PRACTICE EXAM 16 : FE CIVIL SIMULATION (110 QUESTIONS)

110 questions. Recommended time: 5 hours 20 minutes.

1. Water flows at 4 m/s through a pipe of internal diameter 0.25 m. What is the volumetric flow rate?

A. 0.196 m^3/s

B. 0.098 m^3/s

C. 0.785 m^3/s

D. 0.049 m^3/s

2. A $50,000 machine is depreciated straight-line over 10 years to zero salvage. What is its book value after 4 years?

A. $20,000

B. $10,000

C. $30,000

D. $50,000

3. A 6 kN force and an 8 kN force act at right angles at a point. What is the magnitude of their resultant?

A. 10 kN

B. 14 kN

C. 2 kN

D. 48 kN

4. A saturated soil has Gs = 2.65 and void ratio e = 0.65. What is its saturated unit weight ($\gamma w = 9.81$ kN/m³)?

A. 16.0 kN/m³

B. 26.0 kN/m³

C. 10.0 kN/m³

D. 19.6 kN/m³

5. A roadway carries 800 vehicles during the peak 15-minute period. What is the corresponding peak hourly flow rate?

A. 3,200 veh/hr

B. 800 veh/hr

C. 200 veh/hr

D. 3,600 veh/hr

6. A simply supported beam of span 6 m carries a 24 kN point load at midspan. What is the maximum bending moment?

A. 144 kN·m

B. 18 kN·m

C. 72 kN·m

D. 36 kN·m

7. Solve for x: $4x - 8 = 12$.

A. 5

B. 4

C. 1

D. 20

8. The shear modulus G of structural steel is approximately:

A. 200 GPa

B. 77 GPa

C. 25 GPa

D. 350 GPa

9. A trapezoidal channel cross-section is often preferred over a rectangular one because it:

A. Provides a stable, efficient cross-section for earthen channels

B. Eliminates all sediment deposition

C. Requires no lining under any conditions

D. Has zero friction loss

10. A 1,000 kg car accelerates uniformly from rest to 20 m/s over a distance of 100 m. What is its acceleration?

A. 0.2 m/s^2

B. 2 m/s^2

C. 4 m/s^2

D. 10 m/s^2

11. Turbidity in a water sample is a measure of the:

A. Cloudiness caused by suspended particles

B. Dissolved oxygen content

C. Hydrogen ion concentration

D. Free chlorine residual

12. A vertical curve in a roadway profile is provided to:

A. Provide a smooth transition between two grades

B. Increase the roadway's superelevation

C. Replace a horizontal curve

D. Drain water from the pavement

13. A soil containing gravel and sand sizes but lacking intermediate sizes is described as:

A. Well-graded

B. Uniformly graded

C. Fine-grained

D. Gap-graded

14. What is the present worth of a perpetual annual benefit of $2,000 at an interest rate of 8%?

A. $16,000

B. $2,160

C. $160,000

D. $25,000

15. A uniform 100 N beam rests on two supports at its ends. What is the reaction at each support?

A. 100 N

B. 50 N

C. 25 N

D. 200 N

16. What is the gauge pressure at a depth of 5 m in seawater (specific gravity 1.025)?

A. 49.1 kPa

B. 5.0 kPa

C. 10.3 kPa

D. 50.3 kPa

17. The first warrant typically evaluated for installing a traffic signal is the:

A. Eight-hour vehicular volume

B. Local pedestrian fashion preference

C. Roadway pavement color

D. Number of nearby driveways

18. For a pin-ended steel column, doubling the unbraced length (same section) changes the Euler buckling load by a factor of:

A. 1/2

B. 2

C. 4

D. 1/4

19. What is the derivative of e^(2x)?

A. e^(2x)

B. 2x·e^(2x)

C. e^(2x)/2

D. 2e^(2x)

20. The Atterberg limits are determined on the soil fraction passing the:

A. No. 4 sieve

B. No. 200 sieve

C. No. 40 sieve

D. No. 10 sieve

21. An after-tax cash flow analysis must include the effects of:

A. Depreciation and income taxes

B. Only the purchase price

C. Inflation alone

D. The salvage value only

22. A 0.2 kg ball is thrown at 15 m/s. What is its momentum?

A. 30 kg·m/s

B. 3 kg·m/s

C. 0.3 kg·m/s

D. 75 kg·m/s

23. A fluid flowing through a horizontal converging nozzle experiences:

A. Decreasing velocity and decreasing pressure

B. Constant velocity throughout

C. Increasing velocity and decreasing pressure

D. Increasing pressure and velocity

24. A closed-loop traverse whose angular misclosure exceeds the allowable limit should be:

A. Accepted without any change

B. Remeasured to locate the error

C. Multiplied by two

D. Ignored if it appears small

25. A circular shaft carries a torque T producing maximum shear stress $\tau = 16T/(\pi d^3)$. If T is doubled, the shear stress:

A. Is halved

B. Is quadrupled

C. Is doubled

D. Stays the same

26. Spiral-reinforced concrete columns outperform tied columns primarily in:

A. Pure tension capacity

B. Reduced material cost

C. Thermal resistance

D. Ductility and core confinement

27. A soil's coefficient of permeability is measured in the laboratory using a:

A. Triaxial compression test

B. Atterberg limits test

C. Constant-head or falling-head test

D. Standard Proctor test

28. A nominal annual rate of 6% compounded semiannually gives an effective annual rate of:

A. 6.00%

B. 3.00%

C. 6.09%

D. 12.0%

29. A two-way stop-controlled intersection assigns priority to:

A. The minor-road approach

B. The uncontrolled major-road approach

C. Pedestrians only

D. The widest leg

30. The standard deviation of a data set is 4. What is its variance?

A. 2

B. 8

C. 16

D. 4

31. Friction head loss in a pipe is directly proportional to the:

A. Pipe length

B. Pipe diameter

C. Fluid color

D. Pipe material cost

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

A. Equal and acting at one point

B. Unequal and opposite

C. Collinear and equal

D. Equal, opposite, and parallel but offset

33. The settlement of a granular soil under load is caused primarily by:

A. Immediate compression and particle rearrangement

B. Slow consolidation over decades

C. Chemical dissolution of the grains

D. Frost action alone

34. When the interest rate increases, the present worth of a fixed future cash flow:

A. Decreases

B. Increases

C. Stays constant

D. Becomes negative

35. A 2 kg object moving at 6 m/s collides with and sticks to a 4 kg object at rest. What is their common velocity?

A. 6 m/s

B. 3 m/s

C. 4 m/s

D. 2 m/s

36. The plastic neutral axis of a cross-section divides it into:

A. Two equal areas

B. Two equal moments of inertia

C. The flange and web exactly

D. Equal-stress regions only

37. A Pitot tube measures flow velocity by relating it to the:

A. Fluid density alone

B. Pipe wall roughness

C. Temperature rise of the fluid

D. Difference between stagnation and static pressure

38. An expansive-clay foundation problem is best mitigated by:

A. Adding more water to the soil

B. Increasing the building weight

C. Controlling moisture and using proper foundation design

D. Ignoring the soil type

39. Dividing the annual average daily traffic into the design-hour volume yields the:

A. Truck percentage

B. K-factor (design-hour proportion)

C. Crash rate

D. Level of service

40. In a present-worth analysis, the salvage value is treated as a:

A. Negative cost at year zero

B. Recurring annual expense

C. Positive cash inflow at the end of life

D. Sunk cost to be ignored

41. A 45-45-90 right triangle has legs of length 5. What is the hypotenuse?

A. $5\sqrt{2}$

B. 10

C. 5

D. $5\sqrt{3}$

42. A continuous beam is preferred over a series of simple spans because it:

A. Eliminates all support reactions

B. Reduces midspan moments and deflections

C. Requires no supports

D. Removes the need for materials

43. The specific weight of a fluid is defined as its:

A. Mass per unit volume

B. Force per unit area

C. Weight per unit volume

D. Volume per unit mass

44. The shear strength relation $\tau = c + \sigma' \tan\varphi$ is known as the:

A. Mohr-Coulomb failure criterion

B. Darcy's law

C. Bernoulli equation

D. Terzaghi consolidation equation

45. A 5 kg mass hung from a spring stretches it 0.1 m. What is the spring constant ($g = 9.81\ m/s^2$)?

A. 50 N/m

B. 5 N/m

C. 98 N/m

D. 490 N/m

46. In a level-payment loan amortization schedule, the early payments consist mostly of:

A. Principal only

B. Equal principal and interest always

C. Interest

D. Fees only

47. A trapezoid has parallel sides of 8 and 12 and a height of 5. What is its area?

A. 100

B. 40

C. 20

D. 50

48. The strength of a fillet weld depends primarily on its:

A. Color and surface finish

B. Effective throat and length

C. Surrounding bolt spacing

D. Applied paint thickness

49. Flow in a pipe is generally considered fully turbulent above a Reynolds number of about:

A. 40

B. 4,000

C. 40,000

D. 400,000

50. A footing is sometimes placed deeper below grade in order to:

A. Reduce the concrete volume

B. Lower the groundwater table

C. Reach competent soil for greater bearing capacity

D. Avoid the need for reinforcement

51. The superelevation transition of a horizontal curve consists of the tangent runout plus the:

A. Vertical curve length

B. Crest curve length

C. Sight triangle

D. Superelevation runoff

52. The future worth of equal annual deposits is determined using the:

A. (P/F) factor

B. (F/A) factor

C. (A/P) factor

D. (P/G) factor

53. If $\sin \theta = 0.6$ for an acute angle, what is $\cos \theta$?

A. 0.6

B. 0.8

C. 0.4

D. 1.0

54. The reaction force at a roller support acts:

A. Along the beam axis

B. As a moment only

C. In any arbitrary direction

D. Perpendicular to the supporting surface

55. The toughness of a material is represented by the:

A. Slope of the elastic region

B. Yield point alone

C. Total area under the stress-strain curve

D. Maximum strain alone

56. Increasing the diameter of a pipe carrying a given flow from a reservoir will:

A. Increase the friction loss

B. Have no effect on the flow

C. Reduce friction loss and increase flow

D. Stop the flow entirely

57. The seepage force in a soil mass acts in the direction of:

A. Water flow

B. Gravity only

C. The slope face only

D. Opposite to the flow

58. A project requires $100,000 now and returns $30,000 per year for 5 years. What is its simple payback period?

A. 5.0 years

B. 2.0 years

C. 3.33 years

D. 10 years

59. Stopping sight distance is the sum of the brake-reaction distance and the:

A. Passing distance

B. Decision distance

C. Curve length

D. Braking distance

60. In how many ways can 4 distinct books be arranged in a row on a shelf?

A. 12

B. 24

C. 16

D. 4

61. Bracing in a steel building frame is provided primarily to resist:

A. Gravity dead loads only

B. Thermal expansion only

C. Lateral wind and seismic loads

D. Foundation settlement

62. The discharge through an orifice under a head h increases with the:

A. Square root of the head

B. Square of the head

C. Cube of the diameter

D. Inverse of the head

63. A retaining wall's stability against overturning is checked by comparing the resisting moments to the:

A. Sliding forces only

B. Soil bearing pressures

C. Seepage gradients

D. Overturning moments about the toe

64. The economic service life of an asset is the period that:

A. Maximizes its purchase price

B. Minimizes its equivalent uniform annual cost

C. Equals the manufacturer's warranty

D. Doubles the payback period

65. A 1,200 kg car travels around a circular track of radius 100 m at 20 m/s. What is the centripetal force?

A. 240 N

B. 2,400 N

C. 4,800 N

D. 48,000 N

66. The slope of a horizontal line is:

A. Zero

B. Undefined

C. One

D. Infinite

67. Prestress losses in a concrete member result from:

A. Initial elastic shortening only

B. Elastic shortening, creep, shrinkage, and relaxation

C. Corrosion of the tendons alone

D. Temperature changes alone

68. A pump installed in a pipeline increases the fluid's energy by adding:

A. Mass

B. Head (energy per unit weight)

C. Viscosity

D. Density

69. A boring log records the:

A. Soil and rock encountered at various depths in a borehole

B. Traffic volume on a roadway

C. Concrete mix design proportions

D. Steel reinforcement layout

70. Signal coordination along an arterial corridor aims to:

A. Increase the posted speed limit

B. Eliminate all left turns

C. Reduce the number of lanes

D. Provide green progression for vehicle platoons

71. Capital recovery cost combines depreciation recovery with the:

A. Operating fuel cost

B. Interest (return) on the invested capital

C. Property taxes only

D. Labor wages

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

A. 64

B. 32

C. 16

D. 10

73. A simply supported beam with an overhang can develop a:

A. Positive moment only

B. Zero moment everywhere

C. Pure torsional load

D. Negative bending moment over the support

74. The dimensionless Froude number is most relevant to:

A. Laminar pipe flow

B. Open-channel free-surface flow

C. Compressible gas flow only

D. Static fluids

75. The plastic limit of a soil is the water content at the boundary between the:

A. Liquid and plastic states

B. Plastic and semisolid states

C. Solid and gaseous states

D. Saturated and dry states

76. Two alternatives are compared, and the extra investment of the more expensive option yields a 15% incremental rate of return. If the MARR is 10%, you should:

A. Select the cheaper alternative

B. Reject both alternatives

C. Select the more expensive alternative

D. Defer the decision indefinitely

77. What is the work done by gravity on a 10 kg object lowered 3 m ($g = 9.81\ m/s^2$)?

A. 30 J

B. 294 J

C. 98 J

D. 2,940 J

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

A. Combined axial load and bending

B. Pure shear only

C. Torsion only

D. Tension only

79. What is the limit of $(\sin x)/x$ as x approaches 0?

A. 0

B. Infinity

C. Undefined

D. 1

80. The magnitude of a water-hammer pressure surge depends on the:

A. Pipe color

B. Atmospheric humidity

C. Valve closure speed and the pressure wave speed

D. Pump efficiency alone

81. A site susceptible to liquefaction can be improved by:

A. Adding more water to the deposit

B. Removing all reinforcement

C. Increasing the building height

D. Densifying the loose saturated sand

82. Space-mean speed is computed as the:

A. Arithmetic mean of spot speeds

B. Maximum observed speed

C. Total distance divided by the mean travel time

D. 85th-percentile speed

83. In evaluating a public project, intangible benefits are:

A. Always ignored

B. Counted as additional costs

C. The only factor considered

D. Considered qualitatively alongside quantifiable benefits

84. What is the probability of drawing a red card from a standard 52-card deck?

A. 1/4

B. 1/13

C. 13/52

D. 1/2

85. A three-hinged arch is statically:

A. Determinate

B. Indeterminate to the first degree

C. A mechanism

D. Indeterminate to the third degree

86. A nozzle attached to the end of a hose primarily increases the water's:

A. Mass flow rate

B. Density

C. Temperature

D. Velocity

87. An undisturbed soil sample is required mainly to measure the:

A. In-situ strength and consolidation properties

B. Grain-size distribution only

C. Specific gravity only

D. Color and odor

88. A break-even analysis identifies the level of output at which:

A. Profit is maximized

B. Total revenue equals total cost

C. Depreciation is zero

D. Salvage equals first cost

89. The rotational kinetic energy of a flywheel is given by:

A. $\frac{1}{2}I\omega^2$

B. $\frac{1}{2}mv^2$

C. $I\omega$

D. $m\omega r$

90. The modular ratio n in reinforced concrete design is the ratio of the:

A. Concrete strength to steel strength

B. Steel area to concrete area

C. Load to resistance

D. Steel modulus to concrete modulus

91. A submerged horizontal surface experiences a uniform pressure equal to:

A. Zero

B. Atmospheric pressure only

C. The velocity head

D. The specific weight times the depth

92. What are the roots of $x^2 - 9 = 0$?

A. 9 only

B. +3 and −3

C. 3 only

D. 0 and 9

93. The standard penetration test drives a split-spoon sampler using a:

A. Static hydraulic jack

B. 140 lb hammer dropped 30 inches

C. Vibratory roller

D. Constant water head

94. The capacity of an entry to a roundabout depends primarily on the:

A. Posted speed limit

B. Pavement surface color

C. Circulating flow rate opposing the entry

D. Number of street lights

95. Money has time value primarily because it can:

A. Earn a return over time

B. Be physically printed

C. Be taxed annually

D. Fade in color over time

96. For a body in equilibrium under exactly three forces, the forces must be:

A. All equal in magnitude

B. Acting at different points

C. All mutually perpendicular

D. Concurrent and form a closed force triangle

97. Energy losses in pipe fittings such as elbows and valves are classified as:

A. Major losses

B. Pump head gains

C. Minor losses

D. Elevation changes

98. A soil's bearing capacity decreases when the groundwater table:

A. Rises to or above the footing level

B. Drops far below the footing

C. Is removed entirely

D. Freezes solid permanently

99. If the position of a body is $s(t) = 4t^2$, what is its velocity?

A. 4t

B. 8t

C. 8

D. $4t^3/3$

100. The first step in designing a steel tension member is to determine the:

A. Required gross and net areas for the factored load

B. Weld electrode color

C. Protective paint thickness

D. Erection crane capacity

101. A traffic study that counts vehicles by type over a period is a:

A. Speed study

B. Delay study

C. Vehicle classification count

D. Origin-destination survey

102. The internal rate of return of a project is found by setting the:

A. Future worth to a maximum

B. Net present worth to zero and solving for i

C. Depreciation equal to salvage

D. Payback equal to the project life

103. The energy equation that incorporates pump and turbine head terms is an extension of:

A. Newton's second law

B. Darcy's law

C. Bernoulli's equation

D. Hooke's law

104. A geosynthetic used to separate and reinforce soil layers is a:

A. Riprap blanket

B. Gabion basket

C. Geotextile

D. Sheet pile

105. What is the cosine of 60°?

A. 0.866

B. 1.0

C. 0.707

D. 0.5

106. A body undergoes simple harmonic motion when its restoring force is:

A. Constant in magnitude

B. Proportional to velocity

C. Proportional to displacement and directed toward equilibrium

D. Zero at all times

107. A floor diaphragm in a building distributes lateral loads to the:

A. Vertical resisting elements such as shear walls and frames

B. Roof drainage system

C. Foundation footings directly

D. Window openings

108. An expense that does not vary with the level of production is a:

A. Variable cost

B. Fixed cost

C. Marginal cost

D. Incremental cost

109. A slope failure occurring along a curved surface in a clay deposit is typically a:

A. Planar wedge failure

B. Toppling failure

C. Rotational (circular) slip failure

D. Flow slide only

110. An engineer must maintain client confidentiality except when:

A. It is never permissible to disclose anything

B. Disclosure is needed to protect public safety or is required by law

C. A competitor requests the information

D. The project has been completed

PRACTICE EXAM 16 — Answer Key and Explanations

1. A — $Q = AV = (\pi/4 \times 0.25^2) \times 4 = 0.0491 \times 4 = 0.196$ m³/s. Flow rate equals cross-sectional area times velocity. The $\pi d^2/4$ area is the decisive computation.

2. C — Book value = cost − (years × annual depreciation) = 50,000 − 4 × 5,000 = $30,000. Straight-line depreciation removes an equal amount each year. After 4 of 10 years, 40% of the value has been depreciated.
3. A — $R = \sqrt{(6^2 + 8^2)} = \sqrt{100} = 10$ kN. Perpendicular forces combine by the Pythagorean theorem. This is a scaled 3-4-5 triangle.
4. D — $\gamma_{sat} = [(G_s + e)/(1 + e)] \times \gamma_w = (3.30/1.65) \times 9.81 = 2.0 \times 9.81 = 19.6$ kN/m³. This phase relationship gives the unit weight of fully saturated soil. The voids are entirely water-filled.
5. A — Peak flow rate = 800 × 4 = 3,200 veh/hr. A 15-minute count is multiplied by four to express an equivalent hourly rate. This captures the peak intensity within the hour.
6. D — $M_{max} = PL/4 = 24 \times 6 / 4 = 36$ kN·m at midspan. For a central point load on a simple span, the maximum moment is one-quarter of the load times the span. It occurs directly under the load.
7. A — $4x - 8 = 12$ gives $4x = 20$, so $x = 5$. Add 8 to both sides, then divide by 4. Substituting back confirms the solution.
8. B — The shear modulus of structural steel is about 77 GPa, derived from $G = E/[2(1 + \nu)]$ with E = 200 GPa and $\nu \approx 0.3$. It governs shear and torsional deformation. It is roughly 40% of the elastic modulus.
9. A — A trapezoidal section provides a stable, hydraulically efficient cross-section well suited to earthen channels, since the sloped sides resist erosion and slumping. Vertical walls would be unstable in soil. This shape is standard for unlined canals.
10. B — $a = v^2/(2s) = 20^2/(2 \times 100) = 400/200 = 2$ m/s². This kinematic relation finds acceleration from velocity and distance without time. Mass does not appear in the equation.
11. A — Turbidity quantifies the cloudiness of water caused by suspended particles that scatter light. It is measured in nephelometric turbidity units (NTU). High turbidity can shield pathogens from disinfection.
12. A — A vertical curve provides a smooth parabolic transition between two roadway grades. It ensures comfort and adequate sight distance at the grade change. Crest and sag curves are the two types.
13. D — A gap-graded soil contains some size ranges but is missing intermediate sizes, leaving a gap in the gradation curve. This produces poorer packing than a well-graded soil. The discontinuity defines the classification.
14. D — Capitalized cost = A/i = 2,000/0.08 = $25,000. The present worth of a perpetual annual benefit is the payment divided by the interest rate. The principal sustains the payment indefinitely.
15. B — Each reaction = 100/2 = 50 N by symmetry. A uniform beam on two end supports has its weight shared equally. Vertical equilibrium requires the reactions to sum to the total weight.
16. D — $P = \rho gh = (1.025 \times 1{,}000) \times 9.81 \times 5 = 50.3$ kPa. Seawater's specific gravity raises its density above fresh water before applying the hydrostatic relation. Greater density yields slightly higher pressure than fresh water.
17. A — The eight-hour vehicular volume is the first signal warrant typically evaluated in the MUTCD. It checks whether traffic volumes justify a signal. Other warrants address pedestrians, crashes, and coordination.
18. D — Euler load varies inversely with the square of length, so doubling the length reduces it to $(1/2)^2 = 1/4$. Longer columns buckle at much lower loads. This shows the strong influence of unbraced length.
19. D — The derivative of e^(2x) is 2e^(2x) by the chain rule. The exponent's coefficient multiplies the exponential. This is a routine differentiation result.

20. C — The Atterberg limits are determined on the soil fraction passing the No. 40 sieve, the fine portion that exhibits plasticity. Coarser particles are excluded because they do not affect plastic behavior. This standardizes the test.
21. A — After-tax analysis must incorporate depreciation and income taxes, since depreciation shields income and reduces taxes owed. These effects change the net cash flows. Ignoring them distorts the true return.
22. B — Momentum = $mv = 0.2 \times 15 = 3$ kg·m/s. Linear momentum is mass times velocity. The result is independent of the ball's path.
23. C — In a converging nozzle, continuity forces the velocity to increase as area decreases, and Bernoulli's equation then requires the pressure to fall. Faster flow corresponds to lower pressure. This is the basis of nozzle and venturi action.
24. B — A traverse exceeding the allowable angular misclosure must be remeasured to locate and correct the error before adjustment. Adjusting an oversized misclosure would mask a blunder. Quality control requires re-checking the work.
25. C — Since $\tau = 16T/(\pi d^3)$ is linear in T, doubling the torque doubles the shear stress. Torsional stress scales directly with the applied torque. Diameter, by contrast, enters as the cube.
26. D — Spiral reinforcement confines the concrete core, giving spiral columns greater ductility and toughness than tied columns. The confinement delays sudden failure under overload. This is valuable in seismic regions.
27. C — Soil permeability is measured with a constant-head test (for coarse soils) or a falling-head test (for fine soils). Both relate measured flow to the hydraulic gradient via Darcy's law. The choice depends on the soil's permeability range.
28. C — Effective rate = $(1 + 0.06/2)^2 - 1 = 1.03^2 - 1 = 6.09\%$. Semiannual compounding raises the effective rate above the 6% nominal rate. More frequent compounding increases the effective return.
29. B — A two-way stop assigns priority to the uncontrolled major-road approach, which proceeds without stopping. The minor-road traffic must stop and yield. This control suits intersections of unequal traffic importance.
30. C — Variance = (standard deviation)$^2 = 4^2 = 16$. Variance is the square of the standard deviation. It expresses dispersion in squared data units.
31. A — Friction head loss is directly proportional to pipe length, as shown by the L term in the Darcy-Weisbach equation. A longer pipe accumulates more loss. Diameter and velocity enter through other terms.
32. D — A couple consists of two equal, opposite, parallel forces whose lines of action are offset, producing pure rotation. Their net force is zero but their moment is not. The moment is the same about any point.
33. A — Granular soils settle almost immediately through elastic compression and rearrangement of particles, because their high permeability allows fast drainage. There is little time-dependent consolidation. This contrasts with clays.
34. A — A higher interest rate increases the discount factor's denominator, so the present worth of a fixed future amount decreases. Future money is valued less when the rate is higher. This is fundamental to discounting.
35. D — Conservation of momentum: $m_1v_1 = (m_1 + m_2)v$, so $v = (2 \times 6)/6 = 2$ m/s. The two bodies move together after a perfectly inelastic collision. Kinetic energy is not conserved in this case.

36. A — The plastic neutral axis divides a cross-section into two equal areas, since at full plastification the tension and compression forces (stress times area) must balance. This differs from the elastic neutral axis at the centroid. It is used to compute the plastic moment.
37. D — A Pitot tube relates velocity to the difference between stagnation pressure and static pressure. The stagnation point converts kinetic energy to pressure. Applying Bernoulli's equation yields the flow speed.
38. C — Expansive-clay problems are mitigated by controlling soil moisture and using appropriate foundation systems such as deep or stiffened footings. Stabilizing moisture limits the shrink-swell cycle. Proper design accommodates or avoids the movement.
39. B — Dividing the design-hour volume by the AADT gives the K-factor, the proportion of daily traffic in the design hour. It converts daily counts into an hourly design value. Typical values range from about 0.08 to 0.12.
40. C — Salvage value is treated as a positive cash inflow occurring at the end of the asset's life. It offsets the cost of ownership. It is discounted to present worth like any future receipt.
41. A — In a 45-45-90 triangle, the hypotenuse equals a leg times $\sqrt{2}$, so $5\sqrt{2} \approx 7.07$. The equal legs and right angle fix this ratio. It is a standard reference triangle.
42. B — A continuous beam develops negative moments over interior supports that reduce the positive midspan moments and deflections compared with simple spans. This makes more efficient use of material. The trade-off is greater analysis complexity and indeterminacy.
43. C — Specific weight is the weight per unit volume of a fluid, $\gamma = \rho g$. It differs from density, which is mass per unit volume. Specific weight is used directly in hydrostatic pressure calculations.
44. A — $\tau = c + \sigma' \tan\varphi$ is the Mohr-Coulomb failure criterion, combining cohesion and frictional resistance. It defines the shear strength of soil as a function of effective normal stress. It is the foundation of soil-strength analysis.
45. D — $k = mg/x = (5 \times 9.81)/0.1 = 490$ N/m. At equilibrium the spring force balances the weight. Dividing the static weight by the deflection gives the stiffness.
46. C — In a level-payment amortization, early payments are mostly interest because the outstanding balance is largest at the start. As the principal declines, the interest portion shrinks and the principal portion grows. The total payment stays constant.
47. D — Area $= \frac{1}{2}(b_1 + b_2)h = \frac{1}{2}(8 + 12) \times 5 = 50$. The trapezoid area averages the parallel sides and multiplies by the height. The half-factor distinguishes it from a rectangle.
48. B — A fillet weld's strength is governed by its effective throat dimension and its length, which together give the resisting area in shear. Capacity equals this area times the allowable strength. Throat size is set by the weld leg dimension.
49. B — Pipe flow is generally fully turbulent above a Reynolds number of about 4,000, with a transitional zone between roughly 2,000 and 4,000. Higher Re means inertia dominates viscosity. This threshold guides friction-factor selection.
50. C — A deeper footing is used to reach competent bearing soil and develop greater bearing capacity, since capacity increases with embedment depth. It also places the base below weak surface layers. This improves foundation performance.
51. D — The superelevation transition consists of the tangent runout plus the superelevation runoff, the length over which full superelevation develops. The runoff rotates the pavement to the full banked cross-slope. A smooth transition maintains comfort and safety.
52. B — The future worth of equal annual deposits uses the (F/A) uniform-series compound-amount factor. It accumulates the series with compound interest. Its reciprocal is the sinking-fund factor.

53. B — $\cos\theta = \sqrt{(1 - \sin^2\theta)} = \sqrt{(1 - 0.36)} = \sqrt{0.64} = 0.8$ for an acute angle. The Pythagorean identity links sine and cosine. This corresponds to a 3-4-5 reference triangle.
54. D — A roller reaction acts perpendicular to the supporting surface, since a roller cannot resist forces along the surface or moments. It provides one reaction component. This idealization permits thermal expansion and rotation.
55. C — Toughness is the total area under the stress-strain curve, representing the energy absorbed up to fracture. It combines strength and ductility. A tough material absorbs significant energy before failing.
56. C — Increasing the pipe diameter reduces velocity and friction loss for a given flow, allowing greater discharge under the same head. Larger diameters lower the head loss term sharply. This is a common way to increase capacity.
57. A — The seepage force acts in the direction of water flow through the soil, exerted by the moving water on the soil grains. It can reduce effective stress and cause instability. Upward seepage is especially critical for piping.
58. C — Simple payback = initial cost / annual return = 100,000/30,000 = 3.33 years. It measures how quickly the investment is recovered. The method ignores the time value of money.
59. D — Stopping sight distance is the brake-reaction distance plus the braking distance. The first covers driver response time; the second covers deceleration to a stop. Their sum sets the minimum visibility needed.
60. B — The number of arrangements of 4 distinct items is $4! = 24$. Each position is filled by one fewer remaining choice. This is a basic permutation result.
61. C — Bracing in a steel frame resists lateral loads from wind and earthquakes, providing stiffness against side-sway. It carries horizontal forces to the foundation. Gravity loads are handled by beams and columns.
62. A — Orifice discharge varies with the square root of the head, since velocity follows $V = \sqrt{(2gh)}$ by Torricelli's theorem. Doubling the head increases discharge by only about 41%. The head-discharge relationship is nonlinear.
63. D — Overturning stability compares the resisting moments to the overturning moments taken about the toe of the wall. A factor of safety above about 2 is required. The earth pressure provides the overturning moment.
64. B — The economic service life is the holding period that minimizes the equivalent uniform annual cost, balancing rising operating costs against falling capital recovery. It identifies the optimal replacement time. This minimizes total annual ownership cost.
65. C — $F = mv^2/r = 1{,}200 \times 20^2/100 = 1{,}200 \times 4 = 4{,}800$ N. Centripetal force scales with the square of speed and inversely with radius. It points toward the center of the curve.
66. A — A horizontal line has zero slope, since y does not change as x changes. The rise is zero for any run. A vertical line, by contrast, has undefined slope.
67. B — Prestress losses arise from elastic shortening, creep, shrinkage of concrete, and relaxation of the steel. These time-dependent and immediate effects reduce the initial prestress force. Designers must account for all of them.
68. B — A pump adds head, the energy per unit weight of fluid, raising pressure and elevation potential. This head overcomes friction losses and lifts the fluid. It appears as a positive term in the energy equation.
69. A — A boring log records the soil and rock types and properties encountered at successive depths in a borehole. It documents the subsurface stratigraphy. This information guides foundation and earthwork design.

70. D — Signal coordination provides green progression so platoons of vehicles arrive at successive signals during their green phases. This reduces stops and delay along the arterial. Offsets between signals are timed to the travel speed.
71. B — Capital recovery cost combines depreciation recovery with interest (a return) on the capital still invested. It converts the first cost, less salvage, into an equivalent annual amount. This represents the annual cost of owning the asset.
72. B — $2^3 \times 2^2 = 2^{(3+2)} = 2^5 = 32$. Multiplying powers of the same base adds the exponents. This is a basic exponent law.
73. D — A beam with an overhang develops a negative bending moment over the support, where the cantilevered load reverses the curvature. The top fibers there are in tension. This contrasts with the positive moment in the main span.
74. B — The Froude number, comparing inertial to gravitational forces, is most relevant to open-channel free-surface flow. It distinguishes subcritical from supercritical flow. Gravity is the controlling restoring force at a free surface.
75. B — The plastic limit marks the water content at the boundary between the plastic and semisolid states. Below it, the soil crumbles rather than deforms plastically. It is one of the Atterberg limits.
76. C — An incremental rate of return of 15% exceeds the 10% MARR, so the extra investment is justified and the more expensive alternative should be selected. The increment earns more than the required minimum. This is the incremental-analysis decision rule.
77. B — Work = mgh = $10 \times 9.81 \times 3 = 294$ J. Gravity does positive work as the object descends. The result is the energy transferred over the 3 m drop.
78. A — A beam-column carries combined axial load and bending simultaneously. Its design uses an interaction equation that accounts for both effects. Many columns in frames behave this way.
79. D — The limit of $(\sin x)/x$ as x approaches 0 is 1, a fundamental trigonometric limit. It underlies the derivative of the sine function. It can be confirmed with the small-angle approximation.
80. C — Water-hammer surge magnitude depends on how quickly the valve closes and on the pressure-wave speed in the fluid. Rapid closure produces a larger surge. Slow closure and surge protection reduce the pressure spike.
81. D — Liquefaction-prone sites are improved by densifying the loose saturated sand, which raises its resistance to cyclic pore-pressure buildup. Densification methods include vibro-compaction and stone columns. A denser soil is far less prone to liquefaction.
82. C — Space-mean speed equals the total distance traveled divided by the mean travel time of vehicles over a section. It weights slower vehicles appropriately and is used in flow-density relationships. It is generally lower than the time-mean speed.
83. D — In public-project evaluation, intangible benefits are considered qualitatively alongside the quantifiable benefits and costs. They cannot be priced precisely but still inform the decision. Ignoring them would understate a project's value.
84. D — There are 26 red cards in a 52-card deck, so P(red) = 26/52 = 1/2. Half the deck is red (hearts and diamonds). The probability reduces to one-half.
85. A — A three-hinged arch is statically determinate, since the third hinge provides an extra equation that matches the number of unknown reactions. Its reactions can be found from equilibrium alone. This makes it simpler to analyze than a two-hinged arch.
86. D — A nozzle reduces the flow area, so by continuity the water's velocity increases at the outlet. The kinetic energy rises while pressure falls. This produces the high-speed jet.

87. A — An undisturbed sample preserves the soil's natural structure, allowing measurement of in-situ strength and consolidation properties. Disturbance would alter these stress-dependent characteristics. Index tests like gradation can use disturbed samples.
88. B — The break-even point is the output level at which total revenue equals total cost, producing zero profit. Below it the venture loses money; above it, it profits. It is found by equating the revenue and cost functions.
89. A — Rotational kinetic energy is $\frac{1}{2}I\omega^2$, the rotational analog of $\frac{1}{2}mv^2$. The moment of inertia replaces mass and angular velocity replaces linear velocity. A flywheel stores energy this way.
90. D — The modular ratio n is the ratio of the steel modulus to the concrete modulus, Es/Ec. It transforms steel area into an equivalent concrete area in the transformed-section method. It reflects the relative stiffness of the two materials.
91. D — A horizontal submerged surface experiences a uniform pressure equal to the specific weight times the depth, since all points are at the same depth. The pressure is constant across the surface. The resultant force is this pressure times the area.
92. B — $x^2 - 9 = 0$ factors as $(x - 3)(x + 3) = 0$, giving roots $+3$ and -3. A difference of squares yields two real roots of opposite sign. Both satisfy the equation.
93. B — The standard penetration test drives a split-spoon sampler with a 140 lb hammer falling 30 inches, counting blows per increment of penetration. The blow count (N-value) indexes soil density and consistency. This standardized energy makes results comparable.
94. C — Roundabout entry capacity depends primarily on the circulating flow rate that opposes entering vehicles. Higher circulating flow leaves fewer gaps to enter. Entering drivers yield to the circulating stream.
95. A — Money has time value because it can earn a return (interest) over time, making a present dollar worth more than a future one. This is the foundation of discounting and compounding. It justifies all time-value-of-money calculations.
96. D — Three forces in equilibrium must be concurrent (or parallel) and form a closed force triangle when added head to tail. Concurrency prevents a net couple, and closure ensures zero resultant. This is a classic equilibrium condition.
97. C — Losses in fittings such as elbows, tees, and valves are minor losses, computed from a loss coefficient times the velocity head. They arise from local flow disturbances. Pipe-length friction, by contrast, gives the major losses.
98. A — Bearing capacity decreases when the water table rises to or above the footing, because buoyancy lowers the effective unit weight and thus the soil's frictional resistance. The reduced effective stress weakens the soil. Designers account for the highest expected water level.
99. B — Velocity is the derivative of position: $\frac{d}{dt}(4t^2) = 8t$. Differentiating the position function gives the instantaneous velocity. A second derivative would give the acceleration.
100. A — The first design step for a steel tension member is determining the required gross and net cross-sectional areas to carry the factored load. These control yielding and rupture limit states. Member selection follows from these area requirements.
101. C — A vehicle classification count records the number of vehicles by type over a period. It supports pavement design, capacity analysis, and planning. It differs from speed, delay, and origin-destination studies.
102. B — The internal rate of return is the interest rate that makes the net present worth equal to zero. Solving NPW = 0 for i gives the IRR. It is then compared with the MARR for acceptance.

103. C — The energy equation with pump and turbine head terms extends Bernoulli's equation to real systems with energy addition and removal. It adds head-gain and head-loss terms to the ideal energy balance. This makes it applicable to pumped and frictional systems.

104. C — A geotextile is a geosynthetic used to separate soil layers and provide reinforcement and filtration. It prevents intermixing of materials and adds tensile strength. It is common in roadways and embankments.

105. D — cos 60° = 0.5, a standard reference value. It equals the adjacent side over the hypotenuse in a 30-60-90 triangle. The value 0.866 is cos 30°.

106. C — Simple harmonic motion occurs when the restoring force is proportional to displacement and directed toward equilibrium ($F = -kx$). This produces sinusoidal oscillation. A spring-mass system is the classic example.

107. A — A floor diaphragm collects lateral loads and distributes them to the vertical resisting elements such as shear walls and frames. It acts as a horizontal beam spanning between these elements. This load path is central to lateral design.

108. B — A fixed cost does not change with the level of production, such as rent or insurance. Variable costs, by contrast, rise with output. Distinguishing them is essential for break-even analysis.

109. C — A slip failure along a curved surface in clay is a rotational (circular) slope failure, common in cohesive soils. The soil mass rotates about a center above the slope. It is analyzed with circular-arc methods such as the method of slices.

110. B — An engineer must keep client information confidential except when disclosure is necessary to protect public safety or is required by law. The duty to the public overrides confidentiality in such cases. This balances professional discretion with public welfare.