
- 77. B** — A soil with LL 65 and high plasticity is classified CH in the USCS. C denotes clay and H denotes high plasticity (LL over 50). It is a fat clay.
- 78. B** — Sealing documents for a project where one was not in responsible charge is an ethics violation, regardless of firm pressure. The seal certifies personal professional responsibility. It cannot be applied to unsupervised work.
- 79. A** — Delay per vehicle is the key measure used to assign a signalized intersection's level of service. The Highway Capacity Manual grades service by control delay. Higher delay means a poorer grade.
- 80. B** — The engineer must report a colleague's unsafe practice to the appropriate authority. The duty to protect the public overrides collegial loyalty. Ignoring or covering it would be unethical.
- 81. C** — Bearing capacity increases with friction angle, footing width, and depth, but the water table rising to the surface reduces it. Submergence lowers the effective unit weight and effective stress. This decreases the capacity.
- 82. D** — A contour line connects points of equal elevation. Contours map the terrain's vertical form. The interval between lines shows the elevation change.
- 83. B** —  $\text{Runoff} = \text{depth} \times \text{area} = 0.05 \text{ m} \times 20,000 \text{ m}^2 = 1,000 \text{ m}^3$ . A fully impervious lot ( $C = 1.0$ ) converts all rainfall to runoff. The 2 hectares equal  $20,000 \text{ m}^2$ .
- 84. D** — Compression members can buckle at a load below the yield strength, so buckling must be checked. Slender members fail by instability, not crushing. Euler's load sets the limit.
- 85. B** — Aeration adds oxygen and strips dissolved gases or odors from water. It also oxidizes iron and manganese. It is a physical gas-transfer process.
- 86. A** —  $\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2} \times 1,200 \times 25^2 = 375,000 \text{ J} = 375 \text{ kJ}$ . Kinetic energy varies with the square of velocity. The result converts to kilojoules.
- 87. B** — There are 6 ways to roll a 7 out of 36 outcomes, so  $P = 6/36 = 0.167$ . Seven is the most likely sum with two dice. The probability is one-sixth.
- 88. A** — In freezing forecasts, the contractor should take cold-weather concreting precautions such as heating and insulation. Freezing can disrupt hydration and damage fresh concrete. Adding water would worsen it.

- 89. D** —  $\ln(e^3) = 3$ , since the natural log and exponential are inverse functions. The logarithm returns the exponent. The base  $e$  cancels.
- 90. C** — A uniform load on a simple span gives equal reactions, each half the total load. Symmetry splits the load evenly. Each support carries  $wL/2$ .
- 91. D** — The polar moment of inertia of a solid circular shaft is  $\pi d^4/32$ . It governs torsional stiffness and stress. The fourth-power dependence makes diameter highly effective.
- 92. C** — By the power rule,  $d/dx(x^5) = 5x^4$ . The exponent multiplies the term and is reduced by one. This is a basic derivative.
- 93. C** — Time of concentration is the travel time from the most hydraulically remote point to the outlet. At this duration the whole watershed contributes. It sets the design storm duration.
- 94. A** — A total station records distance and angle data electronically for direct download. It integrates an EDM and a theodolite with data storage. This streamlines field-to-office data transfer.
- 95. D** — The energy grade line lies above the hydraulic grade line by the velocity head. The velocity head represents the flow's kinetic energy. Adding it to the HGL gives the total energy line.
- 96. B** — A pinned connection transfers force but not moment. It allows rotation, so no moment develops. This idealization simplifies frame analysis.
- 97. B** — Creep is the gradual time-dependent deformation of concrete under sustained load. It occurs slowly below the failure stress. Long-term loading and high stress increase it.
- 98. A** — Area =  $\int_0^3 2x \, dx = [x^2]_0^3 = 9$ . The definite integral of  $2x$  is  $x^2$  evaluated over the limits. The lower limit contributes zero.
- 99. C** — A geotextile between subgrade and base provides separation and filtration. It keeps the layers from mixing while allowing water to pass. This preserves the base's structural function.
- 100. A** — Stream discharge = cross-sectional area  $\times$  mean flow velocity. This is the continuity relationship for open-channel flow. Temperature and bank height do not enter it.
- 101. B** — For a central point load on a simple span, the maximum moment is  $PL/4$  at midspan. Each reaction is  $P/2$  and acts over  $L/2$ . Their product gives  $PL/4$ .
- 102. C** — Third angle =  $180^\circ - 50^\circ - 60^\circ = 70^\circ$ . The interior angles of a triangle sum to  $180^\circ$ . Subtracting the two known angles gives the third.
- 103. A** — Determining elevation differences with a level and graduated rod is differential leveling. Backsight and foresight readings yield the height difference. It is the standard vertical survey method.

**104. D** — The minimum acceptable return used to screen investments is the minimum attractive rate of return (MARR). Projects must meet or exceed it to be considered. It reflects the cost of capital and risk.

**105. C** — Equivalent concentrated force =  $w \times \text{length} = 4 \times 5 = 20 \text{ kN}$ . The total of a uniform load is its intensity times its length. It acts at the load's centroid.

**106. B** — Centripetal acceleration =  $v^2/r = 4^2/2 = 16/2 = 8 \text{ m/s}^2$ . It points toward the center of the circular path. Mass does not affect the acceleration value.

**107. B** — A couple is two equal, parallel forces, opposite in direction and separated by a distance. They produce a pure moment with no net force. The moment equals force times separation.

**108. C** —  $f(2) = 3(2^2) + 2(2) = 12 + 4 = 16$ . Substituting  $x = 2$  into the function gives the value. The terms sum to 16.

**109. B** — A one-way slab places main reinforcement perpendicular to the supports, spanning the short direction. The steel carries the bending in the span direction. Distribution steel runs the other way.

**110. B** — Computing coordinates from a known point using a line's latitude and departure is the method of latitudes and departures. The components add to the known coordinates. It builds traverse station positions.