PRACTICE EXAM 13 : FE CIVIL SIMULATION (110 QUESTIONS)

110 questions. Recommended time: 5 hours 20 minutes.

1. A horizontal curve has a radius of 1,910 ft. Using the arc definition D = 5,729.58/R, what is its degree of curve?

A. 0.52°

B. 19.1°

C. 1.0°

D. 3.0°

2. A 12 m uniform beam weighs 600 N and rests on supports placed 2 m from each end. By symmetry, what is each support reaction?

A. 600 N

B. 150 N

C. 1,200 N

D. 300 N

3. A crew of 5 workers completes a task in 8 days. Assuming linear productivity, how long would 8 workers take?

A. 5 days

B. 12.8 days

C. 8 days

D. 40 days

4. A 1,500 kg car accelerates from 10 m/s to 30 m/s. Using the work-energy theorem, what is the work done by the net force?

A. 1,200 kJ

B. 300 kJ

C. 600 kJ

D. 150 kJ

5. A fully saturated soil has a total unit weight of 20 kN/m³. What is its buoyant (submerged) unit weight?

A. 29.81 kN/m³

B. 20 kN/m³

C. 10.19 kN/m³

D. 9.81 kN/m³

6. A 30-60-90 right triangle has a hypotenuse of 10. What is the length of the side opposite the 30° angle?

A. 5

B. 8.66

C. 10

D. 7.07

7. A spring of stiffness 400 N/m is compressed 0.2 m. What is the potential energy stored?

A. 80 J

B. 40 J

C. 8 J

D. 16 J

8. A pipe with a Hazen-Williams coefficient of 130 is relined, raising C to 150. For the same head loss, the carrying capacity will:

A. Increase, because a higher C indicates a smoother pipe

B. Decrease, because friction rises with C

C. Remain exactly the same

D. Drop to zero

9. What is the second derivative of $f(x) = x^3$?

A. $3x^2$

B. $x^4/4$

C. $3x$

D. $6x$

10. A simply supported beam carries a uniform load of 20 kN/m over a 5 m span. What is the maximum shear force at a support?

A. 100 kN

B. 25 kN

C. 12.5 kN

D. 50 kN

11. A force vector is $F = 3i + 4j$ N. What angle does it make with the positive x-axis?

A. 36.87°

B. 53.13°

C. 45.00°

D. 60.00°

12. An engineer must choose between a design that minimally meets code at low cost and one that exceeds code at higher cost, both safe. The engineer should:

A. Exercise professional judgment, since a code-compliant safe design is acceptable

B. Always choose the most expensive option regardless of need

C. Ignore the code entirely

D. Choose whichever option pays the engineer the most

13. A traverse leg has a latitude of −40 m and a departure of +30 m. What is its length?

A. 70 m

B. 10 m

C. 50 m

D. 35 m

14. An increase in the water table within a soil mass will:

A. Increase the effective stress

B. Have no effect on stress

C. Decrease the effective stress

D. Eliminate the total stress

15. Equipment costs $60,000 with a salvage value of $10,000 after 5 years. Using straight-line depreciation, what is the book value after 2 years?

A. $10,000

B. $50,000

C. $20,000

D. $40,000

16. The compressive strength of concrete is typically far greater than its:

A. Tensile strength

B. Density

C. Elastic modulus

D. Coefficient of thermal expansion

17. The dimensionless number characterizing the ratio of inertial to viscous forces in a flow is the:

A. Froude number

B. Mach number

C. Weber number

D. Reynolds number

18. A 1 m^3/s flow is diverted equally into four identical channels. How much does each channel carry?

A. 4 m^3/s

B. 1 m^3/s

C. 0.5 m^3/s

D. 0.25 m^3/s

19. Heating steel and cooling it slowly to relieve internal stresses and increase ductility is called:

A. Annealing

B. Quenching

C. Galvanizing

D. Welding

20. An error that follows a known mathematical relationship and can be computed and removed, such as tape expansion with temperature, is a:

A. Random error

B. Systematic error

C. Gross blunder

D. Personal mistake

21. A signal cycle of 120 s gives an approach 48 s of green. What is its green ratio (g/C)?

A. 0.40

B. 2.5

C. 0.60

D. 0.20

22. A point experiences a uniaxial tensile stress of 60 MPa. What is the maximum shear stress (on the 45° plane)?

A. 30 MPa

B. 60 MPa

C. 120 MPa

D. 15 MPa

23. A leveling instrument is set up exactly midway between two rods to eliminate the error due to:

A. Earth's curvature only

B. Rod graduation errors

C. Atmospheric refraction only

D. Collimation (line of sight not horizontal)

24. A rectangular beam section is 100 mm wide and 200 mm deep. Using $S = bh^2/6$, what is its section modulus about the strong axis?

A. 333,333 mm^3

B. 1,000,000 mm^3

C. 200,000 mm^3

D. 666,667 mm^3

25. A project's earned value is $90,000 and its planned value is $100,000. What is the schedule variance (EV − PV)?

A. +$10,000

B. −$10,000

C. +$190,000

D. 0.90

26. Stopping sight distance has two components: the brake reaction distance and the:

A. Acceleration distance

B. Curve radius

C. Braking distance

D. Passing distance

27. A material that fails suddenly with little plastic deformation, like cast iron or glass, is described as:

A. Ductile

B. Brittle

C. Malleable

D. Elastic-plastic

28. A safety data sheet (SDS) is required on a construction site primarily to:

A. Track the project schedule

B. List the subcontractors' bids

C. Provide hazard information for chemicals used

D. Record the daily weather

29. A beam's flexural stress is greatest at the:

A. Neutral axis

B. Quarter depth from the neutral axis

C. Extreme fibers farthest from the neutral axis

D. Geometric center of the section

30. A 50 N·m clockwise moment and a 30 N·m counterclockwise moment act on a body. What is the net moment?

A. 80 N·m

B. 20 N·m

C. 1,500 N·m

D. 0 N·m

31. $1,000 is invested at 5% simple interest for 4 years. What total interest is earned?

A. $50

B. $1,200

C. $200

D. $215

32. A thin-walled spherical pressure vessel of radius r and wall thickness t under internal pressure p has a wall stress of:

A. pr/t

B. 2pr/t

C. pr^2/t

D. pr/(2t)

33. Reinforcing steel and concrete work together effectively partly because they have nearly equal:

A. Densities

B. Tensile strengths

C. Coefficients of thermal expansion

D. Elastic moduli

34. By signing a design certification, an engineer is primarily affirming:

A. Professional responsibility for the engineering work

B. A guarantee of zero construction defects

C. Ownership of the project site

D. The contractor's profit margin

35. In LRFD design, the factored load effect must not exceed the:

A. Service load

B. Factored (design) resistance

C. Nominal load alone

D. Dead load only

36. A clay's sensitivity is the ratio of its undisturbed strength to its:

A. Saturated unit weight

B. Remolded strength

C. Liquid limit

D. Optimum moisture content

37. In a precedence diagram, activity B cannot start until activity A finishes. This is a:

A. Start-to-finish relationship

B. Finish-to-finish relationship

C. Start-to-start relationship

D. Finish-to-start relationship

38. A 6 m simply supported beam has a 30 kN point load 2 m from the left support. What is the right reaction?

A. 10 kN

B. 20 kN

C. 30 kN

D. 15 kN

39. A footing on clay shows continued settlement for years after construction. This time-dependent settlement is due to:

A. Consolidation as pore water slowly drains

B. Immediate elastic compression

C. Instantaneous shear failure

D. Thermal expansion of the soil

40. Passing sight distance on a two-lane highway allows a vehicle to:

A. Stop before a stationary object

B. Turn at an intersection

C. Safely overtake a slower vehicle and return to its lane

D. Park on the shoulder

41. A reservoir's safe yield is the:

A. Maximum instantaneous inflow recorded

B. Total volume of the reservoir

C. Peak flood discharge

D. Reliable quantity of water it can supply over time

42. A 0.2 kg ball moving at 10 m/s is caught and stopped in 0.05 s. What is the average force on the ball?

A. 2 N

B. 100 N

C. 0.1 N

D. 40 N

43. As a column's slenderness ratio increases, its tendency to fail by buckling rather than yielding will:

A. Decrease

B. Increase

C. Stay the same

D. Become zero

44. What is the integral of $3x^2$ with respect to x?

A. $6x + C$

B. $x^3/3 + C$

C. $x^3 + C$

D. $3x^3 + C$

45. A water jet ($\rho = 1{,}000$ kg/m³, $Q = 0.02$ m³/s, $V = 8$ m/s) strikes a flat plate perpendicularly. Using $F = \rho QV$, what is the force on the plate?

A. 160 N

B. 80 N

C. 320 N

D. 16 N

46. A material's toughness is best represented by:

A. The slope of the elastic region

B. The total area under the stress-strain curve

C. The yield stress alone

D. The Poisson's ratio

47. A traffic volume of 720 vehicles is counted in 30 minutes. What is the hourly flow rate?

A. 360 veh/hr

B. 1,440 veh/hr

C. 720 veh/hr

D. 24 veh/hr

48. A flow with a very low Reynolds number is dominated by:

A. Inertial forces

B. Gravitational forces

C. Surface tension only

D. Viscous forces

49. In the rational method, the runoff coefficient C represents the fraction of rainfall that:

A. Evaporates immediately

B. Infiltrates into the soil

C. Is stored permanently

D. Becomes surface runoff

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

A. Increased pile material strength

B. Reduced soil unit weight

C. Group efficiency effects from overlapping stress zones

D. A higher water table

51. A 4 m steel column ($E = 200$ GPa, $I = 8\times10^{-6}$ m⁴) is fixed at one end and free at the other ($K = 2$). Using $P_{cr} = \pi^2EI/(KL)^2$, what is the buckling load?

A. 987 kN

B. 62 kN

C. 1,974 kN

D. 247 kN

52. A uniform annual cost of $2,000 over 10 years at 8% with (P/A, 8%, 10) = 6.7101 has a present worth of:

A. $20,000

B. $13,420

C. $2,980

D. $6,710

53. An excavation must be dewatered before placing a foundation. The most common method to lower the surrounding groundwater table is:

A. Spraying water on the soil surface

B. Adding cement to the soil

C. Installing wellpoints or pumps

D. Increasing the excavation depth

54. Shear reinforcement (stirrups) in a concrete beam primarily resists:

A. Diagonal tension caused by shear

B. Axial compression in the beam

C. Flexural tension in the bottom steel

D. Torsion at the supports only

55. A cohesionless soil ($c = 0$, $\varphi = 30°$) is under a normal stress of 100 kPa. Using $\tau = \sigma \tan\varphi$, what is its shear strength?

A. 100 kPa

B. 30 kPa

C. 50 kPa

D. 57.7 kPa

56. A baseline is measured twice as 200.05 m and 199.95 m. What is the most probable length?

A. 400.00 m

B. 0.10 m

C. 200.00 m

D. 100.00 m

57. A contractor's critical path determines the:

A. Total cost of materials

B. Number of workers required

C. Shortest time to complete the project

D. Profit margin on the bid

58. Pavement design that anticipates yearly traffic growth uses:

A. Cumulative ESALs over the design life

B. A single day's traffic count only

C. The peak-hour pedestrian volume

D. The intersection's signal timing

59. The water-cement ratio most directly controls a concrete's:

A. Strength and durability

B. Color

C. Aggregate gradation

D. Total volume only

60. Water at 4°C has its maximum:

A. Viscosity

B. Density

C. Vapor pressure

D. Compressibility

61. A vehicle decelerates from 20 m/s to a stop at 4 m/s^2. What is the stopping distance?

A. 50 m

B. 100 m

C. 25 m

D. 5 m

62. A line has a slope of 2 and passes through (0, 3). What is its equation in slope-intercept form?

A. $y = 2x + 3$

B. $y = 3x + 2$

C. $y = 2x - 3$

D. $y = x + 5$

63. A bearing of N 45° W and a bearing of S 45° E describe lines that are:

A. Perpendicular to each other

B. Parallel but pointing the same way

C. Parallel and opposite (the same line in reverse)

D. Intersecting at 90°

64. The lateral pressure of fresh concrete on formwork increases with:

A. A lower placement rate

B. A higher temperature

C. A faster placement rate and greater pour height

D. A reduced concrete density

65. An engineer is asked to review and approve their own previous design for a permit. This situation presents:

A. A conflict of interest requiring disclosure or independent review

B. No ethical concern whatsoever

C. A required cost-saving measure

D. A standard contractual obligation

66. A fully developed laminar flow in a circular pipe has a velocity profile that is:

A. Uniform (flat) across the pipe

B. Parabolic, with the maximum at the center

C. Maximum at the pipe wall

D. Zero at the center

67. What is the value of cos(60°)?

A. 0.866

B. 1.0

C. 0.0

D. 0.5

68. Cavitation in a pump occurs when the local pressure drops below the fluid's:

A. Atmospheric pressure

B. Critical Reynolds number

C. Vapor pressure

D. Maximum density point

69. An aquifer confined between two impermeable layers and under pressure is a:

A. Water-table aquifer

B. Perched aquifer

C. Unconfined aquifer

D. Confined (artesian) aquifer

70. The equivalent uniform annual cost method is most useful for comparing alternatives that have:

A. Identical cash flows

B. No initial cost

C. Different useful lives

D. A zero interest rate

71. A simply supported beam carries a point load not at midspan. Its bending moment diagram is:

A. A parabola

B. Constant throughout

C. Zero everywhere

D. Two straight lines peaking under the load

72. A soil boring meets refusal on hard rock. This depth typically marks the:

A. Top of the water table

B. Practical limit of the boring or competent bearing stratum

C. Center of a soft clay layer

D. Surface organic topsoil

73. A 10 m × 20 m flat roof receives 40 mm of rain. What volume of water is collected?

A. 8 m^3

B. 80 m^3

C. 0.8 m^3

D. 200 m^3

74. A car rounds a flat curve of radius 80 m at 20 m/s. Using $\mu = v^2/(gr)$, what minimum friction coefficient prevents skidding?

A. 0.10

B. 0.25

C. 0.51

D. 1.02

75. What is the mode of the data set 4, 6, 6, 8, 10, 12?

A. 7.67

B. 6

C. 8

D. 10

76. A truss diagonal carries tension under a given load. If the load direction reverses, that member will:

A. Carry compression instead

B. Carry the same tension

C. Carry zero force permanently

D. Fail immediately

77. An engineer publishes a paper using a graduate student's data without giving credit. This violates the ethical principle of:

A. Public safety

B. Competitive bidding

C. Holding paramount the environment

D. Giving proper credit for professional work

78. A long plateau after yield on a ductile material's stress-strain curve represents:

A. Elastic recovery

B. Brittle fracture

C. Plastic flow at nearly constant stress

D. The initial linear region

79. Adding more cement paste than needed to fill the aggregate voids in concrete tends to increase:

A. Aggregate interlock strength

B. Shrinkage and cost

C. The pipe roughness

D. The water table

80. A theodolite reading is taken in both direct and reversed positions and averaged to eliminate:

A. The observer's height

B. Atmospheric pressure errors

C. Random rounding only

D. Instrumental errors such as collimation and trunnion axis errors

81. A steel beam is checked for both moment and shear capacity. For a short, heavily loaded beam, the governing limit state is often:

A. Shear

B. Lateral-torsional buckling

C. Deflection

D. Bearing only

82. Hardness in water is caused primarily by dissolved:

A. Sodium and potassium

B. Calcium and magnesium

C. Chlorine and fluorine

D. Iron and aluminum oxides

83. An interest rate of 12% per year compounded monthly has a monthly rate of:

A. 12%

B. 0.12%

C. 1%

D. 6%

84. Compression steel is added to a doubly reinforced concrete beam primarily to:

A. Increase the concrete's tensile capacity

B. Increase moment capacity and reduce long-term deflection

C. Replace the need for stirrups

D. Decrease the beam's depth requirement only

85. What is the pressure at the bottom of a 5 m column of oil with specific gravity 0.8?

A. 39.24 kPa

B. 49.05 kPa

C. 4.0 kPa

D. 9.81 kPa

86. A combined sewer that discharges untreated flow during heavy rain produces a:

A. Septic backup

B. Reverse osmosis event

C. Groundwater recharge

D. Combined sewer overflow (CSO)

87. A body subjected to only two forces is in equilibrium. The forces must be:

A. Equal, opposite, and along the same line

B. Perpendicular and equal

C. At 60° to each other

D. Unequal and parallel

88. A cantilever retaining wall resists overturning primarily through:

A. The active pressure behind it

B. The weight of the wall and the soil on its heel

C. Wind load on the stem

D. The water table elevation

89. Increasing a soil's dry density by compaction generally results in:

A. Lower shear strength

B. Higher shear strength and lower permeability

C. Higher permeability

D. No change in engineering properties

90. A frame member loaded at three points (not a two-force member) generally carries:

A. Only axial force

B. Only torsion

C. No internal forces

D. Axial force, shear, and bending moment

91. The standard penetration test value N is correlated with the relative density of:

A. Soft clays

B. Organic peats

C. Bedrock

D. Granular (sandy) soils

92. A rectangular open channel is most hydraulically efficient when its width equals:

A. Its full discharge

B. Twice its flow depth

C. Half its flow depth

D. Four times its flow depth

93. A bar fixed at both ends is heated. Because it cannot expand freely, it develops:

A. Thermal compressive stress

B. No internal stress

C. Tensile stress only

D. Pure shear stress

94. A flexible footing on clay produces a settlement profile that is:

A. Uniform across the footing

B. Greatest at the edges

C. Zero at the center

D. Greatest at the center (dished)

95. A simply supported beam carries a uniformly varying (triangular) load. The reactions are:

A. Equal at both supports

B. Larger at the support nearer the heavier end of the load

C. Zero at both supports

D. Larger at the support nearer the lighter end

96. A normally consolidated clay's compression index Cc is the slope of the:

A. Shear stress versus strain curve

B. Void ratio versus log effective stress curve

C. Grain-size distribution curve

D. Compaction curve

97. The departures of a closed traverse must theoretically sum to:

A. The total perimeter

B. The latitude sum

C. Zero

D. The number of sides

98. What is log(100) in base 10?

A. 10

B. 1

C. 2

D. 100

99. Retaining wall backfill must be placed and compacted in:

A. Thin lifts, compacted layer by layer

B. One single large dump

C. Loose piles left uncompacted

D. Saturated mud only

100. A traffic signal's yellow (change) interval is timed primarily based on the:

A. Number of lanes

B. Pedestrian count

C. Approach speed and driver reaction

D. Pavement color

101. A 5 kg object moving at 4 m/s collides elastically with a stationary 5 kg object. After the collision, the first object's velocity is:

A. 4 m/s

B. 2 m/s

C. 0 m/s

D. 8 m/s

102. How many ways can 2 items be chosen from 5 distinct items?

A. 20

B. 10

C. 25

D. 120

103. Sedimentation tank efficiency depends on the overflow rate, which is the flow divided by the:

A. Surface area of the tank

B. Tank depth only

C. Inlet pipe diameter

D. Detention time squared

104. The centroid of a triangle lies at a distance from its base equal to:

A. One-third of the height

B. One-half of the height

C. Two-thirds of the height

D. The full height

105. A continuous beam develops negative moments over its interior supports. The tension fibers there are on the:

A. Bottom of the beam

B. Neutral axis

C. Both faces equally

D. Top of the beam

106. An engineer finds that following the client's cost-cutting instruction would violate the building code. The engineer must:

A. Follow the client's instruction to keep the contract

B. Refuse to violate the code and inform the client

C. Comply but hide the violation

D. Subcontract the decision to the client

107. A pump's available net positive suction head must exceed the required value to avoid:

A. Cavitation

B. Overheating of the motor

C. Excessive flow rate

D. Reverse rotation

108. A freeway's free-flow speed is the average traffic speed under conditions of:

A. Heavy congestion

B. Low volume with no restrictions

C. A complete stoppage

D. Maximum density

109. What is the limit of (3x + 2) as x approaches 4?

A. 4

B. 2

C. 14

D. 12

110. A bond with a face value of $1,000 pays 6% annual interest. What is the annual interest payment?

A. $1,060

B. $60

C. $600

D. $6

PRACTICE EXAM 13 – ANSWER KEY AND EXPLANATIONS

1. D — D = 5,729.58/R = 5,729.58/1,910 = 3.0°. The arc definition relates the degree of curve to the radius for a 100-ft arc. A larger radius gives a smaller, flatter degree of curve.

2. D — By symmetry, each reaction = total weight/2 = 600/2 = 300 N. The uniform beam's weight acts at its center, equidistant from the two symmetric supports. Each support carries half.

3. A — Work is constant: 5 × 8 = 40 worker-days, so 40/8 = 5 days with 8 workers. Adding workers proportionally shortens the duration. This assumes ideal linear productivity.

4. C — Work = $\Delta KE = \frac{1}{2}m(v_2^2 - v_1^2) = \frac{1}{2}(1{,}500)(900 - 100) = 750 \times 800 = 600{,}000$ J = 600 kJ. The net work equals the change in kinetic energy. Velocity squared drives the result.

5. C — Buoyant unit weight = $\gamma sat - \gamma w = 20 - 9.81 = 10.19$ kN/m³. Submergence reduces the effective weight by the buoyant force of water. This value governs effective stress below the water table.

6. A — Opposite the 30° angle = hypotenuse × sin 30° = 10 × 0.5 = 5. In a 30-60-90 triangle the short side is half the hypotenuse. The sine of 30° is exactly one-half.

7. C — $PE = \frac{1}{2}kx^2 = \frac{1}{2}(400)(0.2^2) = \frac{1}{2}(400)(0.04) = 8$ J. Spring energy grows with the square of compression. The stiffness scales it linearly.

8. A — A higher Hazen-Williams C indicates a smoother pipe, so for the same head loss the capacity increases. Flow varies directly with C in the Hazen-Williams equation. Relining reduces roughness and raises capacity.

9. D — The first derivative of x^3 is $3x^2$, and its derivative is 6x. Differentiating twice applies the power rule successively. The result is linear in x.

10. D — Maximum shear = wL/2 = 20 × 5/2 = 50 kN at each support. For a uniformly loaded simple beam, shear peaks at the supports. Each reaction equals this maximum.

11. B — The angle = arctan(4/3) = 53.13°. The vector's direction is the arctangent of the y-component over the x-component. This is the classic 3-4-5 angle.

12. A — The engineer should exercise professional judgment, since a safe, code-compliant design is acceptable. Codes set the minimum standard for safety. Exceeding them is a judgment call, not an ethical requirement.

13. C — Length = $\sqrt{(\text{latitude}^2 + \text{departure}^2)} = \sqrt{(40^2 + 30^2)} = \sqrt{2{,}500} = 50$ m. The leg length is the resultant of its north-south and east-west components. This is a 3-4-5 relationship scaled by ten.

14. C — A rising water table increases pore pressure, which decreases the effective stress. Effective stress equals total stress minus pore pressure. Buoyancy reduces the load carried by the soil skeleton.

15. D — Annual depreciation = (60,000 − 10,000)/5 = 10,000; book value after 2 years = 60,000 − 2(10,000) = $40,000. Straight-line depreciation removes an equal amount each year. Two years of depreciation are subtracted from the cost.

16. A — Concrete's compressive strength far exceeds its tensile strength, typically by about a factor of ten. This is why steel reinforcement carries the tension. Concrete is used mainly in compression.

17. D — The Reynolds number is the ratio of inertial to viscous forces. It determines whether flow is laminar or turbulent. The other named numbers compare different force pairs.

18. D — Each channel carries 1/4 = 0.25 m^3/s. The total flow divides equally among four identical channels. Conservation of mass requires the parts to sum to the whole.

19. A — Annealing heats steel and cools it slowly to relieve internal stresses and increase ductility. The slow cooling allows a softer, more workable microstructure. Quenching, by contrast, hardens steel.

20. B — A systematic error follows a known relationship and can be computed and removed, like tape expansion with temperature. Such errors are predictable and correctable. Random errors instead vary unpredictably.

21. A — Green ratio g/C = 48/120 = 0.40. It is the fraction of the cycle allotted to the approach as green. This ratio scales the approach capacity.

22. A — Maximum shear = $\sigma/2$ = 60/2 = 30 MPa. In uniaxial stress, the peak shear acts on the 45° plane at half the normal stress. This is the radius of Mohr's circle.

23. D — Setting the level midway between rods makes the backsight and foresight sight lengths equal, canceling collimation (and curvature/refraction) error. Equal distances make any line-of-sight tilt affect both readings equally. The error then drops out of the difference.

24. D — $S = bh^2/6 = 100 \times 200^2/6 = 100 \times 40{,}000/6 = 666{,}667\ mm^3$. The section modulus relates bending moment to extreme-fiber stress. The depth squared dominates.

25. B — Schedule variance = EV − PV = 90,000 − 100,000 = −$10,000. A negative value indicates the project is behind schedule. Less value was earned than planned.

26. C — Stopping sight distance is the sum of the brake reaction distance and the braking distance. The first covers driver perception and reaction; the second covers deceleration to a stop. Both must be available to a driver.

27. B — A brittle material fails suddenly with little plastic deformation, like cast iron or glass. It absorbs little energy before fracture. Ductile materials instead deform substantially first.

28. C — A safety data sheet provides hazard information for chemicals used on site. It informs workers of risks and safe handling. It is required under hazard communication rules.

29. C — Flexural stress is greatest at the extreme fibers farthest from the neutral axis. Bending stress varies linearly with distance from the neutral axis. The maximum occurs at the top and bottom faces.

30. B — Net moment = 50 − 30 = 20 N·m clockwise. Opposing moments subtract algebraically. The larger clockwise moment prevails.

31. C — Simple interest = P·i·n = 1,000 × 0.05 × 4 = $200. Simple interest is computed only on the principal each year. No compounding occurs.

32. D — A thin-walled sphere has a wall stress of pr/(2t) in all directions. The spherical shape halves the stress compared with a cylinder's hoop stress. This makes spheres efficient pressure vessels.

33. C — Steel and concrete bond well partly because they have nearly equal coefficients of thermal expansion. Similar thermal movement prevents internal stresses and debonding with temperature change. This compatibility is essential to reinforced concrete.

34. A — Signing a certification affirms professional responsibility for the engineering work. The signature and seal carry legal and ethical accountability. It is not a guarantee against all defects.

35. B — In LRFD, the factored load effect must not exceed the factored (design) resistance. Loads are amplified and resistance is reduced to provide a safety margin. This is the core limit-state inequality.

36. B — Sensitivity is the ratio of undisturbed to remolded shear strength. It measures how much strength a clay loses when disturbed. High-sensitivity clays can lose most of their strength.

37. D — "B cannot start until A finishes" is a finish-to-start relationship. It is the most common precedence link. The predecessor must complete before the successor begins.

38. A — Right reaction = P × (distance from left)/span = 30 × 2/6 = 10 kN. Taking moments about the left support isolates the right reaction. The load is nearer the left, so the right carries less.

39. A — Years-long settlement of a clay footing is consolidation as pore water slowly drains. The low permeability of clay delays volume change. Sand, by contrast, settles immediately.

40. C — Passing sight distance lets a vehicle safely overtake a slower vehicle and return to its lane. It must account for the oncoming traffic gap. It is far longer than stopping sight distance.

41. D — Safe yield is the reliable quantity of water a reservoir can supply over time. It reflects sustainable delivery through droughts. It is not the total volume or a peak flow.

42. D — $F = m\Delta v/\Delta t = 0.2 \times 10/0.05 = 2/0.05 = 40$ N. The impulse-momentum relation gives the average force. A shorter stopping time means a larger force.

43. B — As the slenderness ratio increases, the tendency to fail by buckling rather than yielding increases. Slender members are unstable at lower loads. Short members instead crush by yielding.

44. C — $\int 3x^2\,dx = x^3 + C$. The power rule raises the exponent and divides by the new power, giving x^3. The constant of integration is added.

45. A — $F = \rho QV = 1{,}000 \times 0.02 \times 8 = 160$ N. The momentum principle equates force to the rate of momentum destroyed. Stopping the jet transfers its momentum to the plate.

46. B — Toughness is the total area under the stress-strain curve, representing energy absorbed to fracture. It combines strength and ductility. A tough material resists fracture under impact.

47. B — Hourly rate = 720 × 2 = 1,440 veh/hr. The 30-minute count is doubled to an hourly equivalent. It expresses the short-term demand per hour.

48. D — Very low Reynolds number flow is dominated by viscous forces. Viscosity overwhelms inertia, producing smooth laminar flow. This is the creeping-flow regime.

49. D — The runoff coefficient C is the fraction of rainfall that becomes surface runoff. The remainder infiltrates, evaporates, or is stored. Impervious surfaces have C near 1.0.

50. C — A pile group's capacity may be reduced by group efficiency effects, where overlapping stress zones lower individual contributions. Closely spaced piles interfere with each other's load transfer. The group capacity can be less than the sum.

51. D — $P_{cr} = \pi^2 EI/(KL)^2 = \pi^2(200\times10^9)(8\times10^{-6})/(2 \times 4)^2 = \pi^2(1{,}600{,}000)/64 \approx 247$ kN. The fixed-free condition gives K = 2, doubling the effective length. This sharply lowers the buckling load.

52. B — $PW = A(P/A) = 2{,}000 \times 6.7101 = \$13{,}420$. The uniform-series present-worth factor discounts ten annual costs to today. The result is less than the undiscounted total.

53. C — Installing wellpoints or pumps lowers the groundwater table around an excavation. Active pumping draws the water down for dry working conditions. Surface spraying or cement would not dewater.

54. A — Stirrups primarily resist the diagonal tension produced by shear. Shear creates diagonal tensile stresses that can crack concrete. Vertical stirrups intercept and carry this tension.

55. D — $\tau = \sigma \tan\varphi = 100 \times \tan 30° = 100 \times 0.577 = 57.7$ kPa. For a cohesionless soil, shear strength is the normal stress times the tangent of the friction angle. Cohesion is zero here.

56. C — Most probable length = mean = (200.05 + 199.95)/2 = 200.00 m. Averaging repeated measurements gives the most probable value. Random errors tend to cancel.

57. C — The critical path determines the shortest time to complete the project. It is the longest sequence of dependent activities. Delays on it directly delay completion.

58. A — Pavement design for traffic growth uses cumulative ESALs over the design life. ESALs convert mixed, growing traffic into equivalent standard axle loads. The pavement is sized for the total.

59. A — The water-cement ratio most directly controls strength and durability. A lower ratio yields denser, stronger, more durable concrete. It is the single most important mix parameter.

60. B — Water reaches its maximum density at about 4°C. Below this temperature it expands again before freezing. This anomaly causes ice to float.

61. A — Stopping distance = $v^2/(2a) = 20^2/(2 \times 4) = 400/8 = 50$ m. The constant-deceleration relation links speed to stopping distance. Distance grows with the square of speed.

62. A — With slope 2 and intercept 3, the line is $y = 2x + 3$. Slope-intercept form places the slope as the coefficient of x and the intercept as the constant. The point (0, 3) confirms $b = 3$.

63. C — N 45° W and S 45° E point in exactly opposite directions along the same line. One is the reverse bearing of the other. They are parallel and opposite.

64. C — Formwork pressure increases with a faster placement rate and greater pour height. Rapid filling and tall lifts raise the fluid head before the concrete stiffens. Both increase the lateral load.

65. A — Reviewing and approving one's own design is a conflict of interest requiring disclosure or independent review. Self-review undermines the objectivity of the check. An independent engineer should verify the work.

66. B — Fully developed laminar pipe flow has a parabolic velocity profile, maximum at the center. Viscous drag at the wall makes the velocity zero there. The profile rises smoothly to a peak at the axis.

67. D — $\cos(60°) = 0.5$. It is a standard trigonometric value. The cosine of 60° equals one-half.

68. C — Cavitation occurs when the local pressure drops below the fluid's vapor pressure. Vapor bubbles form and collapse violently, damaging the pump. Adequate suction head prevents it.

69. D — An aquifer confined between impermeable layers and under pressure is a confined (artesian) aquifer. Water rises above the confining layer when tapped. This pressure distinguishes it from an unconfined aquifer.

70. C — The equivalent uniform annual cost method best compares alternatives with different useful lives. It puts all options on a common annual basis. This avoids mismatched analysis periods.

71. D — A point load off midspan gives a bending moment diagram of two straight lines peaking under the load. The moment rises linearly from each support to the load point. Its maximum is at the load.

72. B — Refusal on hard rock marks the practical limit of the boring or a competent bearing stratum. The drill can advance no further into the rock. It often defines the foundation bearing depth.

73. A — Volume = depth × area = $0.04 \times (10 \times 20) = 0.04 \times 200 = 8$ m³. The rainfall depth times the roof area gives the collected volume. Unit consistency is essential.

74. C — $\mu = v^2/(gr) = 20^2/(9.81 \times 80) = 400/784.8 = 0.51$. The required friction balances the centripetal demand on a flat curve. Higher speed or smaller radius demands more friction.

75. B — The mode is the most frequent value, which is 6 (appearing twice). The mode identifies the value occurring most often. No other value repeats.

76. A — Reversing the load direction reverses the member force, so a tension diagonal carries compression instead. Truss member forces reverse with the applied load. This matters for members that can buckle.

77. D — Publishing a student's data without credit violates the principle of giving proper credit for professional work. Engineers must acknowledge the contributions of others. This protects honesty and fairness.

78. C — The post-yield plateau on a ductile curve represents plastic flow at nearly constant stress. The material deforms permanently without much added load. This precedes strain hardening.

79. B — Excess cement paste beyond what fills the aggregate voids increases shrinkage and cost. More paste means more drying shrinkage and a costlier mix. Optimal mixes minimize excess paste.

80. D — Averaging direct and reversed theodolite readings eliminates instrumental errors such as collimation and trunnion-axis errors. The two positions produce equal and opposite instrumental effects. Averaging cancels them.

81. A — For a short, heavily loaded beam, shear often governs the design. Short spans develop high shear relative to moment. Long slender beams instead tend to be controlled by moment or buckling.

82. B — Hardness is caused primarily by dissolved calcium and magnesium ions. These form scale and reduce soap effectiveness. Softening removes them.

83. C — Monthly rate = 12%/12 = 1%. The nominal annual rate divides by the number of compounding periods. This periodic rate applies each month.

84. B — Compression steel increases moment capacity and reduces long-term deflection (creep). It adds resistance on the compression side and restrains time-dependent deformation. It is used when the section is otherwise limited.

85. A — $p = \gamma\_oil \times h = (0.8 \times 9.81) \times 5 = 7.848 \times 5 = 39.24$ kPa. The oil's specific weight is its specific gravity times water's. Pressure increases linearly with depth.

86. D — A combined sewer that discharges untreated flow during heavy rain produces a combined sewer overflow. The mixed sanitary-and-storm flow exceeds capacity and bypasses treatment. CSOs are a known pollution concern.

87. A — A two-force body in equilibrium must have equal, opposite, collinear forces. Only such a pair gives both force and moment balance. The forces act along the line joining their points of application.

88. B — A cantilever retaining wall resists overturning mainly through the weight of the wall and the soil resting on its heel. This weight provides a stabilizing moment about the toe. It counteracts the overturning earth pressure.

89. B — Increasing dry density by compaction raises shear strength and lowers permeability. Denser packing improves particle interlock and reduces void space. This is the purpose of compaction.

90. D — A member loaded at more than two points generally carries axial force, shear, and bending moment. Unlike a two-force member, its internal forces are not purely axial. Frame members are analyzed for all three.

91. D — The SPT N-value correlates with the relative density of granular (sandy) soils. Blow counts reflect resistance to penetration in sands. In clays, N relates instead to consistency.

92. B — A rectangular channel is most hydraulically efficient when its width equals twice the flow depth. This best-hydraulic-section ratio minimizes the wetted perimeter for a given area. It maximizes conveyance.

93. A — A bar fixed at both ends and heated develops thermal compressive stress because it cannot expand. The restrained expansion induces internal compression. The stress equals $E\alpha\Delta T$.

94. D — A flexible footing on clay settles most at the center, producing a dished profile. The uniform contact pressure causes greater central deflection. A rigid footing instead settles uniformly.

95. B — Under a triangular load, the reaction is larger at the support nearer the heavier (higher-intensity) end. The resultant acts toward that end, closer to that support. That support therefore carries more.

96. B — Cc is the slope of the void-ratio versus log-effective-stress curve along the virgin compression line. It quantifies how much a clay compresses with stress. A larger Cc means more settlement.

97. C — The departures of a closed traverse must theoretically sum to zero. The east and west components cancel for a closed figure. Any nonzero sum is the closure error to be distributed.

98. C — $\log_{10}(100) = 2$, since $10^2 = 100$. The base-10 logarithm asks the power of ten that gives the number. Two tens multiplied give one hundred.

99. A — Retaining wall backfill must be placed and compacted in thin lifts, layer by layer. Thin lifts allow proper compaction throughout the depth. Dumping in bulk would leave loose, weak zones.

100. C — The yellow change interval is timed mainly from the approach speed and driver reaction (plus deceleration). It must let approaching drivers safely stop or clear. Faster approaches require longer yellows.

101. C — In an equal-mass elastic collision with a stationary target, the velocities exchange, so the first object stops ($v = 0$). Both momentum and kinetic energy are conserved. The moving body transfers all its velocity.

102. B — Combinations C(5,2) = 5!/(2!3!) = 10. Order does not matter when choosing items. There are ten distinct pairs.

103. A — The overflow rate is the flow divided by the tank's surface area. It governs whether particles can settle before reaching the outlet. A lower overflow rate improves removal efficiency.

104. A — The centroid of a triangle lies one-third of the height above the base. It is located at the average of the vertices' positions. This is a standard area property.

105. D — Over interior supports of a continuous beam, the moment is negative (hogging), placing the tension fibers on top. The beam bends concave-down there. Top reinforcement is required at these locations.

106. B — The engineer must refuse to violate the code and inform the client. Code compliance protects public safety and overrides a client's cost instruction. The engineer cannot knowingly produce an unsafe, noncompliant design.

107. A — The available NPSH must exceed the required NPSH to avoid cavitation. Adequate suction head keeps the local pressure above the vapor pressure. Insufficient NPSH leads to bubble formation and damage.

108. B — Free-flow speed is the average speed under low volume with no restrictions. Drivers travel at their desired speed when traffic is light. It is the upper anchor of the speed-flow relationship.

109. C — The limit of $(3x + 2)$ as $x \to 4$ is $3(4) + 2 = 14$. The function is continuous, so direct substitution gives the limit. Linear functions have no discontinuities.

110. B — Annual interest = face value × coupon rate = 1,000 × 0.06 = \$60. The coupon payment is the rate applied to the face value. It is paid each year regardless of market price.