PRACTICE EXAM 18: FE CIVIL SIMULATION (110 QUESTIONS)

110 questions. Recommended time: 5 hours 20 minutes.

1. Water flows at 2.5 m/s through a pipe of internal diameter 0.4 m. What is the volumetric flow rate?

A. 0.10 m^3/s

B. 0.63 m^3/s

C. 0.31 m^3/s

D. 1.00 m^3/s

2. What is the future worth of $3,000 invested for 4 years at 10% compounded annually?

A. $4,392

B. $3,300

C. $4,000

D. $5,000

3. A 9 kN force and a 12 kN force act at right angles at a point. What is the magnitude of their resultant?

A. 15 kN

B. 21 kN

C. 3 kN

D. 108 kN

4. A soil has a dry unit weight of 16 kN/m^3 and Gs = 2.70. What is its void ratio (γw = 9.81 kN/m^3)?

A. 0.40

B. 1.66

C. 0.27

D. 0.65

5. Short-duration traffic counts must be converted to annual average daily traffic by applying:

A. The pavement type factor

B. The number of lanes

C. Seasonal and daily adjustment factors

D. The posted speed limit

6. A simply supported beam of span 4 m carries a uniformly distributed load of 10 kN/m. What is the maximum bending moment?

A. 20 kN·m

B. 40 kN·m

C. 80 kN·m

D. 5 kN·m

7. Solve for x: $5x + 3 = 28$.

A. 31

B. 25

C. 6

D. 5

8. The coefficient of thermal expansion of structural steel is approximately:

A. 1.2×10^{-3} /°C

B. 12×10^{-6} /°C

C. 0.5 /°C

D. 200×10^{-6} /°C

9. Critical flow in an open channel corresponds to the minimum:

A. Channel longitudinal slope

B. Average flow velocity

C. Wetted perimeter

D. Specific energy for a given discharge

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

A. 30 kJ

B. 150 kJ

C. 375 kJ

D. 750 kJ

11. The most common method of disinfecting wastewater effluent before discharge is:

A. Coagulation with alum

B. Chlorination or UV disinfection

C. Primary sedimentation

D. Aeration alone

12. A slope distance of 30 m is measured along a slope that rises 4 m vertically. What is the horizontal distance?

A. 34 m

B. 26 m

C. 30 m

D. 29.7 m

13. The total settlement of a footing on clay includes immediate settlement, primary consolidation, and:

A. Frost heave

B. Secondary compression (creep)

C. Liquefaction

D. Surface erosion

14. A $20,000 loan at 8% per year is repaid in a single payment after 3 years. What amount is owed?

A. $24,800

B. $22,400

C. $25,194

D. $28,000

15. A cantilever beam 2 m long carries a 5 kN load at its free end. What is the reaction moment at the fixed support?

A. 5 kN·m

B. 10 kN·m

C. 2.5 kN·m

D. 20 kN·m

16. Bernoulli's equation cannot be applied directly across a:

A. Smooth straight pipe

B. Gradual contraction

C. Pump or major energy loss

D. Horizontal streamline

17. The braking distance of a vehicle increases with the:

A. Square of its speed

B. Inverse of its speed

C. Pavement width

D. Number of lanes

18. For a simply supported beam under a uniform load, the maximum bending moment occurs where the:

A. Reaction is largest

B. Deflection is zero

C. Load first begins

D. Shear force is zero

19. What is the derivative of x^{-1}?

A. $-1/x^2$

B. $1/x^2$

C. $\ln(x)$

D. x

20. Field soil compaction is verified by comparing the field density to the:

A. Maximum dry density from a Proctor test

B. Atterberg liquid limit

C. Specific gravity of solids

D. In-situ water table depth

21. A cash flow series in which payments grow by a constant percentage each year is analyzed with the:

A. Straight-line depreciation method

B. Arithmetic gradient factor

C. Sinking fund factor

D. Geometric gradient formula

22. A 4 kg object experiences a net force of 12 N. What is its acceleration?

A. 48 m/s^2

B. 3 m/s^2

C. 0.33 m/s^2

D. 16 m/s^2

23. In a flow field, the point where velocity is zero and pressure is maximum is the:

A. Stagnation point

B. Vena contracta

C. Critical point

D. Separation point

24. A survey performed to establish the legal limits of a parcel of land is a:

A. Topographic survey

B. Boundary (cadastral) survey

C. Construction stakeout

D. Hydrographic survey

25. A 2 m steel rod (E = 200 GPa, A = 200 mm²) carries 40 kN of tension. What is its elongation?

A. 0.5 mm

B. 1.0 mm

C. 2.0 mm

D. 4.0 mm

26. Reinforcing bars are concentrated near the bottom of a beam at midspan because that location experiences the greatest:

A. Compressive stress

B. Shear force

C. Beam thickness

D. Tensile stress from positive moment

27. A pile that transfers most of its load to the soil through friction along its sides is a:

A. Friction pile

B. End-bearing pile

C. Batter pile

D. Sheet pile

28. The equivalent uniform annual cost method is most appropriate when the alternatives have:

A. Identical first costs only

B. No salvage value

C. Different useful lives

D. Equal annual benefits only

29. A fair coin is tossed four times. What is the probability of getting all heads?

A. 1/4

B. 1/8

C. 1/16

D. 1/2

30. Level of service F on a roadway represents:

A. Free-flow conditions

B. Stable flow with minor delay

C. Near-capacity stable flow

D. Forced breakdown flow with congestion

31. A fluid whose viscosity is independent of the shear rate is classified as a:

A. Newtonian fluid

B. Dilatant fluid

C. Pseudoplastic fluid

D. Bingham plastic

32. Active earth pressure on a retaining wall is lower than the at-rest pressure because the wall:

A. Moves into the soil mass

B. Remains perfectly rigid

C. Moves slightly away, allowing the soil to expand

D. Carries no load at all

33. A sunk cost is best defined as:

A. A future operating expense

B. The asset's salvage value

C. A past expenditure that cannot be recovered

D. The interest paid on a loan

34. What is the solution set of $|x| = 5$?

A. $x = 5$ only

B. $x = 0$

C. $x = 25$

D. $x = 5$ or $x = -5$

35. The moment of inertia of a cross-section is increased most effectively by:

A. Adding material at the neutral axis

B. Reducing the overall depth

C. Placing material farther from the neutral axis

D. Choosing a lighter material

36. A flow of 0.1 m^3/s passes through a 0.2 m diameter pipe. What is the average velocity?

A. 0.5 m/s

B. 1.0 m/s

C. 5.0 m/s

D. 3.18 m/s

37. The undrained shear strength of a soft clay is commonly estimated in the field with a:

A. Sieve analysis

B. Vane shear test

C. Standard Proctor test

D. Hydrometer test

38. The minimum radius of a horizontal curve decreases when the:

A. Design speed increases

B. Vehicle weight increases

C. Lane width increases

D. Superelevation and side friction increase

39. The capital recovery factor combines the effects of:

A. Inflation and income taxes

B. Salvage and operating costs

C. Labor and material costs

D. Interest and recovery of the initial investment

40. A wheel of radius 0.5 m rotates at 4 rad/s. What is the linear speed at its rim?

A. 8 m/s

B. 2 m/s

C. 0.125 m/s

D. 20 m/s

41. What is the indefinite integral of $3x^2\,dx$?

A. $6x + C$

B. $3x^3 + C$

C. $x^3 + C$

D. $x^3/3 + C$

42. A truss that has more members than the minimum required for stability is:

A. Statically indeterminate

B. A mechanism

C. Always unstable

D. Statically determinate

43. A surge tank installed in a pipeline is provided to:

A. Increase the flow velocity

B. Relieve pressure transients such as water hammer

C. Filter out sediment

D. Heat the conveyed water

44. What is the total vertical stress at the base of a 5 m soil column with a unit weight of 19 kN/m^3?

A. 19 kPa

B. 24 kPa

C. 5 kPa

D. 95 kPa

45. The break-even number of units produced is found by dividing the fixed cost by the:

A. Contribution margin per unit

B. Total revenue

C. Variable cost only

D. Salvage value

46. A weaving maneuver requires drivers to:

A. Stop completely before proceeding

B. Maintain a single constant lane

C. Change lanes amid merging and diverging traffic

D. Reverse their direction of travel

47. What is the sum $1 + 2 + 3 + \cdots + 100$?

A. 5,050

B. 10,000

C. 5,000

D. 10,100

48. The theoretical effective length factor K equals 0.5 when both ends of a column are:

A. Pinned

B. Fixed against rotation and translation

C. Free at one end

D. Supported on rollers

49. Cavitation damage in a pump is caused by:

A. Excessive fluid viscosity

B. The collapse of vapor bubbles near the impeller

C. High fluid temperature alone

D. Corrosion of the pipe wall

50. Compressibility is greatest in:

A. Dense gravel

B. Well-compacted fill

C. Soft normally consolidated clay

D. Sound bedrock

51. When two alternatives have equal present worths, the deciding factor may be:

A. The interest rate alone

B. The salvage value only

C. The first cost only

D. Non-economic or qualitative considerations

52. A spring stores 8 J of energy when compressed 0.2 m. What is its stiffness?

A. 40 N/m

B. 80 N/m

C. 400 N/m

D. 200 N/m

53. What is the value of tan 45°?

A. 0

B. 0.5

C. 1

D. √2

54. For a simply supported beam carrying any load along its span, the sum of the two support reactions always equals:

A. The total applied load

B. Twice the applied load

C. Half the applied load

D. Zero

55. The hydraulic radius of a flow section equals the flow area divided by the:

A. Top water-surface width

B. Wetted perimeter

C. Flow depth

D. Channel slope

56. The coefficient of curvature is used together with the coefficient of uniformity to assess:

A. How well-graded a soil is

B. The soil's plasticity

C. The shear strength

D. The permeability directly

57. A pavement's present serviceability index (PSI) reflects the:

A. Total construction cost

B. Number of travel lanes

C. Ride quality and surface condition

D. Traffic signal timing

58. Working capital recovered at the end of a project is treated as a:

A. Cost in year zero only

B. Cash inflow in the final year

C. Recurring annual expense

D. Sunk cost to be ignored

59. How many combinations are there of 5 items taken 2 at a time?

A. 20

B. 5

C. 10

D. 25

60. A beam most commonly fails in shear near the:

A. Midspan, where moment peaks

B. Supports, where shear is largest

C. Tip of a cantilever

D. Centroid of the span

61. The energy grade line equals the hydraulic grade line plus the:

A. Friction slope

B. Pressure head

C. Elevation head

D. Velocity head

62. Bearing-capacity failure of a footing on dense sand is typically a:

A. General shear failure

B. Punching shear failure

C. Long-term consolidation

D. Frost heave failure

63. The annual worth of an alternative equals its present worth multiplied by the:

A. Capital recovery factor (A/P)

B. Single-payment factor (F/P)

C. Gradient factor (A/G)

D. Sinking fund factor (A/F)

64. A body's acceleration is the derivative of its:

A. Position with respect to mass

B. Force with respect to time

C. Mass with respect to velocity

D. Velocity with respect to time

65. What is the value of 100^(1/2)?

A. 50

B. 1

C. 1,000

D. 10

66. Web stiffeners are added to a steel plate girder primarily to prevent:

A. Web buckling under shear or concentrated loads

B. Flange yielding in tension

C. Corrosion of the web plate

D. Lateral movement of the supports

67. Flow in which fluid particles move in smooth, parallel layers is termed:

A. Laminar

B. Turbulent

C. Transitional

D. Supercritical

68. The measured SPT N-value is corrected for:

A. Air temperature

B. Pile spacing

C. Overburden pressure and hammer energy

D. The color of the water

69. A bond's yield to maturity is the:

A. Interest rate that equates its price to the present worth of its cash flows

B. Coupon rate stated on the bond

C. Face value paid at maturity

D. Annual coupon payment

70. Two objects have equal momentum but different masses. The lighter object has the:

A. Greater velocity

B. Greater mass

C. Lower momentum

D. Same velocity as the heavier one

71. What is the slope of the line passing through the points (2, 3) and (2, 9)?

A. 3

B. 0

C. 6

D. Undefined

72. The radius of gyration of a cross-section equals the square root of:

A. The moment of inertia divided by the area

B. The area times the length

C. The section modulus

D. The polar moment times the area

73. A venturi meter has a lower permanent head loss than an orifice meter because it has:

A. A larger throat opening

B. No pressure taps

C. A gradual, streamlined contraction and expansion

D. A higher discharge coefficient only

74. A quick clay is hazardous because it can:

A. Swell only when wetted

B. Resist all applied loading

C. Drain water very rapidly

D. Lose nearly all its strength when disturbed

75. The design of a sag vertical curve at an underpass may also be governed by:

A. Pavement surface color

B. Lane striping width

C. Overhead clearance and sight distance under the structure

D. Toll booth spacing

76. Depreciation recapture arises when an asset is sold for more than its:

A. Original purchase cost

B. Estimated salvage value

C. Book value

D. Replacement market value

77. What is the mean of the data set {10, 20, 30, 40}?

A. 20

B. 25

C. 30

D. 100

78. In LRFD, the design strength of a member is the nominal strength multiplied by:

A. The load factor

B. The safety factor Ω

C. The modulus of elasticity

D. The resistance factor φ

79. The discharge of a pump operating at a fixed speed is set by the:

A. Color of the suction pipe

B. Atmospheric humidity

C. Motor supply voltage alone

D. Intersection of the pump and system curves

80. Migration of fine soil through a coarser drainage layer, which can clog it, is prevented by following:

A. Field compaction standards

B. Filter gradation criteria

C. Bearing-capacity rules

D. Slope-stability charts

81. A 1,000 kg car traveling at 20 m/s brakes with a force of 5,000 N. What is its deceleration?

A. 0.2 m/s^2

B. 5 m/s^2

C. 50 m/s^2

D. 2.5 m/s^2

82. The logarithm property log(ab) is equal to:

A. log a − log b

B. log a × log b

C. log a + log b

D. (log a)/(log b)

83. Under gravity load, a simply supported beam deflects downward at midspan, placing the:

A. Top fibers in tension

B. Bottom fibers in tension

C. Neutral axis in tension

D. Support reactions in tension

84. Flow rate is conserved through a pipe of varying diameter because of:

A. Conservation of mass (continuity)

B. Conservation of momentum

C. Conservation of energy

D. Newton's third law

85. A grain-size distribution curve from a sieve analysis plots:

A. Stress versus strain

B. Percent finer versus particle size

C. Void ratio versus effective stress

D. Time versus settlement

86. A present-worth-of-costs comparison of alternatives is valid only when they are evaluated over:

A. Different study periods

B. The same study period

C. Infinite horizons only

D. A single year only

87. The time headway between successive vehicles is the inverse of the:

A. Traffic density

B. Vehicle speed

C. Traffic flow rate

D. Vehicle spacing

88. The expansion of $(x + 3)^2$ is:

A. $x^2 + 9$

B. $x^2 + 3x + 9$

C. $x^2 + 6x + 9$

D. $x^2 + 3x + 3$

89. A base plate beneath a steel column is provided to:

A. Resist lateral wind loads only

B. Distribute the column load over the foundation

C. Provide thermal insulation

D. Reduce the column's height

90. For pipe flow, doubling the diameter while holding the flow rate constant reduces the velocity to:

A. One-half

B. Twice

C. The same value

D. One-quarter

91. The settlement caused by the slow expulsion of pore water from a saturated clay is:

A. Immediate elastic settlement

B. Secondary compression

C. Frost heave

D. Primary consolidation

92. Inflation acts to reduce the:

A. Purchasing power of future money

B. Nominal interest rate always

C. Initial investment cost

D. Number of compounding periods

93. An object in free fall near the Earth's surface accelerates at approximately:

A. 32.2 m/s^2

B. 1.0 m/s^2

C. 9.81 m/s^2

D. 0 m/s^2

94. If $2^x = 16$, what is the value of x?

A. 8

B. 4

C. 32

D. 2

95. A connection designed to carry bending moment in addition to shear is a:

A. Moment (rigid) connection

B. Simple shear tab

C. Slip-critical bolt only

D. Roller support

96. The pressure exerted by a fluid at rest increases:

A. Quadratically with depth

B. Linearly with depth

C. Inversely with depth

D. Not at all with depth

97. A drainage system installed behind a retaining wall is provided to:

A. Increase the soil weight

B. Add aesthetic value

C. Support the footing directly

D. Reduce hydrostatic pressure buildup behind the wall

98. A standard four-leg intersection has approximately how many total vehicle conflict points?

A. 32

B. 8

C. 4

D. 64

99. A square has a diagonal of length 10. What is its area?

A. 100

B. 50

C. 25

D. 70.7

100. The dead load of a structure consists of:

A. Wind and snow forces

B. Moving vehicle loads

C. The permanent weight of the structure and fixed components

D. Earthquake forces only

101. A fluid's bulk modulus measures its resistance to:

A. Shear deformation

B. Compression

C. Tension

D. Temperature change

102. The effective stress in a soil increases when the:

A. Total stress decreases

B. Water table is lowered

C. Pore pressure rises

D. Soil becomes more saturated

103. Selecting an alternative based only on the lowest first cost can be a poor decision because it ignores the:

A. Operating and maintenance costs over the service life

B. Purchase price of the asset

C. Name of the contractor

D. Geographic location of the project

104. The centripetal acceleration of an orbiting satellite is directed:

A. Tangent to the orbit

B. Away from the Earth

C. In the direction of motion

D. Toward the center of the orbit

105. The derivative of a sum $f(x) + g(x)$ equals:

A. $f'(x) \times g'(x)$

B. $f'(x) - g'(x)$

C. $f(x) + g'(x)$

D. $f'(x) + g'(x)$

106. The live load on a building floor represents the:

A. Movable and occupancy loads

B. Self-weight of the slab

C. Wind pressure on the walls

D. Foundation reaction force

107. The differential form of the continuity equation expresses conservation of:

A. Energy

B. Momentum

C. Mass

D. Force

108. The angle of internal friction is highest for:

A. Dense, angular sand

B. Soft saturated clay

C. Loose, rounded sand

D. Organic peat

109. The functional classification of highways ranges from local roads up to:

A. Driveways only

B. Parking lots

C. Bicycle paths only

D. Principal arterials and freeways

110. An engineer offered a contract through bribery of a public official should:

A. Accept it if it is profitable

B. Refuse the contract and report the impropriety

C. Offer a smaller bribe instead

D. Quietly subcontract the work

PRACTICE EXAM 18 — Answer Key and Explanations

1. C — $Q = AV = (\pi/4 \times 0.4^2) \times 2.5 = 0.1257 \times 2.5 = 0.31$ m³/s. Flow rate equals area times velocity. The $\pi d^2/4$ area is the decisive step.
2. A — $F = P(1 + i)^n = 3{,}000(1.10)^4 = 3{,}000 \times 1.4641 = \$4{,}392$. Compound interest grows the principal geometrically. Each year's interest is earned on the accumulated balance.
3. A — $R = \sqrt{(9^2 + 12^2)} = \sqrt{225} = 15$ kN. Perpendicular forces combine by the Pythagorean theorem. This is a scaled 3-4-5 triangle.
4. D — $e = (Gs \cdot \gamma w/\gamma d) - 1 = (2.70 \times 9.81/16) - 1 = 1.655 - 1 = 0.65$. This phase relationship links dry unit weight to void ratio. Lower dry density corresponds to higher void ratio.
5. C — Short-duration counts are converted to AADT using seasonal and daily (and sometimes axle) adjustment factors. These correct for time-of-year and day-of-week variation. The result represents average yearly traffic.
6. A — $M_{max} = wL^2/8 = 10 \times 4^2/8 = 20$ kN·m at midspan. For a uniformly loaded simple beam, the maximum moment is one-eighth of wL^2. The span-squared term makes length dominant.

7. D — $5x + 3 = 28$ gives $5x = 25$, so $x = 5$. Subtract the constant, then divide by the coefficient. Substituting back confirms the result.
8. B — The coefficient of thermal expansion of steel is about 12×10^{-6} per °C. This governs thermal movement and stress in restrained members. Expansion joints accommodate this movement in structures.
9. D — Critical flow occurs at the depth that minimizes specific energy for a given discharge. At this point the Froude number equals one. It marks the boundary between subcritical and supercritical flow.
10. C — $KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 1{,}200 \times 25^2 = 375{,}000$ J = 375 kJ. Kinetic energy scales with the square of speed. Distractor B omits the square of velocity.
11. B — Wastewater effluent is most commonly disinfected by chlorination or ultraviolet (UV) treatment before discharge. Both inactivate pathogens to protect receiving waters. UV avoids the chlorine residual and byproduct concerns.
12. D — Horizontal distance $= \sqrt{(30^2 - 4^2)} = \sqrt{884} = 29.7$ m. The slope distance is the hypotenuse, and the vertical rise is one leg. The horizontal distance is the remaining leg.
13. B — Total settlement on clay includes immediate, primary consolidation, and secondary compression (creep). Secondary compression continues slowly after pore pressures dissipate. It is significant in organic and highly plastic soils.
14. C — $F = 20{,}000(1.08)^3 = 20{,}000 \times 1.2597 = \$25{,}194$. Compound interest accrues on the growing balance each year. The single payment repays principal plus accumulated interest.
15. B — Reaction moment $= P \times L = 5 \times 2 = 10$ kN·m at the fixed support. The moment in a tip-loaded cantilever is greatest at the wall. It equals the load times the distance to the support.
16. C — Bernoulli's equation cannot be applied directly across a pump or a major energy loss, because energy is added or dissipated there. The extended energy equation adds head terms for such cases. Bernoulli assumes no energy addition or loss.
17. A — Braking distance increases with the square of speed, since kinetic energy (and thus the distance to dissipate it) scales as v^2. Doubling speed quadruples the braking distance. This strongly influences stopping sight distance.
18. D — The maximum bending moment occurs where the shear force is zero, since the slope of the moment diagram equals the shear. For a uniform load this is at midspan. Locating zero shear pinpoints the peak moment.
19. A — The derivative of x^{-1} is $-x^{-2} = -1/x^2$. The power rule reduces the exponent by one and multiplies by it. The negative exponent yields the negative sign.
20. A — Field density is compared to the maximum dry density from a Proctor test, expressed as percent compaction. This is the standard compaction quality-control measure. Achieving a specified percentage ensures adequate density.
21. D — A series growing by a constant percentage is a geometric gradient, analyzed with the geometric gradient present-worth formula. This handles escalating costs such as inflation-driven expenses. An arithmetic gradient, by contrast, grows by a fixed amount.
22. B — $a = F/m = 12/4 = 3$ m/s². Newton's second law gives acceleration as net force divided by mass. The result is independent of velocity.
23. A — The stagnation point is where the flow is brought to rest, giving zero velocity and maximum (stagnation) pressure. Bernoulli's equation relates this pressure rise to the kinetic energy. Pitot tubes exploit this point.
24. B — A boundary (cadastral) survey establishes the legal limits of a parcel of land. It locates property corners and lines. This differs from topographic and construction surveys.

25. C — $\delta = PL/(AE) = (40{,}000 \times 2{,}000)/(200 \times 200{,}000) = 2.0$ mm. Axial elongation is proportional to load and length and inversely proportional to area and modulus. Consistent N-and-mm units give millimeters.
26. D — Bottom reinforcement at midspan resists the tensile stresses produced by positive bending moment. Concrete is weak in tension, so steel is placed where tension occurs. This is the basic principle of reinforced concrete flexural design.
27. A — A friction pile carries its load mainly through skin friction along its shaft. It is used where no firm bearing stratum is within reach. Load transfers gradually to the surrounding soil.
28. C — The equivalent uniform annual cost method conveniently compares alternatives with different useful lives by expressing each on a per-year basis. It implicitly assumes repeating service cycles. This avoids a common-multiple study period.
29. C — P(all heads) = $(1/2)^4 = 1/16$. Each independent toss has probability 1/2, and the events multiply. There is only one favorable outcome among sixteen.
30. D — Level of service F denotes forced or breakdown flow with severe congestion and stop-and-go conditions. Demand exceeds capacity. It is the worst operating condition on the A-to-F scale.
31. A — A Newtonian fluid has a viscosity that is constant and independent of shear rate. Water and air are examples. Non-Newtonian fluids deviate from this proportionality.
32. C — Active pressure develops when the wall moves slightly away from the soil, allowing the backfill to expand and mobilize its shear strength. This reduces the lateral pressure below the at-rest value. The small outward movement is essential to the active state.
33. C — A sunk cost is a past expenditure that cannot be recovered and is irrelevant to future decisions. Only future cash flows affected by the decision matter. Including sunk costs biases the analysis.
34. D — The equation $|x| = 5$ has two solutions, $x = 5$ and $x = -5$, since both have absolute value 5. The absolute value yields both the positive and negative roots. This is standard for absolute-value equations.
35. C — Moment of inertia is increased most effectively by placing material farther from the neutral axis, since I depends on distance squared. This is why I-beams concentrate area in the flanges. Distance, not quantity alone, drives stiffness.
36. D — $V = Q/A = 0.1/(\pi/4 \times 0.2^2) = 0.1/0.0314 = 3.18$ m/s. Velocity is the flow rate divided by the cross-sectional area. Smaller pipes produce higher velocities for the same flow.
37. B — The field vane shear test directly measures the undrained shear strength of soft clay in place. The torque to rotate the vane gives the strength. It avoids the disturbance of sampling.
38. D — Minimum curve radius $R = V^2/[g(e + f)]$ decreases as superelevation and side friction increase. Greater banking and friction allow tighter curves at the same speed. Higher design speed instead requires larger radii.
39. D — The capital recovery factor combines interest on the invested capital with recovery (depreciation) of the initial investment. It converts a present cost into equal annual amounts. This represents the annual cost of ownership.
40. B — $v = \omega r = 4 \times 0.5 = 2$ m/s. The rim's linear speed equals the angular velocity times the radius. A larger radius gives a higher rim speed at the same rotation rate.
41. C — The integral of $3x^2$ is $x^3 + C$. Raising the exponent and dividing cancels the coefficient of 3. The constant of integration is required.
42. A — A truss with more members than needed for stability has redundant members and is statically indeterminate. Equilibrium equations alone cannot solve it. Compatibility conditions are required.

43. B — A surge tank relieves pressure transients (water hammer) caused by rapid changes in flow, such as valve operation. It provides a free surface that absorbs the surge. This protects the pipeline from damaging pressure spikes.
44. D — Total stress = $\gamma z = 19 \times 5 = 95$ kPa. Total vertical stress equals unit weight times depth. This is the geostatic stress before subtracting pore pressure.
45. A — Break-even units = fixed cost / contribution margin per unit, where the margin is price minus variable cost per unit. Each unit's margin contributes toward covering fixed costs. At break-even, total contribution equals fixed cost.
46. C — A weaving maneuver requires drivers to change lanes while streams of merging and diverging traffic cross paths. These conflicting movements reduce speed and capacity. Adequate length is needed to complete the maneuver safely.
47. A — Sum = $n(n + 1)/2 = 100 \times 101/2 = 5{,}050$. This formula gives the sum of the first n integers. It averages the first and last terms times the count.
48. B — A column fixed against rotation and translation at both ends has a theoretical effective length factor $K = 0.5$. Full end restraint shortens the effective length. This gives the highest buckling capacity among ideal cases.
49. B — Cavitation damage results from the collapse of vapor bubbles near the impeller, where low pressure forms vapor that then implodes against the metal. The repeated implosions pit the surface. Maintaining adequate NPSH prevents it.
50. C — Soft, normally consolidated clay is the most compressible soil, undergoing large consolidation settlement under load. Its high void ratio and low stiffness allow substantial volume change. Dense granular soils and rock compress far less.
51. D — When two alternatives have equal present worths, non-economic or qualitative factors (such as safety, flexibility, or aesthetics) can decide the choice. The economic analysis no longer differentiates them. Judgment then governs the final decision.
52. C — $k = 2(PE)/x^2 = 2 \times 8/0.2^2 = 16/0.04 = 400$ N/m. Spring potential energy is $\frac{1}{2}kx^2$. Solving for stiffness uses the stored energy and the deflection.
53. C — $\tan 45° = 1$, since the opposite and adjacent sides are equal in a 45-45-90 triangle. It is a standard reference value. The tangent is the ratio of sine to cosine, both 0.707 here.
54. A — By vertical equilibrium, the two support reactions of a simple beam always sum to the total applied load. The load distribution determines how it splits between them. This holds regardless of load position.
55. B — Hydraulic radius = flow area / wetted perimeter. It characterizes the channel's flow efficiency. Only the boundary in contact with water counts in the perimeter.
56. A — The coefficient of curvature, used with the coefficient of uniformity, assesses whether a soil is well-graded. Both must fall in specified ranges for a well-graded classification. They describe the shape and spread of the gradation curve.
57. C — The present serviceability index reflects the ride quality and surface condition of a pavement, on a scale from 0 to 5. It captures how users experience the pavement. A declining PSI signals the need for rehabilitation.
58. B — Working capital recovered at project end is treated as a cash inflow in the final year, since the tied-up funds are released. It was an outflow when first committed. This recovery is included in the final-period cash flow.
59. C — $C(5, 2) = 5!/(2! \cdot 3!) = 10$. The combination formula counts unordered selections. Order does not matter, so it is fewer than the permutation count.

60. B — Shear force is largest at the supports of a simply supported beam, making them the typical location of shear failure. Shear decreases toward midspan. Stirrups are concentrated near the supports for this reason.
61. D — The energy grade line equals the hydraulic grade line plus the velocity head ($V^2/2g$). The HGL accounts for pressure and elevation head. Adding the kinetic term gives the total energy line.
62. A — A footing on dense sand typically fails by general shear, with a well-defined failure surface reaching the ground surface. Loose or compressible soils instead fail by punching shear. The soil density governs the failure mode.
63. A — Multiplying present worth by the capital recovery factor (A/P) converts it into an equivalent uniform annual worth. This spreads a present value into equal annual amounts. It is the basis of annual-cost comparisons.
64. D — Acceleration is the time derivative of velocity. Velocity in turn is the derivative of position. These relationships form the basis of kinematics.
65. D — 100^(1/2) = √100 = 10. A one-half exponent denotes the square root. Ten squared returns one hundred.
66. A — Web stiffeners prevent buckling of a thin girder web under shear or concentrated loads. They stabilize the web panel and transfer bearing forces. Bearing stiffeners are placed at supports and load points.
67. A — Laminar flow consists of fluid moving in smooth, parallel layers with no mixing between them. It occurs at low Reynolds numbers where viscosity dominates. Turbulent flow, by contrast, is chaotic and mixing.
68. C — The measured SPT N-value is corrected for overburden pressure and hammer energy efficiency to obtain standardized values. These corrections make results comparable across sites and equipment. The corrected value is used in design correlations.
69. A — A bond's yield to maturity is the interest rate that equates its purchase price to the present worth of all its future cash flows. It reflects the investor's true return if held to maturity. It differs from the stated coupon rate when the bond trades at a premium or discount.
70. A — With equal momentum ($p = mv$), the lighter object must have the greater velocity to compensate for its smaller mass. The product mv is the same for both. This follows directly from the momentum definition.
71. D — The two points share the same x-coordinate, so the line is vertical and its slope is undefined. Division by a zero horizontal change is undefined. A vertical line cannot be expressed in slope-intercept form.
72. A — Radius of gyration $r = \sqrt{(I/A)}$, the square root of the moment of inertia divided by the area. It represents the distance at which the area could be concentrated to give the same I. It is used in slenderness-ratio calculations.
73. C — A venturi meter's gradual, streamlined contraction and expansion minimizes flow separation, so its permanent head loss is lower than that of a sharp-edged orifice. Less turbulence means less energy dissipation. This efficiency makes venturis preferred where head loss matters.
74. D — Quick clay can lose nearly all of its strength when disturbed, turning from a solid to a near-liquid state. This sensitivity makes it prone to sudden, large landslides. Its flocculated structure collapses when remolded.
75. C — A sag curve at an underpass may be governed by overhead clearance and the sight distance available beneath the structure, in addition to comfort criteria. The bridge can limit the visible roadway ahead. Both controls must be checked.

76. C — Depreciation recapture occurs when an asset sells for more than its book value, with the excess (up to original cost) taxed as ordinary income. The earlier depreciation is effectively reversed. This affects the after-tax cash flow at disposal.
77. B — Mean = (10 + 20 + 30 + 40)/4 = 100/4 = 25. The arithmetic mean sums the values and divides by the count. For evenly spaced data it equals the midpoint.
78. D — In LRFD, design strength = $\varphi \times$ nominal strength, where φ is the resistance factor (less than 1.0). It accounts for uncertainty in material and member capacity. Loads are separately amplified by load factors.
79. D — A pump operating at fixed speed delivers the flow at the intersection of its head-capacity curve and the system curve. At that point supplied head equals required head. Changing the system resistance shifts the operating point.
80. B — Filter gradation criteria prevent fine soil from migrating into and clogging a coarser drainage layer while still allowing water to pass. The filter must be fine enough to retain soil yet coarse enough to drain. These rules govern drainage and filter design.
81. B — $a = F/m = 5{,}000/1{,}000 = 5\ m/s^2$. Deceleration equals the braking force divided by the mass. The magnitude indicates how rapidly the car slows.
82. C — The logarithm of a product equals the sum of the logarithms: $\log(ab) = \log a + \log b$. This property converts multiplication into addition. It is fundamental to logarithmic manipulation.
83. B — A simply supported beam sagging under gravity load develops tension in the bottom fibers and compression in the top. The downward curvature stretches the bottom. This is why tension reinforcement is placed low at midspan.
84. A — Conservation of mass (continuity) ensures the flow rate is constant through a pipe of varying diameter for an incompressible fluid. Velocity adjusts inversely with area. Mass in equals mass out.
85. B — A grain-size distribution curve plots percent finer (passing) versus particle size on a logarithmic scale. It characterizes the soil's gradation. Key diameters such as D_{10} and D_{60} are read from it.
86. B — A present-worth-of-costs comparison is valid only when alternatives are evaluated over the same study period. Equal time horizons ensure a fair comparison. Unequal lives require a common period or the annual-cost method.
87. C — Time headway is the inverse of the traffic flow rate; flow equals 3,600 divided by the average headway in seconds. Shorter headways correspond to higher flow. This links microscopic and macroscopic traffic measures.
88. C — $(x + 3)^2 = x^2 + 2(3)x + 9 = x^2 + 6x + 9$. The middle term is twice the product of the two terms. Omitting it produces the common error in distractor A.
89. B — A column base plate distributes the concentrated column load over a larger area of the concrete foundation, keeping the bearing pressure within allowable limits. It spreads the load to prevent crushing. Anchor bolts secure it to the foundation.
90. D — Velocity varies inversely with area, which varies with the square of diameter, so doubling the diameter reduces velocity to one-quarter. The fourfold area increase quarters the speed for constant flow. Continuity drives this relationship.
91. D — Primary consolidation is the settlement caused by the slow expulsion of pore water from a saturated clay under load. Effective stress increases as water drains. The low permeability of clay makes it time-dependent.

92. A — Inflation reduces the purchasing power of future money, so a future dollar buys less than a present one. This erosion is why real (inflation-adjusted) analysis matters. It does not by itself change the initial cost.
93. C — Free-fall acceleration near the Earth's surface is about 9.81 m/s^2. This is the SI value of standard gravity. In US-customary units it is 32.2 ft/s^2.
94. B — $2^x = 16 = 2^4$, so $x = 4$. The exponent that produces 16 from base 2 is four. Recognizing powers of two gives the answer.
95. A — A moment (rigid) connection is designed to transfer bending moment in addition to shear, maintaining the angle between members. It enables frame action against lateral loads. A simple connection transfers shear only.
96. B — Hydrostatic pressure increases linearly with depth, $P = \gamma h$. Each unit of depth adds a constant increment of pressure. This linear relationship underlies all hydrostatic force calculations.
97. D — Drainage behind a retaining wall reduces hydrostatic pressure buildup by relieving water that would otherwise add lateral load. Weep holes and drains carry the water away. This prevents the wall from being overloaded by water pressure.
98. A — A standard four-leg intersection has 32 vehicle conflict points: 16 crossing, 8 merging, and 8 diverging. Reducing conflict points improves safety, which is a benefit of roundabouts. The count reflects all possible vehicle interactions.
99. B — Area = $d^2/2 = 10^2/2 = 50$, since the diagonal of a square equals the side times $\sqrt{2}$. Squaring the side gives area = $(d/\sqrt{2})^2 = d^2/2$. This relates the diagonal directly to area.
100. C — Dead load is the permanent, fixed weight of the structure and its attached components, such as the slab, beams, and finishes. It does not change over time. Live, wind, and seismic loads are treated separately.
101. B — The bulk modulus measures a fluid's resistance to compression, relating pressure change to volumetric strain. A high bulk modulus means the fluid is nearly incompressible. Water has a very high bulk modulus.
102. B — Lowering the water table reduces pore pressure, which increases the effective stress carried by the soil grains. Effective stress equals total stress minus pore pressure. This can increase strength but may also cause settlement.
103. A — Choosing solely by lowest first cost ignores the operating and maintenance costs incurred over the service life. A cheaper initial option may cost more overall. Life-cycle cost analysis captures the full picture.
104. D — Centripetal acceleration is directed toward the center of the orbit, continuously changing the satellite's direction. Gravity supplies this inward acceleration. It is perpendicular to the velocity.
105. D — The derivative of a sum equals the sum of the derivatives: $[f(x) + g(x)]' = f'(x) + g'(x)$. Differentiation is a linear operation. Each term is differentiated independently.
106. A — Live load represents the movable and occupancy loads on a floor, such as people, furniture, and equipment. It varies with use and is not permanent. The slab self-weight is dead load instead.
107. C — The differential continuity equation expresses conservation of mass at a point in the flow field. It states that the net mass flux balances the rate of density change. For incompressible flow it reduces to zero divergence of velocity.
108. A — Dense, angular sand has the highest angle of internal friction, because tightly packed angular grains interlock strongly. Looser or rounded grains slide more easily. Clays and peat rely on cohesion rather than high friction.

109. D — The functional classification of highways ranges from local roads through collectors up to principal arterials and freeways. Higher classes emphasize mobility over access. This hierarchy guides design standards and connectivity.

110. B — An engineer offered a contract through bribery must refuse it and report the impropriety, upholding integrity and the public trust. Participating in or concealing bribery violates ethical and legal duties. Reporting protects the profession and the public.