PRACTICE EXAM 17 : FE CIVIL SIMULATION (110 QUESTIONS)

110 questions. Recommended time: 5 hours 20 minutes.

1. Using Manning's equation V = (1/n)R^(2/3)S^(1/2) with n = 0.013, R = 0.5 m, and S = 0.001, what is the velocity?

A. 0.77 m/s

B. 1.53 m/s

C. 3.06 m/s

D. 0.51 m/s

2. A gas is compressed isothermally. By Boyle's law, halving its volume will:

A. Double the absolute pressure

B. Halve the absolute pressure

C. Leave pressure unchanged

D. Quadruple the pressure

3. A ball is thrown horizontally at 12 m/s from a 20 m cliff. Using h = ½gt², how long until it reaches the ground?

A. 1.43 s

B. 2.02 s

C. 4.08 s

D. 1.67 s

4. What is the determinant of a 3×3 identity matrix?

A. 0

B. 3

C. 9

D. 1

5. $5,000 earns 4% compounded quarterly. What is the effective annual rate?

A. 4.06%

B. 4.00%

C. 1.00%

D. 16.0%

6. An activity has an early start of 5, a duration of 4, and a late finish of 12. What is its total float?

A. 0 days

B. 9 days

C. 7 days

D. 3 days

7. A backsight of 1.85 m is read on a benchmark at elevation 250.00 m. What is the height of instrument?

A. 248.15 m

B. 250.00 m

C. 251.85 m

D. 1.85 m

8. What is the angle whose tangent equals 1 (arctan 1)?

A. 30°

B. 60°

C. 90°

D. 45°

9. Water flows at 2 m/s in a pipe, then enters a section with twice the area. By continuity, the velocity in the larger section is:

A. 1 m/s

B. 4 m/s

C. 2 m/s

D. 0.5 m/s

10. An estimate that itemizes every material, labor, and equipment cost in detail is a:

A. Rough order-of-magnitude estimate

B. Conceptual estimate

C. Parametric estimate

D. Detailed (bottom-up) estimate

11. A geometric series has a first term of 3 and a common ratio of 2. What is its fourth term?

A. 12

B. 24

C. 48

D. 16

12. What is the pressure at the base of a 10 m water column ($\gamma = 9.81$ kN/m³)?

A. 10 kPa

B. 9.81 kPa

C. 981 kPa

D. 98.1 kPa

13. A simply supported beam of span 8 m carries a uniform load of 10 kN/m. What is the maximum bending moment?

A. 80 kN·m

B. 40 kN·m

C. 160 kN·m

D. 20 kN·m

14. A 300 N force acts at 53.13° above horizontal (sin = 0.8). What is its vertical component?

A. 180 N

B. 240 N

C. 300 N

D. 150 N

15. A steel rod (E = 200 GPa) is stressed to 160 MPa within the elastic range. What is its strain?

A. 4×10^{-4}

B. 8×10^{-4}

C. 1.25×10^{-3}

D. 1.6×10^{-3}

16. Crew productivity drops in extreme heat. To plan realistically, the estimator should apply a:

A. Productivity adjustment (efficiency) factor

B. Higher profit margin only

C. Liquidated damages clause

D. Reduced safety factor

17. A column's effective length factor K for a pinned-pinned end condition is:

A. 0.5

B. 2.0

C. 0.7

D. 1.0

18. $1,000 grows to $1,500 over 5 years. What is the total return over the period?

A. 10%

B. 50%

C. 5%

D. 150%

19. A truss member identified as a zero-force member, under the given loading, carries:

A. Maximum tension

B. Maximum compression

C. No axial force

D. Pure bending

20. A watershed has a runoff coefficient of 0.5. For a uniform rainfall, the runoff volume equals the rainfall volume times:

A. 0.5

B. 8.0

C. 4.0

D. 1.0

21. A doubly drained clay layer is 4 m thick. What is the longest drainage path?

A. 8 m

B. 4 m

C. 1 m

D. 2 m

22. A 12 m simply supported beam has a 60 kN point load 4 m from the left support. What is the left reaction?

A. 20 kN

B. 40 kN

C. 60 kN

D. 30 kN

23. A bar is loaded in pure shear. Its shear strain is related to shear stress through the:

A. Modulus of elasticity

B. Shear modulus (modulus of rigidity)

C. Poisson's ratio

D. Bulk modulus

24. A soil's degree of saturation is 50%, meaning the voids are:

A. Half filled with water and half with air

B. Completely filled with water

C. Completely dry

D. Filled with gas under pressure

25. A cantilever supports a 5 kN load at its free end, 3 m from the fixed support. What is the reaction moment at the support?

A. 5 kN·m

B. 15 kN·m

C. 1.67 kN·m

D. 8 kN·m

26. A fluid has a specific gravity of 1.6. What is its density?

A. 0.625 kg/m^3

B. 16,000 kg/m^3

C. 1,600 kg/m^3

D. 160 kg/m^3

27. What is the slope of a line perpendicular to a line of slope 2?

A. 2

B. −2

C. −1/2

D. 1/2

28. A pile driven to refusal on bedrock functions primarily as a(n):

A. End-bearing pile

B. Friction pile

C. Floating foundation

D. Mat foundation

29. A traverse closure error distributed proportionally to course lengths uses the:

A. Transit rule

B. Crandall method

C. Compass (Bowditch) rule

D. Least-squares method

30. Concrete workability is most commonly measured by the:

A. Compression test

B. Modulus of rupture

C. Slump test

D. Rebound hammer

31. Compared with two separate simple spans, a continuous two-span beam generally has:

A. Larger midspan moments

B. No support reactions

C. Zero deflection

D. Smaller midspan moments due to support continuity

32. What is the probability of drawing an ace from a standard 52-card deck?

A. 0.25

B. 0.077

C. 0.50

D. 0.04

33. A 200.00 m distance is measured along a 10% grade slope. What is its horizontal component?

A. 199.0 m

B. 180.0 m

C. 200.0 m

D. 220.0 m

34. An engineer is asked to design a structure that will be used in a way violating environmental regulations. The engineer should:

A. Decline to participate in the unlawful use

B. Proceed since the client is responsible

C. Proceed but charge a higher fee

D. Design it and report nothing

35. For a body in equilibrium under three forces, the force polygon must:

A. Form an open triangle

B. Close, with the forces forming a closed polygon

C. Be a straight line always

D. Have a net resultant

36. An engineer learns of a safety-related defect in a product already in service. The engineer's duty is to:

A. Keep silent to protect the manufacturer

B. Wait for a lawsuit

C. Discuss it only internally and take no further action

D. Disclose the risk to the appropriate authorities

37. A simply supported beam under uniform load has a deflected shape that is:

A. A smooth downward (sagging) curve, maximum at midspan

B. A straight horizontal line

C. An upward arch

D. A sharp V at midspan

38. A pump is 75% efficient and the hydraulic power required is 15 kW. What is the input power?

A. 11.25 kW

B. 20 kW

C. 15 kW

D. 75 kW

39. $2,500 is borrowed at 8% simple interest for 2 years. What total amount must be repaid?

A. $2,540

B. $2,700

C. $2,900

D. $3,200

40. Aggregate that passes a 4.75 mm sieve is classified as:

A. Coarse aggregate

B. Cobbles

C. Boulders

D. Fine aggregate

41. A two-lane highway carries 1,000 veh/hr one way and 800 the other. What is the total two-way volume?

A. 1,800 veh/hr

B. 200 veh/hr

C. 900 veh/hr

D. 1,000 veh/hr

42. A 4 kg block slides on a surface with a kinetic friction coefficient of 0.25. Using $g = 9.81\ m/s^2$, what is the friction force?

A. 1.0 N

B. 9.81 N

C. 39.2 N

D. 4.0 N

43. A simply supported beam carries two equal point loads placed symmetrically. The two reactions are:

A. Unequal

B. Zero

C. Each equal to the total load

D. Equal, each half the total load

44. A 1,000 kg car brakes from 20 m/s to rest over 40 m. Using the work-energy theorem, what is the average braking force?

A. 500 N

B. 10,000 N

C. 250 N

D. 5,000 N

45. In a critical-lane analysis, the sum of flow ratios should be kept below a practical limit of about:

A. 0.30

B. 0.50

C. 0.85–0.95

D. 2.0

46. A rectangular beam's depth is doubled with width unchanged. By $I = bh^3/12$, its moment of inertia increases by a factor of:

A. 2

B. 4

C. 8

D. 16

47. A steel tension member's design strength is the lesser of the yielding and rupture values multiplied by their:

A. Resistance factors (φ)

B. Load factors

C. Slenderness ratios

D. Section moduli

48. A bar bending schedule on a construction project lists the:

A. Cutting and bending details of reinforcing steel

B. Sequence of concrete pours

C. Daily labor hours

D. Equipment rental rates

49. What does e^0 equal?

A. 0

B. 1

C. e

D. Undefined

50. The head loss in a 500 m pipe is 8 m. What is the hydraulic gradient?

A. 4,000

B. 62.5

C. 0.16

D. 0.016

51. A signalized intersection is rated worst (LOS F) when the:

A. Control delay per vehicle is very high

B. Volume is zero

C. Green time is maximized

D. Cycle length is shortest

52. A retaining wall's weep holes and granular backfill are provided to:

A. Increase the active earth pressure

B. Add weight to the wall

C. Relieve hydrostatic pressure behind the wall

D. Improve the wall's appearance

53. A bearing of S 30° W converts to an azimuth of:

A. 30°

B. 150°

C. 210°

D. 330°

54. The optimum moisture content from a compaction test is the water content giving the:

A. Lowest dry density

B. Maximum dry density

C. Highest permeability

D. Maximum void ratio

55. Under a uniform load, a beam's shear diagram is a sloping straight line and its bending moment diagram is:

A. A parabola

B. A straight horizontal line

C. A series of steps

D. A vertical line

56. A soil that swells when wetted and shrinks when dried is characteristic of:

A. Clean sand

B. Gravel

C. Silt with no clay

D. Expansive (high-plasticity) clay

57. Flow in a closed conduit is laminar when the Reynolds number is below about:

A. 10,000

B. 100,000

C. 4,000

D. 2,000

58. A two-dimensional rigid body has how many degrees of freedom?

A. 3

B. 2

C. 6

D. 1

59. What is the value of $2^3 \times 2^4$?

A. 2^{12}

B. 4^{7}

C. 2^{1}

D. 2^{7}

60. A column loaded above its critical buckling load will:

A. Buckle (become laterally unstable)

B. Remain perfectly straight

C. Carry the load with no deflection

D. Yield only in tension

61. What is the hydraulic radius of a full circular pipe of diameter D?

A. D/2

B. D/4

C. D

D. $\pi D/4$

62. An allowable bearing pressure for a footing on sand primarily limits:

A. The soil's friction angle

B. The water table depth

C. The footing's weight

D. Settlement to a tolerable amount

63. A projectile is launched vertically at 30 m/s. Using $h = v^2/(2g)$, what maximum height does it reach?

A. 91.7 m

B. 15.3 m

C. 30.6 m

D. 45.9 m

64. A survey angle is measured four times and averaged. This primarily reduces:

A. Systematic error

B. Blunders

C. Random error

D. Instrument calibration error

65. A standard penetration test blow count of N = 4 in sand indicates the sand is:

A. Very dense

B. Loose

C. Cemented rock

D. Overconsolidated clay

66. A state grants professional engineering licenses primarily to:

A. Protect the public by ensuring minimum competence

B. Guarantee the engineer high income

C. Restrict competition in the market

D. Exempt the engineer from liability

67. A 100 N force acts at the end of a 0.5 m lever arm, perpendicular to it. What is the moment?

A. 200 N·m

B. 50 N·m

C. 100 N·m

D. 25 N·m

68. A roadway's design speed is the maximum safe speed under favorable conditions, used to set:

A. Geometric design elements such as curves and sight distances

B. The posted speed limit always

C. The pavement color

D. The toll rate

69. A project has cash flows of −$10,000 now and +$12,000 in one year. At 0% interest, what is the net present value?

A. $0

B. −$2,000

C. $22,000

D. $2,000

70. The Mohr-Coulomb failure criterion expresses soil shear strength as:

A. σ only

B. $c + \sigma \tan\varphi$

C. σ/2

D. φ alone

71. A surveyor sets out the corners and grade of a building before construction. This process is called:

A. Compaction testing

B. Material sampling

C. Construction layout (staking)

D. Concrete curing

72. A US reinforcing bar designated "#8" has a nominal diameter of approximately:

A. 8 mm

B. 8 inches

C. 1/8 inch

D. 1 inch

73. The available friction and superelevation on a horizontal curve must supply the required:

A. Braking force only

B. Aerodynamic drag

C. Engine power

D. Centripetal (lateral) acceleration

74. What is the integral of x with respect to x?

A. $x^2/2 + C$

B. $1 + C$

C. $x^2 + C$

D. $2x + C$

75. A loan's effective annual rate exceeds its nominal APR when interest is:

A. Paid only at maturity

B. Fixed for the term

C. Simple

D. Compounded more than once per year

76. A bolt fails by shearing across its cross-section. This is a:

A. Tension failure

B. Shear failure

C. Bending failure

D. Bearing failure of the plate

77. A soil with a uniformity coefficient near 1 is:

A. Well-graded

B. Gap-graded

C. Poorly graded (uniform)

D. Highly plastic

78. A triangle has sides of 5, 12, and 13. It is a:

A. Equilateral triangle

B. Obtuse triangle

C. Right triangle

D. Isosceles triangle

79. A geotechnical boring log records the soil profile, sample depths, and:

A. The contractor's bid

B. The pavement design

C. The traffic volume

D. Groundwater (water table) observations

80. A real-time kinematic (RTK) GPS survey achieves centimeter accuracy using:

A. A single uncorrected receiver

B. A magnetic compass

C. Barometric pressure

D. A base station broadcasting corrections to a rover

81. The fundamental diagram of traffic flow relates flow, speed, and:

A. Pavement thickness

B. Density

C. Cost

D. Lane width

82. A 3 kg mass moves at 6 m/s. What is its momentum?

A. 18 kg·m/s

B. 9 kg·m/s

C. 54 kg·m/s

D. 2 kg·m/s

83. An engineer is pressured to reduce a design's safety margin below code to save cost. The engineer should:

A. Reduce it as requested

B. Reduce it slightly as a compromise

C. Refuse and maintain code-required safety

D. Reduce it only if undocumented

84. A 2 km² catchment is 60% impervious. With impervious C = 0.9 and pervious C = 0.2, what is the composite runoff coefficient?

A. 0.45

B. 0.62

C. 0.90

D. 0.20

85. A material's stiffness in tension is characterized by its:

A. Yield strength

B. Ductility

C. Hardness

D. Modulus of elasticity

86. The horizontal hydrostatic force on a submerged vertical gate is computed using the pressure at the gate's:

A. Top edge

B. Bottom edge

C. Centroid

D. Free surface

87. An engineer reviews a colleague's work and finds an error. The professional approach is to:

A. Publicly criticize the colleague

B. Conceal the error

C. Inform the colleague constructively so it can be corrected

D. Report the colleague to the police

88. A detention pond reduces a storm's peak outflow relative to peak inflow by providing:

A. Temporary storage that delays and attenuates the flow

B. Additional rainfall

C. A steeper channel slope

D. A larger runoff coefficient

89. A fillet-welded connection is designed based on the weld's:

A. Color

B. Length only

C. Bolt diameter

D. Effective throat area and strength

90. A flow of 0.5 m^3/s passes through a channel 2 m wide and 0.5 m deep. What is the velocity?

A. 2 m/s

B. 0.5 m/s

C. 1 m/s

D. 0.25 m/s

91. A shaft transmits 10 kW at 100 rad/s. Using $T = P/\omega$, what is the torque?

A. 1,000,000 N·m

B. 10 N·m

C. 1,000 N·m

D. 100 N·m

92. The "first flush" in urban stormwater refers to:

A. The initially high pollutant concentration in early runoff

B. The peak flood discharge

C. The cleanest portion of runoff

D. The groundwater recharge

93. Pavement fatigue cracking is caused primarily by:

A. A single overload event

B. Frost heave only

C. Repeated traffic loading over time

D. The pavement color

94. A retaining wall is most stable and economical when the resultant of forces falls within the:

A. Top third of the stem

B. Backfill zone

C. Middle third of the base

D. Toe only

95. The interior angles of a closed five-sided traverse should sum to:

A. 540°

B. 360°

C. 720°

D. 180°

96. An admixture added to slow concrete's setting time in hot weather is a:

A. Accelerator

B. Air-entraining agent

C. Retarder

D. Superplasticizer

97. In the construction safety hierarchy of controls, the most effective control is:

A. Personal protective equipment

B. Warning signs

C. Elimination of the hazard

D. Administrative procedures

98. A material loaded and unloaded repeatedly within its elastic region will:

A. Return to its original shape each time

B. Accumulate permanent deformation each cycle

C. Fail on the first cycle

D. Increase in stiffness

99. A breakeven analysis finds the point where:

A. Profit is maximized

B. Costs are zero

C. Total revenue equals total cost

D. Depreciation ends

100. A simply supported beam with a central point load has a bending moment diagram shaped as:

A. A rectangle

B. A parabola

C. A triangle peaking at midspan

D. A constant value throughout

101. A water sample's turbidity measures the:

A. Cloudiness from suspended particles

B. Dissolved oxygen content

C. Total hardness

D. Chlorine residual

102. The primary reinforcement in a simply supported reinforced concrete beam is placed near the:

A. Top face throughout

B. Neutral axis

C. Bottom face at midspan

D. Supports only

103. A sanitary sewer is designed to flow:

A. Partially full under gravity at a self-cleaning velocity

B. Always completely full under pressure

C. Uphill against gravity

D. Backward during peak flow

104. A construction project's punch list is prepared:

A. Before bidding

B. Near completion, listing items to finish or correct

C. During the geotechnical survey

D. To set the contract price

105. Checking a steel beam for deflection under service loads is a:

A. Strength limit state

B. Serviceability limit state

C. Fatigue limit state

D. Stability limit state

106. The slump of concrete is too low for proper placement. The best remedy without weakening the concrete is to:

A. Add water on site

B. Reduce the cement content

C. Add a water-reducing admixture (superplasticizer)

D. Increase the aggregate size

107. A traffic signal that adjusts its timing in real time based on detected demand is:

A. A fixed-time (pretimed) signal

B. An actuated (adaptive) signal

C. A flashing beacon

D. A stop sign

108. A pipe carrying 0.2 m^3/s is replaced by two parallel pipes sharing the flow equally. Each new pipe carries:

A. 0.4 m^3/s

B. 0.1 m^3/s

C. 0.2 m^3/s

D. 0.05 m^3/s

109. A roundabout improves intersection safety primarily by:

A. Increasing vehicle speeds

B. Adding more conflict points

C. Reducing the number and severity of conflict points

D. Eliminating the need for any signs

110. A roller support on a beam provides:

A. A moment and a force

B. A horizontal force only

C. A single reaction perpendicular to the rolling surface

D. Three reaction components

PRACTICE EXAM 17 — ANSWER KEY AND EXPLANATIONS

1. B — V = (1/0.013)(0.5^0.667)(0.001^0.5) = 76.9 × 0.630 × 0.0316 = 1.53 m/s. Manning's equation gives open-channel velocity from roughness, hydraulic radius, and slope. The two-thirds power on R dominates.

2. A — By Boyle's law, pressure and volume are inversely related at constant temperature, so halving the volume doubles the pressure. The product pV stays constant. This is isothermal compression.

3. B — $t = \sqrt{(2h/g)} = \sqrt{(2 \times 20/9.81)} = \sqrt{4.08} = 2.02$ s. Horizontal launch leaves the vertical motion as free fall. The horizontal speed does not affect the fall time.

4. D — The determinant of any identity matrix is 1. Its diagonal entries are all 1 with zeros elsewhere. The product of the diagonal gives one.

5. A — Effective rate = $(1 + 0.04/4)^4 - 1 = (1.01)^4 - 1 = 0.0406 = 4.06\%$. Quarterly compounding raises the effective rate above the 4% nominal. Interest earns interest within the year.

6. D — Total float = LF − (ES + duration) = 12 − (5 + 4) = 3 days. Float is the slack between the latest finish and the earliest possible finish. Three days of delay are available.

7. C — Height of instrument = benchmark + backsight = 250.00 + 1.85 = 251.85 m. The backsight raises the line of sight above the known point. Foresights are later subtracted from this value.

8. D — arctan(1) = 45°, since tan 45° = 1. The tangent equals one when the opposite and adjacent sides are equal. This is a standard angle.

9. A — By continuity $A_1V_1 = A_2V_2$, so doubling the area halves the velocity: 2/2 = 1 m/s. A larger area carries the same flow more slowly. Mass is conserved.

10. D — A detailed (bottom-up) estimate itemizes every material, labor, and equipment cost. It is the most accurate and time-consuming estimate type. Conceptual and parametric estimates are quicker approximations.

11. B — Fourth term = $a \cdot r^3 = 3 \times 2^3 = 3 \times 8 = 24$. Each term multiplies the previous by the common ratio. Three doublings give 24.

12. D — $p = \gamma h = 9.81 \times 10 = 98.1$ kPa. Pressure increases linearly with depth. Ten meters of water gives about one atmosphere.

13. A — $M_{max} = wL^2/8 = 10 \times 8^2/8 = 80$ kN·m. For a uniformly loaded simple span, the peak moment is at midspan. This is the standard result.

14. B — Vertical component = F sin θ = 300 × 0.8 = 240 N. The sine resolves the force vertically. At 53.13° the sine is 0.8.

15. B — $\varepsilon = \sigma/E = 160\times10^{6}/200\times10^{9} = 8\times10^{-4}$. Within the elastic range, strain is stress divided by the modulus. The ratio is dimensionless.

16. A — A productivity (efficiency) adjustment factor accounts for reduced output in extreme heat. It scales the ideal production to realistic field conditions. This keeps the estimate accurate.

17. D — A pinned-pinned column has an effective length factor K of 1.0. The effective length equals the actual length. Other end conditions raise or lower K.

18. B — Total return = (1,500 − 1,000)/1,000 = 50%. The gain over the period is divided by the initial amount. This is the cumulative, not annual, return.

19. C — A zero-force member carries no axial force under the given loading. It exists for stability or to handle other load cases. It can be identified by joint inspection.

20. A — The runoff volume equals the rainfall volume times the runoff coefficient, here 0.5. The coefficient is the fraction of rainfall that becomes runoff. The rest infiltrates or evaporates.

21. D — In a doubly drained layer, the longest drainage path is half the thickness: 4/2 = 2 m. Water escapes through both the top and bottom boundaries. The shorter path speeds consolidation.

22. B — Left reaction = P × (distance from right)/span = 60 × 8/12 = 40 kN. Taking moments about the right support isolates the left reaction. The load is nearer the left, so it carries more.

23. B — In pure shear, shear strain relates to shear stress through the shear modulus (modulus of rigidity). It is the shear analog of Young's modulus. It governs torsional and shear deformation.

24. A — A degree of saturation of 50% means the voids are half filled with water and half with air. Saturation is the fraction of void volume occupied by water. Full saturation would be 100%.

25. B — Reaction moment = P × L = 5 × 3 = 15 kN·m at the fixed support. A cantilever's fixed end resists the full moment of the end load. It is the maximum moment in the beam.

26. C — Density = specific gravity × 1,000 = 1.6 × 1,000 = 1,600 kg/m³. Specific gravity compares the fluid's density to water's. Multiplying by water's density recovers it.

27. C — The perpendicular slope is the negative reciprocal: −1/2. Perpendicular lines have slopes whose product is −1. The reciprocal of 2 is 1/2, negated.

28. A — A pile driven to refusal on bedrock acts as an end-bearing pile. The hard rock at the tip carries the load. Friction piles instead rely on shaft resistance.

29. C — The compass (Bowditch) rule distributes closure error in proportion to course lengths. It assumes errors grow with distance. It is a standard traverse adjustment.

30. C — The slump test measures concrete workability. A higher slump indicates a wetter, more workable mix. It does not measure hardened strength.

31. D — A continuous beam develops negative support moments that relieve the positive midspan moments, making them smaller than in simple spans. Continuity redistributes the bending. This makes continuous beams more efficient.

32. B — P(ace) = 4/52 = 1/13 = 0.077. Four aces exist among 52 cards. The probability is about 7.7%.

33. A — Horizontal distance = S cos(arctan 0.10) = 200 × cos 5.71° = 200 × 0.995 = 199.0 m. The 10% grade corresponds to a small angle. The slope correction is minor.

34. A — The engineer should decline to participate in the unlawful use. Knowingly aiding a regulatory violation breaches professional ethics. The client's responsibility does not absolve the engineer.

35. B — For three forces in equilibrium, the force polygon must close. A closed triangle means the vector sum is zero. An open polygon would indicate an unbalanced resultant.

36. D — The engineer must disclose a safety-related defect to the appropriate authorities. Public safety is paramount and overrides loyalty to the manufacturer. Silence would be unethical.

37. A — A uniformly loaded simple beam deflects into a smooth sagging curve, maximum at midspan. The supports remain at zero deflection. The shape follows the bending it experiences.

38. B — Input power = hydraulic power/efficiency = 15/0.75 = 20 kW. Losses make the input exceed the useful output. Lower efficiency requires more input.

39. C — Total = principal + simple interest = 2,500 + 2,500 × 0.08 × 2 = 2,500 + 400 = $2,900. Simple interest accrues only on the principal. No compounding occurs.

40. D — Aggregate passing the 4.75 mm sieve is fine aggregate (sand). Coarse aggregate is retained on that sieve. The 4.75 mm size is the standard dividing point.

41. A — Total two-way volume = 1,000 + 800 = 1,800 veh/hr. Directional flows add to give the total. Conservation of vehicles applies.

42. B — Friction force = $\mu N = 0.25 \times 4 \times 9.81 = 9.81$ N. The normal force equals the weight on a level surface. Kinetic friction opposes the sliding motion.

43. D — Two symmetric equal loads give equal reactions, each half the total load. Symmetry splits the load evenly between supports. Each reaction equals the sum of loads divided by two.

44. D — $F = \frac{1}{2}mv^2/d = \frac{1}{2}(1{,}000)(20^2)/40 = 200{,}000/40 = 5{,}000$ N. The braking work equals the initial kinetic energy. Force is that energy divided by distance.

45. C — The sum of critical-lane flow ratios should stay below about 0.85–0.95 (the practical capacity limit). Beyond this the intersection becomes oversaturated. It bounds the usable green allocation.

46. C — Since $I = bh^3/12$, doubling the depth multiplies I by $2^3 = 8$. The cube on depth makes it highly effective. This is why beams are deep.

47. A — A tension member's design strength is the lesser limit-state nominal strength times its resistance factor φ. LRFD reduces nominal strength by φ. The governing (smaller) value controls.

48. A — A bar bending schedule lists the cutting and bending details of reinforcing steel. It guides fabrication and placement. It specifies bar marks, shapes, and lengths.

49. B — $e^0 = 1$. Any nonzero base raised to the zero power equals one. The exponential function passes through (0, 1).

50. D — Hydraulic gradient = head loss/length = 8/500 = 0.016. It is the slope of the energy line along the pipe. A steeper gradient means greater loss per unit length.

51. A — Level of service F occurs when the control delay per vehicle is very high. High delay reflects oversaturated, failing operation. Zero volume would instead give the best service.

52. C — Weep holes and granular backfill relieve hydrostatic pressure behind a retaining wall. They drain water that would otherwise add lateral load. This reduces the pressure the wall must resist.

53. C — S 30° W converts to azimuth = 180° + 30° = 210°. Southwest bearings fall in the third azimuth quadrant. The azimuth is measured clockwise from north.

54. B — The optimum moisture content yields the maximum dry density in a compaction test. It is the water content at the peak of the compaction curve. Field compaction targets it.

55. A — A linearly varying shear (under uniform load) integrates to a parabolic bending moment diagram. The moment is the integral of the shear. Its peak is where shear crosses zero.

56. D — Swelling when wet and shrinking when dry characterizes expansive (high-plasticity) clay. The clay minerals absorb and release water with large volume change. This threatens light structures.

57. D — Pipe flow is laminar below a Reynolds number of about 2,000. Viscous forces dominate in this regime. Above roughly 4,000 the flow is turbulent.

58. A — A two-dimensional rigid body has three degrees of freedom: two translations and one rotation. These define its position and orientation in a plane. Three equilibrium equations match them.

59. D — $2^3 \times 2^4 = 2^{(3+4)} = 2^7$. Multiplying powers of the same base adds the exponents. The result is 2^7, or 128.

60. A — A column loaded above its critical buckling load will buckle, becoming laterally unstable. The straight configuration is no longer stable. Buckling can occur before yielding in slender columns.

61. B — For a full circular pipe, $R = A/P = (\pi D^2/4)/(\pi D) = D/4$. The hydraulic radius is the area over the wetted perimeter. It equals one-quarter of the diameter.

62. D — An allowable bearing pressure on sand primarily limits settlement to a tolerable amount. Sand settlement, not shear failure, usually governs footing design. The pressure is set to control movement.

63. D — $h = v^2/(2g) = 30^2/(2 \times 9.81) = 900/19.62 = 45.9$ m. At the apex the velocity is zero, converting kinetic energy to height. Gravity sets the maximum rise.

64. C — Averaging repeated angle measurements reduces random error. Random errors tend to cancel over many readings. Systematic errors and blunders require other corrections.

65. B — An SPT N-value of 4 in sand indicates loose sand. Low blow counts mean low density. Dense sand would give much higher N-values.

66. A — A professional license protects the public by ensuring minimum competence. The state verifies education, experience, and examination. It is a public-safety mechanism, not an income guarantee.

67. B — Moment = force × lever arm = $100 \times 0.5 = 50$ N·m. The force acts perpendicular to the arm, so the full distance applies. Moment is the turning effect.

68. A — Design speed sets the geometric design elements such as curve radii and sight distances. It is the basis for safe alignment design. It need not equal the posted limit.

69. D — At 0% interest there is no discounting, so NPV = −10,000 + 12,000 = $2,000. Future dollars equal present dollars with no time value of money. The net is the simple sum.

70. B — The Mohr-Coulomb criterion gives shear strength as $c + \sigma \tan\varphi$. Cohesion and frictional resistance combine to resist shear. It is the standard soil strength model.

71. C — Setting out a building's corners and grade before construction is construction layout (staking). It transfers the design to the ground. Stakes guide the contractor's work.

72. D — A US "#8" bar has a nominal diameter of 1 inch (8 eighths of an inch). The bar number gives the diameter in eighths. So #8 is 8/8 = 1 inch.

73. D — Friction and superelevation on a horizontal curve supply the required centripetal (lateral) acceleration. Together they balance the centrifugal demand. Insufficient amounts cause skidding.

74. A — $\int x\,dx = x^2/2 + C$. The power rule raises the exponent and divides by the new power. The constant of integration is added.

75. D — The effective rate exceeds the nominal APR when interest is compounded more than once per year. Each compounding period earns interest on prior interest. More frequent compounding widens the gap.

76. B — A bolt failing across its cross-section is a shear failure. The shear plane cuts through the bolt body. Tension and bearing are separate failure modes.

77. C — A uniformity coefficient near 1 indicates poorly graded (uniform) soil. The grain sizes span a narrow range. Well-graded soils have higher uniformity coefficients.

78. C — Since $5^2 + 12^2 = 25 + 144 = 169 = 13^2$, the triangle is a right triangle. The Pythagorean relation confirms a right angle opposite the longest side. This is a common Pythagorean triple.

79. D — A boring log records the soil profile, sample depths, and groundwater (water table) observations. The water level is essential for design. It documents the subsurface conditions.

80. D — RTK GPS achieves centimeter accuracy using a base station that broadcasts corrections to a rover. The known base position lets the rover correct its readings in real time. This removes much of the GPS error.

81. B — The fundamental diagram relates flow, speed, and density. These three traffic variables are linked by $q = k \cdot v$. The diagram shows their interdependence.

82. A — Momentum = $mv = 3 \times 6 = 18$ kg·m/s. Momentum is mass times velocity. It is conserved in isolated collisions.

83. C — The engineer must refuse and maintain the code-required safety margin. Reducing safety below code endangers the public. Cost pressure does not justify compromising safety.

84. B — Composite $C = 0.6 \times 0.9 + 0.4 \times 0.2 = 0.54 + 0.08 = 0.62$. The area-weighted average combines the impervious and pervious fractions. Each land type contributes by its share.

85. D — A material's tensile stiffness is characterized by its modulus of elasticity. Modulus is the ratio of stress to strain in the elastic range. A higher modulus means a stiffer material.

86. C — The horizontal force on a submerged vertical gate uses the pressure at the gate's centroid times its area. Pressure varies with depth, and the centroid gives the average. The resultant acts below the centroid.

87. C — The professional approach is to inform the colleague constructively so the error can be corrected. This respects the colleague while protecting the work's integrity. Public criticism or concealment would be improper.

88. A — A detention pond provides temporary storage that delays and attenuates flow, lowering the peak outflow. Storing part of the runoff spreads its release over time. This protects downstream channels.

89. D — A fillet weld is designed based on its effective throat area and strength. The throat is the critical shear plane. The weld size and length set its capacity.

90. B — $V = Q/A = 0.5/(2 \times 0.5) = 0.5/1 = 0.5$ m/s. Velocity is the discharge divided by the flow area. The channel area is one square meter.

91. D — $T = P/\omega = 10{,}000/100 = 100$ N·m. Torque equals power divided by angular speed. Consistent units (watts and rad/s) give newton-meters.

92. A — The first flush refers to the initially high pollutant concentration in early storm runoff. Accumulated surface pollutants wash off first. Capturing it improves water quality.

93. C — Pavement fatigue cracking is caused by repeated traffic loading over time. Each load cycle adds damage until cracks form. It is a cumulative, not single-event, failure.

94. C — A retaining wall is most stable when the resultant falls within the middle third of the base. This keeps the entire base in compression with no uplift. It avoids tension at the heel.

95. A — Interior angles of a five-sided traverse sum to $(5 - 2) \times 180° = 540°$. The polygon angle-sum formula gives the theoretical total. Misclosure is the difference from this value.

96. C — A retarder slows concrete's setting time, useful in hot weather. It delays hydration to allow placement and finishing. Accelerators do the opposite.

97. C — Elimination of the hazard is the most effective control in the safety hierarchy. Removing the hazard entirely is preferable to controlling exposure. PPE is the least effective, last line.

98. A — A material cycled within its elastic range returns to its original shape each time. Elastic strain is fully recoverable. Permanent deformation requires exceeding the yield point.

99. C — Breakeven occurs where total revenue equals total cost. At that point profit is zero. Beyond it the venture becomes profitable.

100. C — A central point load gives a bending moment diagram shaped as a triangle peaking at midspan. The moment rises linearly from each support to the load. Its maximum is $PL/4$.

101. A — Turbidity measures the cloudiness of water from suspended particles. It indicates the amount of light-scattering matter present. High turbidity signals poor clarity.

102. C — The main tension reinforcement of a simply supported beam is placed near the bottom face at midspan. That is where flexural tension is greatest. The steel carries the tension the concrete cannot.

103. A — A sanitary sewer is designed to flow partially full under gravity at a self-cleaning velocity. Partial flow allows ventilation and surge capacity. Adequate velocity prevents solids from settling.

104. B — A punch list is prepared near completion, listing items to finish or correct. It identifies remaining deficiencies before final acceptance. It guides closeout.

105. B — Checking deflection under service loads is a serviceability limit state. It addresses function and comfort rather than collapse. Strength limit states instead govern safety against failure.

106. C — A water-reducing admixture (superplasticizer) raises slump without adding water, preserving strength. Adding water on site would increase the water-cement ratio and weaken the concrete. The admixture improves workability safely.

107. B — An actuated (adaptive) signal adjusts its timing in real time based on detected demand. Detectors sense vehicles and modify the phases. A fixed-time signal cannot respond to demand.

108. B — Each parallel pipe carries half the flow: $0.2/2 = 0.1$ m^3/s. The total discharge splits equally between identical pipes. Conservation of mass requires the parts to sum to the whole.

109. C — A roundabout improves safety by reducing the number and severity of conflict points. Slower, one-directional circulation eliminates high-speed crossing conflicts. This lowers crash severity.

110. C — A roller support provides a single reaction perpendicular to the rolling surface. It permits movement along the surface and rotation. It supplies no moment and no parallel force.