PRACTICE EXAM 9: FE CIVIL SIMULATION (110 QUESTIONS)

110 questions. Recommended time: 5 hours 20 minutes.

1. A closed traverse 1,200 m in total length has a linear misclosure of 0.24 m. What is the relative precision of the traverse?

A. 1/240

B. 1/1,200

C. 1/2,500

D. 1/5,000

2. A 3 m beam is pinned at A (left) and on a roller at B (right). A 12 kN downward load acts 1 m from A. What is the vertical reaction at B?

A. 8 kN

B. 4 kN

C. 12 kN

D. 6 kN

3. A pin-ended column has L = 4 m, E = 200 GPa, and I = 4×10^{-6} m⁴. Using $P_{cr} = \pi^2EI/L^2$, what is the Euler buckling load?

A. 123 kN

B. 1,974 kN

C. 493 kN

D. 247 kN

4. A 50 N force acts along the line from the origin to the point (3, 4). What is its x-component?

A. 40 N

B. 30 N

C. 50 N

D. 25 N

5. Concrete cured underwater for 28 days, compared with the same mix cured in dry air, will generally develop:

A. Lower strength due to water damage

B. Identical strength regardless of curing

C. No measurable strength at all

D. Higher strength due to sustained hydration

6. A signalized movement has a capacity of 600 veh/hr and a demand of 540 veh/hr. What is the degree of saturation (v/c)?

A. 1.11

B. 60

C. 0.60

D. 0.90

7. A 3 m sand layer (γ = 18 kN/m³) overlies clay, with the water table at the ground surface. What is the pore water pressure at the base of the sand?

A. 54 kPa

B. 18 kPa

C. 29.4 kPa

D. 0 kPa

8. A watershed has a time of concentration of 45 minutes. For the rational method, the design storm duration should be:

A. 90 minutes

B. 45 minutes

C. 22.5 minutes

D. 10 minutes

9. A simply supported beam carries a uniform load with maximum deflection $5wL^4/(384EI)$. For w = 10 kN/m, L = 4 m, and EI = 12,000 kN·m², what is the maximum deflection?

A. 1.39 mm

B. 2.78 mm

C. 5.56 mm

D. 0.69 mm

10. A tank holds water 4 m deep. What is the gauge pressure at the bottom?

A. 39.24 kPa

B. 9.81 kPa

C. 4.0 kPa

D. 78.5 kPa

11. A line has a bearing of N 30° E and a length of 100 m. What is its latitude (northing component)?

A. 86.6 m

B. 50.0 m

C. 100 m

D. 30.0 m

12. A uniform series of $1,000 per year for 5 years is discounted at 10%, with (P/A, 10%, 5) = 3.7908. What is its present worth?

A. $5,000

B. $6,105

C. $3,791

D. $2,500

13. The plasticity index of a soil is the difference between:

A. The liquid limit and the plastic limit

B. The plastic limit and the shrinkage limit

C. The liquid limit and the shrinkage limit

D. The water content and the liquid limit

14. A water has a chlorine demand of 2.5 mg/L, and a residual of 0.5 mg/L is desired. What chlorine dose is required?

A. 2.0 mg/L

B. 2.5 mg/L

C. 3.0 mg/L

D. 5.0 mg/L

15. The primary purpose of curing concrete is to:

A. Accelerate the initial set within minutes

B. Reduce the concrete's final strength

C. Maintain moisture for continued hydration

D. Remove entrained air from the mix

16. $5,000 grows at 8% compounded annually with (F/P, 8%, 10) = 2.1589. What is its value after 10 years?

A. $10,795

B. $9,000

C. $5,400

D. $2,316

17. Darcy's law gives the discharge velocity. The actual seepage velocity through the pores equals the Darcy velocity divided by the:

A. Hydraulic gradient

B. Hydraulic conductivity

C. Cross-sectional area

D. Effective porosity

18. What is the derivative of f(x) = ln(x)?

A. x

B. 1/x

C. e^x

D. ln(x)/x

19. A 0.3 m diameter pipe flows full carrying 0.14 m^3/s. What is the flow velocity?

A. 0.47 m/s

B. 4.7 m/s

C. 1.98 m/s

D. 0.99 m/s

20. The maximum aggregate size in concrete is generally limited to:

A. Three times the slab thickness

B. The total cement content by weight

C. One-third the slab depth or three-quarters the bar clear spacing

D. The water-cement ratio expressed in millimeters

21. A simply supported beam carries a uniform load over its full span. What is the shear force at the center of the span?

A. Zero

B. Maximum positive

C. Maximum negative

D. Equal to the total load

22. A bar chart that displays project activities against a time scale using horizontal bars is a:

A. Gantt chart

B. Mohr's circle

C. Flow net

D. Histogram

23. A vertical angle of +6° is measured along an 80 m slope distance. What is the vertical rise?

A. 79.6 m

B. 13.3 m

C. 4.8 m

D. 8.36 m

24. For the immediate (undrained, $\varphi = 0$) bearing capacity of a strip footing on saturated clay using Terzaghi, the bearing capacity factor Nc is approximately:

A. 9.0

B. 1.0

C. 5.7

D. 0

25. An engineer is pressured by a supervisor to approve a design the engineer believes is unsafe. The engineer should:

A. Approve it to follow the chain of command

B. Decline to approve and document the safety concerns

C. Approve it but verbally note disagreement

D. Resign without reporting the concern

26. A theodolite is used primarily to measure:

A. Only vertical distances

B. Horizontal and vertical angles

C. Soil bearing capacity

D. Water flow rates

27. Two roads carry 800 and 1,200 veh/hr toward a merge. What is the combined merging flow rate?

A. 400 veh/hr

B. 1,000 veh/hr

C. 2,000 veh/hr

D. 960,000 veh/hr

28. The modulus of rupture of concrete measures its:

A. Compressive strength in a cylinder

B. Flexural tensile strength in a beam

C. Elastic modulus under axial load

D. Shear strength at the supports

29. A cantilever beam carries a uniform load with free-end deflection $wL^4/(8EI)$. For $w = 6$ kN/m, $L = 3$ m, and $EI = 9{,}000$ kN·m², what is the maximum deflection?

A. 1.69 mm

B. 13.5 mm

C. 3.38 mm

D. 6.75 mm

30. On a compaction curve of dry unit weight versus water content, the peak of the curve corresponds to the:

A. Liquid limit of the soil

B. Optimum moisture content

C. Saturated unit weight

D. Plastic limit of the soil

31. A pump adds 25 m of head to water flowing at 0.10 m^3/s. What is the hydraulic (water) power delivered?

A. 2.45 kW

B. 245 kW

C. 9.81 kW

D. 24.5 kW

32. A vehicle accelerates from rest at 2 m/s^2 for 6 s. What distance does it travel?

A. 12 m

B. 36 m

C. 72 m

D. 6 m

33. A soil with high permeability and rapid drainage during loading is most likely:

A. A saturated fat clay

B. A clean coarse sand or gravel

C. A soft organic silt

D. A highly plastic clay

34. A reservoir has a surface area of 50,000 m^2, and the water level drops 0.2 m over a day with no inflow. What daily volume is lost?

A. 10,000 m^3

B. 250,000 m^3

C. 100 m^3

D. 1,000 m^3

35. An engineer is offered a substantial gift by a vendor seeking selection for a project. Accepting the gift would most directly:

A. Improve the project's technical quality

B. Reduce the project's construction cost

C. Demonstrate professional competence

D. Create a conflict of interest

36. The hydrologic-cycle process by which water vapor returns to liquid form is:

A. Evaporation

B. Condensation

C. Infiltration

D. Transpiration

37. A project has a budgeted cost of $200,000 and is 40% complete. What is the earned value?

A. $200,000

B. $40,000

C. $80,000

D. $120,000

38. A rod of 500 mm^2 cross-section carries an axial tensile force of 100 kN. What is the normal stress?

A. 200 MPa

B. 50 MPa

C. 100 MPa

D. 400 MPa

39. What is the value of $\log_2(32)$?

A. 4

B. 5

C. 6

D. 16

40. A steel shows a clear yield point followed by strain hardening. The stress at which permanent deformation begins is the:

A. Ultimate tensile strength

B. Modulus of elasticity

C. Yield strength

D. Fracture toughness

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

A. 15

B. 21

C. 10.8

D. 225

42. Settlement of a footing on dense sand occurs:

A. Slowly over many years due to consolidation

B. Only after the water table rises

C. Never, since sand does not settle

D. Almost immediately upon loading

43. A steel beam is selected so its flexural design strength φMn equals or exceeds the factored moment Mu. The limit state being satisfied is:

A. Deflection serviceability

B. Shear capacity

C. Flexural strength

D. Bearing at the supports

44. Under professional ethics, an engineer's public statement on a technical matter must be:

A. Persuasive regardless of accuracy

B. Objective and truthful

C. Favorable to the engineer's employer

D. Limited to opinions only

45. A fluid is described as Newtonian. This means its shear stress is:

A. Independent of the velocity gradient

B. Proportional to pressure only

C. Linearly proportional to the rate of shear strain

D. Constant at all temperatures

46. A 100-year flood has a probability of being equaled or exceeded in any single year of:

A. 0.01

B. 0.10

C. 1.0

D. 100

47. The total stress at a point in soil equals the sum of the effective stress and the:

A. Shear strength

B. Atmospheric pressure

C. Overburden weight only

D. Pore water pressure

48. What is the sum of the interior angles of a triangle?

A. 180°

B. 360°

C. 90°

D. 270°

49. When an engineer signs a contract to provide services, the engineer assumes a duty of:

A. Guaranteeing zero risk on the project

B. Competent, professional performance

C. Maximizing personal profit only

D. Avoiding all communication with the client

50. A cohesive soil fails in an unconfined compression test at an axial stress of 120 kPa. Using su = qu/2, what is its undrained shear strength?

A. 240 kPa

B. 120 kPa

C. 30 kPa

D. 60 kPa

51. A shaft has $J = 2\times10^{-6}$ m⁴, radius 0.025 m, and carries a torque of 800 N·m. Using $\tau = Tr/J$, what is the maximum shear stress?

A. 40 MPa

B. 2.5 MPa

C. 20 MPa

D. 10 MPa

52. A truss loaded only at its joints has members that carry primarily:

A. Bending moment

B. Torsion

C. Axial force, in tension or compression

D. Transverse shear

53. A critical-path activity is delayed by 3 days with no available float. The project completion date will:

A. Stay the same

B. Move 3 days earlier

C. Become impossible to determine

D. Move 3 days later

54. An engineer discovers a calculation error in their own sealed design after construction has begun. The engineer should:

A. Ignore it unless someone notices

B. Promptly notify the responsible parties and correct it

C. Quietly revise the drawings without telling anyone

D. Wait until the project is complete to disclose it

55. Flexural cracks in a reinforced concrete beam typically initiate:

A. On the compression face near the supports

B. On the tension face in the region of maximum moment

C. Only at the neutral axis

D. Uniformly across the entire section at once

56. A concrete cylinder reaches 70% of its 28-day strength at 7 days. If the 28-day design strength is 30 MPa, the approximate 7-day strength is:

A. 30 MPa

B. 43 MPa

C. 21 MPa

D. 9 MPa

57. A beam-column is a structural member subjected simultaneously to:

A. Pure tension only

B. Pure torsion only

C. Shear and bearing only

D. Axial compression and bending

58. An asset of $40,000 cost depreciates by double-declining balance at 20% per year. What is the first-year depreciation?

A. $4,000

B. $8,000

C. $16,000

D. $2,000

59. A pile driven into soft clay derives most of its load capacity from:

A. End bearing on bedrock

B. Lateral earth pressure alone

C. Skin friction along the shaft

D. Buoyancy of the pile

60. A 4 kg block moving at 5 m/s collides and sticks to a 6 kg block at rest. By conservation of momentum, what is the common velocity?

A. 5 m/s

B. 2 m/s

C. 3 m/s

D. 0.5 m/s

61. The capacity of a single freeway lane under ideal conditions is approximately:

A. 500 veh/hr

B. 1,000 veh/hr

C. 2,400 veh/hr

D. 5,000 veh/hr

62. A two-force member in a frame, loaded only at its two ends, carries a force directed:

A. Perpendicular to its axis

B. At 45° to its axis

C. Along the line connecting the two end points

D. In a circular pattern

63. A traffic study counts 360 vehicles in a 15-minute period. What is the equivalent hourly flow rate?

A. 1,440 veh/hr

B. 360 veh/hr

C. 90 veh/hr

D. 5,760 veh/hr

64. $8,000 is needed in 5 years. At 6% with (P/F, 6%, 5) = 0.7473, what present deposit is required?

A. $5,978

B. $8,000

C. $10,705

D. $6,667

65. A beam has exactly three unknown reaction components and three available equilibrium equations. The beam is:

A. Unstable

B. Statically indeterminate

C. Statically determinate

D. A mechanism

66. A fair die is rolled once. What is the probability of rolling a number greater than 4?

A. 0.50

B. 0.167

C. 0.667

D. 0.333

67. The neutral axis of a beam in pure bending is the location where the:

A. Shear stress is maximum

B. Deflection is greatest

C. Bending moment is zero

D. Bending stress is zero

68. A 2 kg object has a kinetic energy of 64 J. What is its speed?

A. 4 m/s

B. 8 m/s

C. 16 m/s

D. 32 m/s

69. The expression $(x^3)(x^4)$ simplifies to:

A. x^{12}

B. x^{-1}

C. x^7

D. x^1

70. A GPS receiver determines its position by measuring distances to:

A. A single reference station

B. Multiple satellites simultaneously

C. The magnetic north pole

D. Nearby benchmarks only

71. A worker must enter a 4 m deep manhole that may contain hazardous gases. This space is classified as a:

A. Permit-required confined space

B. Standard open excavation

C. Fall-protection-exempt area

D. Temporary scaffold platform

72. For a given pipe flow rate held constant, increasing the diameter will cause the velocity to:

A. Increase proportionally with diameter

B. Increase with the square of diameter

C. Remain unchanged

D. Decrease with the square of diameter

73. The resultant of two equal and opposite parallel forces separated by a distance is:

A. A single larger force

B. Zero net force and zero moment

C. A force equal to their sum

D. A couple producing pure rotation

74. The Highway Capacity Manual rates the operational quality of a facility using:

A. Level of service grades A through F

B. A single pass/fail rating

C. The pavement's structural number

D. The bridge's load rating

75. A 600 N box rests on a surface with a static friction coefficient of 0.4. What is the maximum static friction force before sliding?

A. 600 N

B. 1,500 N

C. 240 N

D. 60 N

76. A vector has components (6, 8). What is its magnitude?

A. 14

B. 48

C. 10

D. 2

77. A benchmark is a fixed reference point of known:

A. Horizontal angle

B. Bearing only

C. Magnetic declination

D. Elevation

78. A car traveling at 25 m/s brakes uniformly to a stop in 5 s. Using the average velocity, what distance does it cover?

A. 62.5 m

B. 125 m

C. 31.25 m

D. 5 m

79. When the live load on a beam is increased, the section modulus required to keep stress within allowable limits must:

A. Decrease

B. Increase

C. Remain unchanged

D. Become zero

80. Galvanizing protects steel from corrosion by coating it with:

A. Copper

B. Aluminum oxide

C. Zinc

D. Epoxy resin

81. Solve for x: 2^x = 16.

A. 2

B. 8

C. 4

D. 32

82. A load-bearing wall transfers loads to the foundation primarily through:

A. Axial compression

B. Pure tension

C. Torsional shear

D. Lateral bending only

83. A storm sewer designed for a peak runoff surcharges when it flows beyond full. The likely result is:

A. Surface flooding or backup

B. Increased infiltration capacity

C. Reduced rainfall intensity

D. Lower time of concentration

84. A beam's bending stress is $\sigma = Mc/I$. For a fixed moment, doubling the moment of inertia (with c unchanged) will:

A. Double the stress

B. Halve the stress

C. Quadruple the stress

D. Leave the stress unchanged

85. A uniform 200 N sign hangs from a horizontal cantilever bracket. The fixed support must provide a reaction that balances:

A. Only a horizontal force

B. Only a moment

C. Zero force and zero moment

D. Both a vertical force and a moment

86. Coagulation in water treatment uses chemicals such as alum primarily to:

A. Disinfect against viruses

B. Adjust the water's pH to neutral

C. Soften the water by removing calcium

D. Neutralize charges so fine particles aggregate

87. The specific weight of water at standard conditions is approximately:

A. 9.81 kN/m^3

B. 1,000 kN/m^3

C. 9.81 N/m^3

D. 62.4 kN/m^3

88. A two-lane rural highway with no passing zones and heavy truck traffic will generally have a level of service that is:

A. Worse than the same road with passing zones and few trucks

B. Unaffected by trucks or passing opportunities

C. Always level of service A

D. Improved by the presence of trucks

89. Bernoulli's equation conserves energy along a streamline by summing pressure head, velocity head, and:

A. Friction head loss

B. Pump head added

C. Reynolds number

D. Elevation head

90. A construction submittal such as a shop drawing is reviewed by the engineer primarily to:

A. Set the contractor's profit margin

B. Determine the project completion date

C. Establish the liquidated damages rate

D. Confirm conformance with the design intent

91. A 1,500 kg vehicle accelerates from 0 to 20 m/s in 8 s. What is the average net force on it?

A. 3,750 N

B. 30,000 N

C. 187.5 N

D. 1,500 N

92. The Manning roughness coefficient n for a smooth concrete-lined channel is closest to:

A. 0.013

B. 0.10

C. 0.50

D. 1.0

93. A simply supported beam with an overhang carries load on the overhang. Over the overhang, the bending moment is:

A. Always zero

B. Negative (hogging)

C. Always positive (sagging)

D. Constant and maximum

94. Sunk costs in an engineering economic analysis should be:

A. Ignored, since they cannot be recovered

B. Added to all future cash flows

C. Doubled to account for inflation

D. Used as the basis for the rate of return

95. Using $dy/dx = 2x$, what is the slope of the tangent to $y = x^2$ at $x = 3$?

A. 9

B. 6

C. 3

D. 12

96. A quick (boiling) condition in sand occurs when upward seepage reduces the effective stress to:

A. Twice the total stress

B. The pore pressure plus overburden

C. Its maximum value

D. Zero

97. A contractor encounters a differing site condition not shown in the contract documents. The typical contractual remedy is:

A. The contractor absorbs all extra cost

B. The project is automatically terminated

C. The engineer is personally liable

D. An equitable adjustment to the contract

98. A tension member is designed against yielding on the gross section to prevent:

A. Excessive elongation and deformation

B. Compression buckling

C. Torsional twisting

D. Bearing crushing

99. A horizontal curve is being designed for a higher speed. To maintain comfort and safety, the designer should provide:

A. A sharper curve with a smaller radius

B. Less superelevation on the curve

C. A shorter sight distance

D. A larger radius and adequate superelevation

100. A clay has an overconsolidation ratio greater than 1. This means the soil:

A. Has never been loaded before

B. Is currently at its highest stress ever

C. Has experienced a higher stress in the past

D. Is fully liquefied

101. A detention basin in stormwater management is used primarily to:

A. Reduce peak discharge through temporary storage

B. Increase the runoff coefficient

C. Permanently store all runoff

D. Raise the flood elevation downstream

102. A machine has an annual operating cost of $3,000 and a life of 8 years. Ignoring interest, what is the total operating cost over its life?

A. $3,000

B. $375

C. $24,000

D. $8,000

103. A 10 m cable anchored at both ends carries a vertical load at midspan, sagging 1 m. The cable tension is greatest:

A. At the midspan low point

B. Uniformly throughout

C. At the load point only

D. At the anchored end supports

104. A material loaded within its elastic range will, upon removal of the load:

A. Return to its original dimensions

B. Retain a permanent deformation

C. Fracture immediately

D. Increase in cross-sectional area

105. A 0.5 kg ball is thrown straight up at 12 m/s. Using $g = 9.81\ m/s^2$, what maximum height does it reach?

A. 1.22 m

B. 12.0 m

C. 7.34 m

D. 24.5 m

106. A traffic signal's all-red interval is provided to:

A. Increase the green time for all approaches

B. Allow the intersection to clear before conflicting movements start

C. Reduce the overall cycle length to zero

D. Permit pedestrians to begin crossing

107. A body acted on by three non-parallel forces is in equilibrium only if the three forces are:

A. Concurrent at a single point

B. All equal in magnitude

C. All horizontal

D. Acting in the same direction

108. The continuity equation for incompressible steady flow expresses conservation of:

A. Energy

B. Momentum

C. Pressure

D. Mass

109. A traverse angle is measured several times and averaged in order to:

A. Increase the closure error

B. Reduce random measurement error

C. Eliminate the need for adjustment

D. Change the traverse shape

110. Removing formwork from cast concrete before it has gained adequate strength can cause:

A. Structural failure or excessive deflection

B. Increased final compressive strength

C. Faster curing with no risk

D. Improved surface finish only

PRACTICE EXAM 9 — ANSWER KEY AND EXPLANATIONS

1. D — Precision = misclosure/length = 0.24/1,200 = 1/5,000. Relative precision expresses the closure error as a fraction of the total distance traversed. A larger denominator indicates a more accurate survey.

2. B — Taking moments about A: R_B × 3 = 12 × 1, so R_B = 4 kN. The reaction at the far support balances the load's moment about the pin. The closer support carries the larger share.

3. C — $P_{cr} = \pi^2 EI/L^2 = \pi^2(200\times10^9)(4\times10^{-6})/4^2 = \pi^2(800{,}000)/16 \approx 493$ kN. The Euler load gives the elastic buckling capacity of a pin-ended column. It falls with the square of the length.

4. B — The unit vector toward (3, 4) is (3/5, 4/5), so Fx = 50 × 3/5 = 30 N. The x-component projects the force onto the horizontal axis. The 3-4-5 geometry gives clean fractions.

5. D — Continuous moisture from underwater curing sustains cement hydration, producing higher strength than air curing. Hydration requires water to continue forming strength-giving products. Drying prematurely halts that process.

6. D — Degree of saturation v/c = 540/600 = 0.90. It compares demand to capacity for the movement. A value near 1.0 signals near-saturated, congested operation.

7. C — Pore pressure $u = \gamma w \times h = 9.81 \times 3 = 29.4$ kPa. With the water table at the surface, the full depth contributes hydrostatic pressure. Only the water column matters for pore pressure.

8. B — The design storm duration equals the time of concentration, 45 minutes. At that duration the entire watershed contributes, producing the peak flow. Shorter or longer durations yield lower peaks.

9. B — $\delta = 5wL^4/(384EI) = 5(10)(4^4)/(384 \times 12{,}000) = 12{,}800/4{,}608{,}000 = 2.78$ mm. Uniform-load deflection grows with the fourth power of span. Stiffness EI reduces it.

10. A — Gauge pressure = $\gamma h = 9.81 \times 4 = 39.24$ kPa. Hydrostatic pressure increases linearly with depth. The free surface is at zero gauge pressure.

11. A — Latitude = L cos(bearing) = $100 \times \cos 30° = 100 \times 0.866 = 86.6$ m. The latitude is the north-south component of the course. The cosine of the bearing angle gives the northing.

12. C — PW = A(P/A) = $1{,}000 \times 3.7908 = \$3{,}791$. The uniform-series present-worth factor discounts five equal payments to today. The result is less than the undiscounted $5,000.

13. A — The plasticity index is the liquid limit minus the plastic limit. It measures the range of water content over which the soil remains plastic. A larger PI indicates a more plastic, clay-rich soil.

14. C — Chlorine dose = demand + desired residual = 2.5 + 0.5 = 3.0 mg/L. The demand must be satisfied before a residual remains. The dose covers both.

15. C — Curing maintains moisture so cement hydration can continue and develop strength. Hydration is a water-dependent chemical reaction. Inadequate curing yields weaker, less durable concrete.

16. A — F = P(F/P) = $5{,}000 \times 2.1589 = \$10{,}795$. The single-payment compound-amount factor grows the deposit over ten years. Compounding earns interest on interest.

17. D — The seepage (pore) velocity equals the Darcy velocity divided by the effective porosity. Flow occurs only through the connected voids, which are a fraction of the total area. The true velocity is therefore higher than the Darcy value.

18. B — The derivative of ln(x) is 1/x. This is a standard result of differential calculus. It is defined for positive x.

19. C — $A = \pi(0.15)^2 = 0.0707$ m²; $V = Q/A = 0.14/0.0707 = 1.98$ m/s. Velocity is the discharge divided by the full pipe area. Continuity governs the relationship.

20. C — Maximum aggregate size is generally limited to one-third the slab depth or three-quarters the clear bar spacing. These limits ensure proper placement and consolidation around reinforcement. Oversized aggregate causes voids and honeycombing.

21. A — For a symmetric uniform load on a simple span, the shear is zero at midspan. Shear varies linearly from a maximum at each support to zero at the center. The bending moment is maximum where shear is zero.

22. A — A Gantt chart shows project activities as horizontal bars against a time scale. It communicates start, duration, and overlap at a glance. It is the most common scheduling display.

23. D — Vertical rise = S sin(angle) = 80 × sin 6° = 80 × 0.1045 = 8.36 m. The vertical component of a slope distance uses the sine of the vertical angle. The horizontal component would use the cosine.

24. C — For a strip footing on saturated clay under undrained ($\varphi = 0$) conditions, Terzaghi's bearing capacity factor Nc is about 5.7. It reflects cohesion-only support. Net ultimate capacity is roughly Nc times the undrained strength.

25. B — The engineer must decline to approve the unsafe design and document the safety concerns. Public safety overrides pressure from a supervisor. Approval would constitute an ethical and professional violation.

26. B — A theodolite measures horizontal and vertical angles precisely. It is a core instrument for traverse and triangulation work. Distances require separate measurement.

27. C — Combined merging flow = 800 + 1,200 = 2,000 veh/hr. Flows merging from two roads simply add at the junction. Conservation of vehicles applies.

28. B — The modulus of rupture measures the flexural tensile strength of concrete from a beam test. Concrete is weak in tension, and this index quantifies it under bending. It is distinct from compressive strength.

29. D — $\delta = wL^4/(8EI) = 6(3^4)/(8 \times 9{,}000) = 486/72{,}000 = 6.75$ mm. The cantilever free-end deflection grows with the fourth power of length. Greater EI reduces it.

30. B — The peak of a compaction curve marks the optimum moisture content, where the maximum dry unit weight is achieved. More or less water than optimum yields lower density. Field compaction targets this water content.

31. D — Water power = $\gamma QH = 9.81 \times 0.10 \times 25 = 24.5$ kW. It is the useful power imparted to the fluid. Input power would be higher by the inverse of efficiency.

32. B — Distance = $\frac{1}{2}at^2 = \frac{1}{2}(2)(6^2) = \frac{1}{2}(2)(36) = 36$ m. Starting from rest, displacement grows with the square of time. Only acceleration and time are needed.

33. B — A clean coarse sand or gravel has high permeability and drains rapidly during loading. Its large, connected pores transmit water freely. Clays drain far more slowly.

34. A — Volume lost = area × drop = 50,000 × 0.2 = 10,000 m³. The drop in level times the surface area gives the volume removed. With no inflow, this equals the loss.

35. D — Accepting a substantial gift from a vendor seeking selection creates a conflict of interest. It can compromise the engineer's impartial judgment. Ethics codes require avoiding even the appearance of such influence.

36. B — Condensation is the process by which water vapor returns to liquid form. It forms clouds and precipitation in the hydrologic cycle. Evaporation is the reverse process.

37. C — Earned value = percent complete × budget = 0.40 × 200,000 = $80,000. It represents the budgeted value of work actually performed. It is compared to planned value and actual cost.

38. A — $\sigma = P/A = 100{,}000/500\times10^{-6} = 200\times10^{6}$ Pa = 200 MPa. Normal stress is the axial force divided by the cross-sectional area. Unit consistency gives megapascals.

39. B — $\log_2(32) = 5$, since $2^5 = 32$. The logarithm asks what power of 2 yields 32. The base-2 result is five.

40. C — The yield strength is the stress at which permanent (plastic) deformation begins. Below it, deformation is elastic and recoverable. Strain hardening follows the yield point.

41. A — Hypotenuse = $\sqrt{(9^2 + 12^2)} = \sqrt{(81 + 144)} = \sqrt{225} = 15$. The Pythagorean theorem relates the legs to the hypotenuse. This is a 3-4-5 triangle scaled by three.

42. D — Settlement of a footing on dense sand occurs almost immediately upon loading. Granular soils drain instantly, so there is no time-dependent consolidation. Consolidation settlement is a clay phenomenon.

43. C — Ensuring $\varphi Mn \geq Mu$ satisfies the flexural strength limit state. The design moment capacity must equal or exceed the factored applied moment. This is the basic LRFD flexure check.

44. B — Professional ethics require public statements on technical matters to be objective and truthful. Engineers must base statements on competent knowledge and disclose relevant interests. Honesty maintains public trust.

45. C — A Newtonian fluid has shear stress linearly proportional to the rate of shear strain. The constant of proportionality is the dynamic viscosity. Water and air behave this way.

46. A — A 100-year flood has an annual exceedance probability of 1/100 = 0.01. The return period is the reciprocal of the yearly probability. It does not guarantee one event per century.

47. D — Total stress equals effective stress plus pore water pressure. This is Terzaghi's effective-stress principle. The soil skeleton carries the effective portion.

48. A — The interior angles of a triangle sum to 180°. This is a fundamental result of Euclidean geometry. It holds for every planar triangle.

49. B — Signing a services contract obligates the engineer to competent, professional performance. The standard is reasonable care and skill, not a guarantee of zero risk. This defines the professional duty.

50. D — $s_u = q_u/2 = 120/2 = 60$ kPa. In an unconfined compression test, the undrained shear strength is half the failure stress. The Mohr's circle radius equals s_u.

51. D — $\tau = Tr/J = 800 \times 0.025/2\times10^{-6} = 20/2\times10^{-6} = 10\times10^{6}$ Pa = 10 MPa. Shear stress in torsion is highest at the outer radius. The polar moment of inertia governs the distribution.

52. C — A truss loaded only at its joints carries axial force—tension or compression—in each member. With no transverse joint loads, bending is negligible. This assumption defines ideal truss analysis.

53. D — A 3-day delay to a critical-path activity with no float pushes completion 3 days later. Critical activities directly control the project finish. There is no slack to absorb the delay.

54. B — The engineer must promptly notify the responsible parties and correct the error. Concealing or delaying disclosure of a known error violates professional honesty and risks safety. Prompt correction protects the public.

55. B — Flexural cracks initiate on the tension face in the region of maximum moment. Concrete cracks where tensile stress first exceeds its limited tensile strength. Reinforcement then carries the tension.

56. C — 7-day strength $\approx 0.70 \times 30 = 21$ MPa. Concrete typically reaches about 70% of its 28-day strength at 7 days. The early test estimates the eventual strength.

57. D — A beam-column carries axial compression and bending simultaneously. Its design uses an interaction of the two effects. Pure beams and pure columns are special cases.

58. B — First-year DDB depreciation = $0.20 \times 40{,}000 = \$8{,}000$. The rate is applied to the current book value, which is the full cost in year one. Later years apply it to a declining balance.

59. C — A pile in soft clay derives most of its capacity from skin friction along the shaft. The soft clay offers little end bearing. Side resistance dominates.

60. B — By momentum conservation, $v = (4 \times 5)/(4 + 6) = 20/10 = 2$ m/s. The inelastic collision merges the masses into one moving body. Momentum is conserved while kinetic energy is not.

61. C — A single freeway lane under ideal conditions has a capacity of about 2,400 passenger cars per hour. This is the Highway Capacity Manual base value. Real conditions reduce it.

62. C — A two-force member carries force directed along the line connecting its two end points. Equilibrium of only two forces requires them to be collinear, equal, and opposite. The force acts along the member's axis.

63. A — Hourly flow rate = $360 \times 4 = 1{,}440$ veh/hr. The 15-minute count is scaled by four to an hourly rate. This expresses the short-term flow as an equivalent hourly demand.

64. A — $P = F(P/F) = 8{,}000 \times 0.7473 = \$5{,}978$. The single-payment present-worth factor discounts the future need to today. This deposit grows to \$8,000 in five years.

65. C — Three unknown reactions matched by three equilibrium equations make the beam statically determinate. The equations exactly suffice to find the reactions. No redundancy exists.

66. D — $P(>4) = P(\{5, 6\}) = 2/6 = 0.333$. Two of six equally likely faces exceed four. The probability is one-third.

67. D — The neutral axis is where the bending stress is zero. Above it the fibers are in compression and below in tension (or vice versa). It passes through the centroid for symmetric bending.

68. B — $v = \sqrt{(2 \cdot KE/m)} = \sqrt{(2 \times 64/2)} = \sqrt{64} = 8$ m/s. Kinetic energy is $\frac{1}{2}mv^2$, solved here for v. The speed follows from the energy and mass.

69. C — $(x^3)(x^4) = x^{(3+4)} = x^7$. Multiplying powers of the same base adds the exponents. The result is x to the seventh.

70. B — A GPS receiver fixes its position by measuring distances to multiple satellites at once. Trilateration from at least four satellites resolves location and time. A single source cannot determine position.

71. A — A 4 m deep manhole that may hold hazardous gases is a permit-required confined space. Limited entry plus an atmospheric hazard triggers the permit requirement. Entry demands testing and controls.

72. D — Since $V = Q/A$ and $A \propto d^2$, increasing the diameter decreases the velocity with the square of the diameter. A larger area carries the same flow more slowly. Doubling the diameter quarters the velocity.

73. D — Two equal, opposite parallel forces separated by a distance form a couple, producing pure rotation. Their net force is zero but their moment is not. A couple's moment is the same about every point.

74. A — The Highway Capacity Manual rates operational quality with level-of-service grades A through F. The grades reflect measures such as delay, density, or speed. They describe the traveler's experience.

75. C — Maximum static friction = $\mu N = 0.4 \times 600 = 240$ N. The normal force equals the weight on a level surface. Sliding begins once the applied force exceeds this.

76. C — Magnitude = $\sqrt{(6^2 + 8^2)} = \sqrt{(36 + 64)} = \sqrt{100} = 10$. The vector magnitude is the root of the sum of squared components. This is a 3-4-5 relationship scaled by two.

77. D — A benchmark is a fixed reference point of known elevation. It anchors leveling surveys to a vertical datum. Elevations are measured relative to it.

78. A — Average velocity = $(25 + 0)/2 = 12.5$ m/s; distance = $12.5 \times 5 = 62.5$ m. Uniform deceleration lets the average velocity times time give the distance. Stopping distance follows directly.

79. B — A larger live load increases the bending moment, so the required section modulus must increase to hold stress within limits. Section modulus relates moment to stress. A bigger or deeper section is needed.

80. C — Galvanizing coats steel with zinc for corrosion protection. The zinc layer acts as a barrier and a sacrificial anode. It corrodes preferentially, protecting the steel.

81. C — $2^x = 16 = 2^4$, so $x = 4$. Equal bases mean equal exponents. The solution is four.

82. A — A load-bearing wall transfers loads to the foundation primarily through axial compression. The wall acts as a vertical compression element. Loads travel downward along its plane.

83. A — A surcharged storm sewer that exceeds full flow causes surface flooding or backup. Excess flow has nowhere to go within the pipe. This is the failure mode the design seeks to avoid.

84. B — Since $\sigma = Mc/I$, doubling I (with c fixed) halves the stress. Bending stress is inversely proportional to the moment of inertia. A stiffer section reduces stress.

85. D — A horizontal bracket holding a sign offset from the support must resist both a vertical force and a moment. The weight produces a downward force and a moment about the fixed end. The support reaction balances both.

86. D — Coagulants such as alum neutralize the charges on fine suspended particles so they aggregate. Destabilized particles collide and form larger flocs. These then settle or filter out.

87. A — The specific weight of water is about 9.81 kN/m^3. It equals the density (1,000 kg/m^3) times gravity. The value 62.4 belongs to lb/ft^3, a different unit system.

88. A — No passing zones and heavy trucks worsen the level of service compared with a road that allows passing and has few trucks. Trucks reduce speeds and passing restrictions trap vehicles in platoons. Both lower operational quality.

89. D — Bernoulli's equation sums pressure head, velocity head, and elevation head along a streamline. These three energy components are conserved for ideal flow. Elevation head accounts for position in the gravity field.

90. D — Shop drawings are reviewed mainly to confirm conformance with the design intent. The engineer checks that the contractor's interpretation matches the design. It is not a means to set cost or schedule.

91. A — $F = ma = 1{,}500 \times (20/8) = 1{,}500 \times 2.5 = 3{,}750$ N. Acceleration is the velocity change over time. Newton's second law gives the net force.

92. A — Manning's n for a smooth concrete-lined channel is about 0.013. Smoother surfaces have lower roughness coefficients. Higher n values indicate rougher channels.

93. B — Over an overhang, the load produces a negative (hogging) bending moment. The overhang acts like a cantilever, with tension on top. This contrasts with the sagging moment in the main span.

94. A — Sunk costs are ignored in economic analysis because they cannot be recovered. Only future cash flows affected by a decision are relevant. Including sunk costs distorts the comparison.

95. B — $dy/dx = 2x$, so at $x = 3$ the slope is $2 \times 3 = 6$. The derivative gives the tangent slope at any point. Evaluating at $x = 3$ yields six.

96. D — A quick condition occurs when upward seepage reduces the effective stress to zero. With no effective stress, the sand loses shear strength and behaves like a fluid. This is the boiling or quicksand condition.

97. D — A differing site condition not shown in the documents typically entitles the contractor to an equitable adjustment. The contract price or time is modified to reflect the changed condition. This allocates the unforeseen risk fairly.

98. A — Designing against gross-section yielding prevents excessive elongation and deformation of the tension member. Yielding over the full length would cause unacceptable stretch. It is one of two tension limit states.

99. D — A higher design speed requires a larger radius and adequate superelevation for safety and comfort. Faster vehicles need gentler curves to balance centrifugal force. Sharper curves would be unsafe.

100. C — An overconsolidation ratio greater than 1 means the soil has carried a higher effective stress in the past. The current stress is below that maximum. Such soils settle less under new load.

101. A — A detention basin reduces peak discharge by temporarily storing runoff and releasing it slowly. It attenuates the flood hydrograph. It does not retain water permanently.

102. C — Total operating cost = 3,000 × 8 = \$24,000. Ignoring interest, the annual cost is simply multiplied by the life. This sums the undiscounted expenditures.

103. D — Cable tension is greatest at the supports, where the cable is steepest. The vertical component of tension is largest there to carry the load. Tension is least at the low point.

104. A — A material loaded within its elastic range returns to its original dimensions when unloaded. Elastic strain is fully recoverable. Permanent set requires loading beyond yield.

105. C — $h = v^2/(2g) = 12^2/(2 \times 9.81) = 144/19.62 = 7.34$ m. At the apex the velocity is zero, converting kinetic energy to height. Gravity sets the maximum rise.

106. B — The all-red interval lets the intersection clear before conflicting movements receive green. It provides a safety buffer after the yellow. This reduces right-angle collisions.

107. A — Three non-parallel forces in equilibrium must be concurrent at a single point. Otherwise a net moment would remain. Concurrency ensures both force and moment balance.

108. D — The continuity equation for incompressible steady flow expresses conservation of mass. The mass entering equals the mass leaving a control volume. For constant density, the volumetric flow is constant.

109. B — Averaging repeated angle measurements reduces random measurement error. Random errors tend to cancel over many readings. Systematic errors require separate correction.

110. A — Stripping formwork before the concrete has gained adequate strength can cause structural failure or excessive deflection. The fresh concrete cannot yet carry its own weight and loads. Premature removal is a serious safety hazard.