PRACTICE EXAM 12 : FE CIVIL SIMULATION (110 QUESTIONS)

110 questions. Recommended time: 5 hours 20 minutes.

1. Water flows at 3 m/s through a pipe of internal diameter 200 mm. The volumetric flow rate is closest to:

A. 0.060 m³/s

B. 0.094 m³/s

C. 0.150 m³/s

D. 0.188 m³/s

2. Using (P/A, 6%, 8) = 6.2098, what is the present worth of a $500 annual payment received for 8 years at 6%?

A. $4,000

B. $2,500

C. $1,500

D. $3,105

3. A 3 kN force and a 4 kN force act at right angles to each other at a point. What is the magnitude of their resultant?

A. 5 kN

B. 7 kN

C. 1 kN

D. 12 kN

4. A soil has a porosity of 0.375. What is its void ratio?

A. 0.375

B. 0.27

C. 1.60

D. 0.60

5. A vehicle travels 0.5 mile in 45 seconds. What is its average speed?

A. 20 mph

B. 30 mph

C. 60 mph

D. 40 mph

6. A simply supported beam of span 5 m carries a uniformly distributed load of 8 kN/m. What is the maximum bending moment?

A. 50 kN·m

B. 25 kN·m

C. 20 kN·m

D. 40 kN·m

7. What is the value of 5! (5 factorial)?

A. 25

B. 20

C. 60

D. 120

8. Manning's roughness coefficient n for a smooth finished concrete channel is approximately:

A. 0.10

B. 0.50

C. 0.035

D. 0.013

9. The modulus of elasticity of structural steel is approximately:

A. 70 GPa

B. 25 GPa

C. 200 GPa

D. 1,000 GPa

10. Which factor converts a uniform annual series into an equivalent future value?

A. (F/A)

B. (P/A)

C. (A/P)

D. (P/F)

11. A 4 kg object accelerates at 2.5 m/s^2. What is the net force acting on it?

A. 1.6 N

B. 6.5 N

C. 2.5 N

D. 10 N

12. The maximum contaminant level goal (MCLG) for a known carcinogen in drinking water is typically set at:

A. Zero

B. The MCL value

C. The detection limit

D. 10 mg/L

13. A bearing of S 30° E expressed as an azimuth (measured clockwise from north) is:

A. 30°

B. 210°

C. 150°

D. 330°

14. A clay with a liquidity index of 1.0 has a natural water content equal to its:

A. Plastic limit

B. Liquid limit

C. Shrinkage limit

D. Optimum moisture content

15. A pressure of 2 atmospheres, expressed in absolute terms, is approximately:

A. 101.3 kPa

B. 50.7 kPa

C. 202.6 kPa

D. 2.0 kPa

16. If $\log_{10}(x) = 2$, what is the value of x?

A. 20

B. 100

C. 10

D. 1,000

17. The minimum length of a passing zone on a two-lane highway is governed by the:

A. Lane width

B. Shoulder surface type

C. Pavement friction value

D. Passing sight distance

18. A column pinned at both ends has a theoretical effective length factor K of:

A. 1.0

B. 0.5

C. 2.0

D. 0.7

19. The salvage value of an asset is its estimated worth:

A. At the time of purchase

B. Halfway through its life

C. At the end of its useful life

D. After it depreciates to zero

20. The period of a simple pendulum depends on its:

A. Mass and swing amplitude

B. Length and gravitational acceleration

C. Color and material

D. Applied driving force only

21. The resilience of a material is its ability to:

A. Resist corrosion over time

B. Conduct heat efficiently

C. Absorb and release elastic energy

D. Deform permanently without fracture

22. For steady incompressible flow, the continuity equation requires that:

A. Pressure is constant everywhere

B. Velocity is uniform at all sections

C. The volumetric flow rate stays constant

D. Energy losses are zero throughout

23. A footing placed below the local frost depth is designed mainly to avoid:

A. Frost heave damage

B. Excessive bearing capacity

C. Lateral earth pressure

D. Buoyant uplift only

24. The method that distributes traverse misclosure in proportion to course length is the:

A. Transit rule

B. Compass (Bowditch) rule

C. Least-squares method only

D. Crandall method

25. A $10,000 loan at 5% simple interest for 3 years accrues total interest of:

A. $500

B. $5,000

C. $1,050

D. $1,500

26. What is the median of the data set {3, 7, 9, 11, 15}?

A. 7

B. 9

C. 11

D. 45

27. A stop sign assigns right-of-way at an intersection using:

A. Signal phasing

B. Roundabout yielding

C. Mandatory stop control

D. Uncontrolled priority

28. Reinforced concrete is efficient because reinforcing steel resists tension while concrete resists:

A. Shear only

B. Torsion only

C. Compression

D. Thermal expansion

29. A fully open gate valve in a pipeline introduces:

A. A large major friction loss

B. No effect on the flow

C. A pump energy gain

D. A small minor head loss

30. The undrained shear strength of a saturated clay is:

A. Equal to the undrained cohesion, independent of normal stress

B. Proportional to the normal stress only

C. Zero in all loading cases

D. Equal to the soil's friction angle

31. Under straight-line depreciation, the book value at the end of the depreciable life equals the:

A. Original cost

B. Zero value in all cases

C. Salvage value

D. Current market value

32. What is the area of a triangle with a base of 10 and a height of 6?

A. 30

B. 60

C. 16

D. 15

33. A body moving at constant velocity has a net force acting on it of:

A. Zero

B. Its weight

C. Its mass

D. An increasing magnitude

34. A simply supported beam with a single midspan load has equal support reactions because of the:

A. Friction at the supports

B. Beam's self-weight alone

C. Symmetry of the load and geometry

D. Modulus of elasticity

35. A piezometer installed in a pipe measures the:

A. Pressure head at a point

B. Velocity of the flow

C. Total energy head

D. Reynolds number

36. The design speed of a roadway is best defined as:

A. The posted speed limit only

B. The average travel speed observed

C. The maximum safe speed the geometry supports

D. The free-flow speed minus 10 mph

37. A well-graded soil is characterized by:

A. Particles of a single uniform size

B. Only clay-sized particles

C. Only gravel-sized particles

D. A wide range of particle sizes

38. In a symmetric beam subjected to pure bending, the neutral axis coincides with the:

A. Top flange

B. Centroidal axis

C. Bottom flange

D. Support line

39. Continuous compounding of interest at rate r over time t uses the growth factor:

A. e^{rt}

B. $(1 + r)^t$

C. $1/(1 + r)^t$

D. $r \times t$

40. The slope-intercept form of the equation of a straight line is:

A. $Ax + By = C$

B. $y = mx + b$

C. $y - y_1 = m(x - x_1)$

D. $x = a$

41. A 2,000 kg truck and a 1,000 kg car travel at the same speed. The truck's momentum is:

A. Twice the car's momentum

B. Half the car's momentum

C. Equal to the car's momentum

D. Four times the car's momentum

42. In a real pipe flow, the energy grade line always:

A. Rises in the direction of flow

B. Stays perfectly horizontal

C. Coincides with the pipe axis

D. Slopes downward due to losses

43. The permeability of a soil is most strongly influenced by its:

A. Color and odor

B. Specific gravity only

C. Void ratio and grain size

D. Plasticity index only

44. The design strength of a bolted tension member is governed by the lesser of gross-section yielding and rupture across the:

A. Weld throat

B. Bolt shank

C. Flange tip

D. Net section

45. Equivalent uniform annual worth is obtained by multiplying the present worth by the factor:

A. (P/F)

B. (A/P)

C. (F/A)

D. (P/A)

46. A vertical datum widely used for elevation reference in North America is:

A. WGS 72

B. NAVD 88

C. UTM Zone 17

D. State Plane only

47. What is the indefinite integral of cos(x) dx?

A. sin(x) + C

B. −sin(x) + C

C. −cos(x) + C

D. tan(x) + C

48. The Highway Capacity Manual defines level of service in terms of:

A. Pavement structural number

B. Crashes recorded per year

C. Total construction cost

D. Operational quality experienced by drivers

49. Surface tension effects are most significant in:

A. Large open-channel flows

B. High-velocity pipe flow

C. Deep reservoir storage

D. Small-scale capillary phenomena

50. An increase in the degree of soil compaction generally:

A. Increases the void ratio

B. Increases permeability

C. Decreases permeability

D. Has no effect on density

51. A shear wall resists lateral building loads primarily through its:

A. Out-of-plane bending alone

B. In-plane shear and bending stiffness

C. Axial tension in diagonals

D. Torsion of the floor slab

52. A project with a negative net present worth at the MARR should be:

A. Accepted immediately

B. Rejected as uneconomical

C. Funded at twice the cost

D. Deferred without further analysis

53. If two angles of a triangle measure 40° and 75°, the third angle is:

A. 45°

B. 55°

C. 65°

D. 115°

54. A satellite in a stable circular orbit experiences:

A. No net force at all

B. A centripetal force supplied by gravity

C. A constant outward force

D. Zero acceleration

55. Pascal's law states that pressure applied to a confined fluid is:

A. Reduced with distance from the source

B. Transmitted equally in all directions

C. Greatest at the container bottom only

D. Dependent on the fluid's color

56. A standard penetration test blow count of N = 50 in sand indicates a soil that is:

A. Very loose

B. A soft clay

C. Very dense

D. An organic deposit

57. Reciprocal leveling is performed primarily to:

A. Measure horizontal angles

B. Establish magnetic bearings

C. Cancel curvature and refraction errors

D. Determine soil bearing capacity

58. The minimum attractive rate of return (MARR) represents the:

A. Maximum profit possible on a project

B. Lowest acceptable return on an investment

C. Inflation rate by itself

D. Risk-free bank rate exactly

59. The expression $x^2 \cdot x^3$ simplifies to:

A. x^5

B. x^6

C. x

D. $2x^5$

60. Lateral bracing of a steel beam's compression flange is provided to prevent:

A. Web shear yielding

B. Tension flange rupture

C. Bearing failure at supports

D. Lateral-torsional buckling

61. Traffic calming devices such as speed humps are intended to:

A. Reduce vehicle speeds in residential areas

B. Increase intersection capacity

C. Eliminate the need for signals

D. Widen the travel lanes

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

A. Water hammer

B. Pipe corrosion

C. Cavitation

D. Surge tank overflow

63. The ultimate purpose of a geotechnical subsurface investigation is to:

A. Estimate construction labor cost

B. Survey the property boundaries

C. Characterize subsurface conditions for design

D. Test the concrete strength

64. When two projects are compared over the same period, the one with the greater present worth of net benefits is:

A. The more economically attractive

B. Always the cheaper to construct

C. The one with the shorter life

D. Rejected automatically

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

A. 1/52

B. 1/13

C. 1/4

D. 4/13

66. The impulse delivered by a force equals the area under the:

A. Force-versus-distance curve

B. Force-versus-time curve

C. Velocity-versus-time curve

D. Acceleration-versus-mass curve

67. A truss loaded only at its joints carries, in each member:

A. Bending and shear

B. Torsion only

C. Distributed transverse load

D. Axial force only

68. For a very wide rectangular open channel, the hydraulic radius approaches the:

A. Channel width

B. Half the width

C. Flow depth

D. Twice the depth

69. A dewatering system at an excavation is installed to:

A. Lower the groundwater table for a dry excavation

B. Increase the soil's water content

C. Add cohesion to a sandy soil

D. Compact the subgrade automatically

70. Depreciation is best described as the:

A. Direct cash outflow each year

B. Increase in an asset's market value

C. Systematic allocation of cost over the asset's life

D. Interest paid on a loan

71. A closed traverse that returns to its starting point permits checking of:

A. Only the instrument calibration

B. Both angular and positional closure

C. Only the magnetic declination

D. The soil bearing capacity

72. The roots of $ax^2 + bx + c = 0$ are given by:

A. $x = [-b \pm \sqrt{(b^2 - 4ac)}] / (2a)$

B. $x = b / (2a)$

C. $x = -c / b$

D. $x = \sqrt{(b^2 - 4ac)}$

73. Where two traffic streams merge into one, the location is most likely to become:

A. A reduction in total demand

B. An increase in free-flow speed

C. A permanent gain in capacity

D. A bottleneck where demand may exceed capacity

74. The plastic moment Mp of a beam section is reached when:

A. Only the extreme fiber yields

B. The section first cracks

C. The entire cross-section has yielded

D. Deflection reaches its limit

75. An ideal fluid is assumed to be:

A. Inviscid and incompressible

B. Highly viscous and compressible

C. Turbulent at all speeds

D. Subject to large friction losses

76. The angle of repose of a granular material is most closely related to its:

A. Angle of internal friction

B. Specific gravity

C. Plasticity index

D. Compression index

77. When an alternative produces no positive cash inflows, it is evaluated on the basis of:

A. Maximum revenue

B. Highest rate of return

C. Greatest benefit-cost ratio

D. Least equivalent cost

78. The sum of the interior angles of any quadrilateral is:

A. 360°

B. 180°

C. 540°

D. 720°

79. A 10 N·m torque is applied to a disk with a moment of inertia of 2 kg·m². What is the angular acceleration?

A. 20 rad/s²

B. 0.2 rad/s²

C. 12 rad/s²

D. 5 rad/s²

80. Stirrups in a reinforced concrete beam primarily resist:

A. Axial compression

B. Bending moment

C. Diagonal tension (shear)

D. Thermal stress

81. A flow-measuring device that creates a constriction and reads the resulting pressure drop is the:

A. Pitot-static tube

B. Orifice or venturi meter

C. Current meter

D. Weir gauge

82. Relative density is the index commonly used to describe the state of:

A. Saturated clays

B. Granular cohesionless soils

C. Organic peat

D. Solid bedrock

83. A capital expenditure differs from an operating expense in that it:

A. Provides benefits over multiple years

B. Is incurred only once each month

C. Has no effect on depreciation

D. Is always less than $100

84. Earth curvature over a long level sight causes the distant rod reading to appear:

A. Exactly correct

B. Too low by a constant

C. Random and uncorrectable

D. Too high, requiring a downward correction

85. The derivative of a constant is:

A. The constant itself

B. One

C. Zero

D. Undefined

86. A 0.5 kg ball is thrown straight up at 10 m/s. What is its maximum height ($g = 9.81\ m/s^2$)?

A. 10.2 m

B. 1.0 m

C. 20.4 m

D. 5.1 m

87. The tip deflection of a cantilever beam under an end point load is proportional to:

A. L

B. L^3

C. L^2

D. $1/L$

88. The discharge coefficient of a real orifice accounts for:

A. The pipe roughness only

B. The fluid's color

C. The atmospheric pressure

D. Contraction and friction that reduce ideal flow

89. A laterally loaded pile resists the applied load primarily through:

A. End bearing at the tip

B. Negative skin friction

C. Buoyant uplift

D. Passive soil resistance along its length

90. If inflation is 4% and the market interest rate is 9%, the approximate real interest rate is:

A. 5%

B. 13%

C. 2.25%

D. 36%

91. The standard equation of a circle of radius r centered at the origin is:

A. $y = r^2$

B. $x + y = r$

C. $x^2 + y^2 = r^2$

D. $xy = r^2$

92. A traffic signal warrant analysis is conducted to determine whether:

A. The pavement needs resurfacing

B. A bridge can carry heavy trucks

C. A signal is justified at an intersection

D. A speed limit should be changed

93. Creep in concrete refers to the:

A. Gradual increase in strain under sustained load

B. Sudden brittle fracture under impact

C. Loss of mass due to corrosion

D. Increase in compressive strength with age

94. For laminar flow in a circular pipe, the Darcy friction factor equals:

A. A constant 0.02

B. Re / 64

C. A function of relative roughness only

D. 64 / Re

95. A soil that undergoes significant volume change with moisture variation is typically a:

A. Clean coarse gravel

B. High-plasticity expansive clay

C. Uniform fine sand

D. Crushed rock fill

96. Sunk costs are correctly handled in a decision analysis by:

A. Excluding them entirely

B. Adding them to future costs

C. Discounting them at the MARR

D. Splitting them evenly across years

97. A block on a rough horizontal surface stays at rest until the applied force exceeds the:

A. Kinetic friction force

B. Block's own weight

C. Maximum static friction force

D. Normal force alone

98. What is the mean of the integers 1, 2, 3, 4, and 5?

A. 3

B. 2.5

C. 15

D. 5

99. Bearing stress at a bolted connection is computed as the load divided by:

A. The bolt cross-sectional area

B. The weld throat area

C. The gross plate area

D. The bolt diameter times the plate thickness

100. Water hammer in a pipeline is caused by:

A. A gradual rise in water temperature

B. A rapid change in flow velocity, such as sudden valve closure

C. A drop in atmospheric pressure

D. An open surge tank alone

101. The 85th-percentile speed of traffic is commonly used to:

A. Determine pavement thickness

B. Set appropriate posted speed limits

C. Calculate crash severity

D. Size drainage culverts

102. Primary consolidation of a clay layer is complete when:

A. The clay first becomes saturated

B. The footing is first loaded

C. The water table reaches the surface

D. Excess pore water pressure has fully dissipated

103. The rule of 72 provides a quick estimate of the time required for an investment to:

A. Triple in value

B. Double in value

C. Lose half its value

D. Reach zero salvage

104. The trigonometric identity $\sin^2\theta + \cos^2\theta$ is equal to:

A. 0

B. 2

C. $\tan^2\theta$

D. 1

105. An axial force applied through the centroid of a straight member produces:

A. Uniform axial stress with no bending

B. Pure torsion

C. A bending moment only

D. Zero stress everywhere

106. The specific gravity of a substance compares its density to that of:

A. Air at sea level

B. Water at a reference temperature

C. Mercury at 0°C

D. A perfect vacuum

107. A simply supported beam becomes a collapse mechanism when:

A. Enough plastic hinges form to allow free rotation

B. The first flexural crack appears

C. Deflection reaches L/360

D. The supports are widened

108. In Terzaghi's bearing capacity equation, the factor Nc applies to the:

A. Surcharge term

B. Soil-weight term

C. Cohesion term

D. Settlement term

109. An annuity due differs from an ordinary annuity in that its payments occur:

A. Only once at the end of the term

B. At the end of each period

C. At the beginning of each period

D. At random intervals

110. An engineer asked to certify work that violates an applicable safety code should:

A. Approve it if the client insists

B. Refuse and decline to certify the noncompliant work

C. Approve it with only a verbal warning

D. Delegate the decision to the contractor

PRACTICE EXAM 12 — Answer Key and Explanations

1. B — $Q = AV = (\pi/4 \times 0.2^2) \times 3 = 0.0314 \times 3 = 0.094$ m³/s. Flow rate equals cross-sectional area times average velocity. Using the $\pi d^2/4$ area is the step that separates this from the distractors.
2. D — $P = A(P/A, 6\%, 8) = 500 \times 6.2098 = \$3{,}105$. The uniform-series present-worth factor discounts equal annual payments to a single present value. The sum is well below the undiscounted total of $4,000 because of the time value of money.
3. A — $R = \sqrt{(3^2 + 4^2)} = \sqrt{25} = 5$ kN. Perpendicular forces combine by the Pythagorean theorem. This is the classic 3-4-5 right triangle.
4. D — $e = n/(1 - n) = 0.375/0.625 = 0.60$. Void ratio relates voids to solids, while porosity relates voids to total volume. Converting correctly between the two is a routine phase-relationship task.
5. D — Speed = 0.5 mi ÷ (45/3,600 hr) = 0.5 ÷ 0.0125 = 40 mph. Average speed is distance divided by elapsed time, with time converted to hours. Consistent units produce miles per hour directly.
6. B — $M_{max} = wL^2/8 = 8 \times 5^2/8 = 25$ kN·m. For a simple beam under uniform load, the maximum moment occurs at midspan. The span-squared dependence makes length the dominant factor.
7. D — $5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$. The factorial multiplies all positive integers up to the given number. It is fundamental to counting and probability.
8. D — Manning's n for finished concrete is about 0.013, reflecting its smooth surface. Lower n means less flow resistance and higher velocity. Rougher channels such as natural streams have much larger values.
9. C — The modulus of elasticity of structural steel is about 200 GPa (29,000 ksi). This stiffness value governs elastic deflection and buckling. It is roughly three times that of aluminum.
10. A — The (F/A) factor, the uniform-series compound-amount factor, converts equal annual deposits into a future value. It accumulates the series with compound interest. Its reciprocal, A/F, is the sinking-fund factor.
11. D — $F = ma = 4 \times 2.5 = 10$ N. Newton's second law gives net force as mass times acceleration. The result is independent of the body's velocity.
12. A — The MCLG for a known carcinogen is set at zero because no exposure level is presumed safe. It is a non-enforceable health goal. The enforceable MCL is set as close to it as feasible.

13. C — Azimuth = 180° − 30° = 150° for a bearing of S 30° E, measured clockwise from north. Southeast bearings convert to azimuths between 90° and 180°. This conversion is essential for traverse computation.
14. B — A liquidity index of 1.0 means the natural water content equals the liquid limit. The soil is therefore at the boundary of liquid behavior. Values above 1.0 indicate very soft, sensitive soils.
15. C — 2 atm = 2 × 101.3 = 202.6 kPa absolute. Standard atmospheric pressure is about 101.3 kPa. Multiplying by the number of atmospheres gives the absolute value.
16. B — If $\log_{10}(x) = 2$, then $x = 10^2 = 100$. The base-10 logarithm asks what power of 10 gives x. Recognizing the exponent yields the answer directly.
17. D — Passing zone length is governed by passing sight distance, the distance needed to safely complete a pass using the opposing lane. It depends on speeds of the passing and oncoming vehicles. Inadequate sight distance prohibits passing.
18. A — A pinned-pinned column has an effective length factor K = 1.0. The effective length equals the actual unbraced length. End restraint that resists rotation would lower K.
19. C — Salvage value is the asset's estimated worth at the end of its useful life. It is the residual value used in depreciation and replacement analysis. It is subtracted from cost to find the depreciable base.
20. B — A simple pendulum's period depends on its length and gravitational acceleration, $T = 2\pi\sqrt{(L/g)}$. For small swings it is independent of mass and amplitude. Longer pendulums swing more slowly.
21. C — Resilience is a material's capacity to absorb energy elastically and release it upon unloading. It corresponds to the area under the stress-strain curve up to the elastic limit. Toughness, by contrast, includes plastic energy to fracture.
22. C — For steady incompressible flow, continuity requires the volumetric flow rate to remain constant along a streamtube. Velocity must therefore increase where area decreases. This conserves mass.
23. A — Founding below the frost depth avoids frost heave, the upward movement caused by freezing soil moisture. This protects the structure from seasonal soil expansion. It is standard practice in cold climates.
24. B — The compass (Bowditch) rule distributes traverse misclosure in proportion to each course length. It assumes errors accumulate with distance traveled. It is the most common traverse-adjustment method.
25. D — Simple interest = P × r × t = 10,000 × 0.05 × 3 = $1,500. Simple interest accrues only on the original principal. Compounding would yield a slightly larger amount.
26. B — The median of {3, 7, 9, 11, 15} is the middle value, 9. With five ordered values, the third is the median. It is unaffected by the magnitude of the extremes.
27. C — A stop sign establishes mandatory stop control, requiring drivers to halt and yield before proceeding. It assigns right-of-way at lower-volume intersections. This differs from signal or roundabout control.
28. C — Concrete resists compression while steel resists tension, and combining them exploits each material's strength. Concrete is weak in tension, so steel is placed where tension occurs. This composite action defines reinforced concrete.
29. D — A fully open gate valve adds only a small minor (local) head loss, since it presents little obstruction. Minor losses come from fittings and valves rather than pipe length. A partially closed valve would add substantially more.

30. A — Under undrained conditions, a saturated clay's shear strength equals its undrained cohesion and is independent of normal stress ($\varphi = 0$). Pore water cannot drain quickly, so strength does not increase with confinement. This governs short-term stability analyses.
31. C — Under straight-line depreciation, the book value at the end of the depreciable life equals the salvage value. Depreciation reduces book value from cost down to salvage over the life. Salvage is the floor of the depreciation schedule.
32. A — Triangle area = ½ × base × height = ½ × 10 × 6 = 30. The one-half factor distinguishes it from a rectangle. Base and height must be perpendicular.
33. A — A body moving at constant velocity has zero net force, by Newton's first law. Balanced forces produce no acceleration. Constant velocity includes both speed and direction being unchanged.
34. C — Equal reactions arise from the symmetry of the load and geometry about midspan. A centered load and equal support distances split the load evenly. Symmetry is the controlling reason, not material properties.
35. A — A piezometer measures the pressure head at a point by the height to which fluid rises in an open tube. It captures only the pressure component, not velocity. The reading gives the piezometric (pressure plus elevation) head when referenced properly.
36. C — Design speed is the maximum safe speed for which a roadway's geometric features are designed. It governs curve radii, sight distances, and superelevation. The posted limit may be set at or below it.
37. D — A well-graded soil contains a wide, continuous range of particle sizes, allowing dense packing. The variety lets smaller grains fill voids between larger ones. This yields good strength and low compressibility.
38. B — In a symmetric section under pure bending, the neutral axis passes through the centroidal axis, where bending stress is zero. Stresses vary linearly with distance from it. Locating the centroid is the first step in bending analysis.
39. A — Continuous compounding uses the factor e^{rt} to grow a present sum. As compounding frequency approaches infinity, the discrete factor converges to the exponential form. This gives the maximum growth for a given nominal rate.
40. B — The slope-intercept form is $y = mx + b$, where m is the slope and b is the y-intercept. It expresses the line directly in terms of these two parameters. The other forms are standard, point-slope, and vertical-line equations.
41. A — Momentum $p = mv$, so doubling the mass at equal speed doubles the momentum. The truck's 2,000 kg gives twice the 1,000 kg car's momentum. Momentum scales directly with mass.
42. D — The energy grade line in a real pipe always slopes downward in the flow direction because of friction and minor losses. Energy is continuously dissipated. A pump would produce a localized upward step.
43. C — Permeability is most strongly influenced by void ratio and grain size, since flow occurs through the pore network. Larger voids and coarser grains allow faster seepage. Fine-grained soils have very low permeability.
44. D — Tension member capacity is the lesser of gross-section yielding and net-section rupture. The net section accounts for the area removed by bolt holes. Both limit states must be checked.
45. B — Multiplying present worth by the (A/P) capital-recovery factor converts it into an equivalent uniform annual worth. This spreads a present value into equal annual amounts. It is the basis of annual-cost comparisons.

46. B — NAVD 88 (North American Vertical Datum of 1988) is the standard vertical datum for elevations in North America. It provides a consistent reference for leveling and mapping. WGS 72 and UTM relate to horizontal positioning.
47. A — The integral of cos(x) is sin(x) + C. This reverses the derivative of sine. The constant of integration is required for the indefinite integral.
48. D — The HCM defines level of service by the operational quality drivers experience, such as delay, speed, and freedom to maneuver. Letters A through F grade this quality. It is a qualitative measure tied to quantitative thresholds.
49. D — Surface tension is significant in small-scale phenomena such as capillary rise, where it dominates over gravity. At larger scales its effect becomes negligible. It explains water movement in fine soils and tubes.
50. C — Greater compaction reduces void ratio and thus decreases permeability. Closing the pore spaces slows seepage. This is why compacted clay liners control water flow.
51. B — A shear wall carries lateral loads through its in-plane shear and bending stiffness, acting as a vertical cantilever. Its strength is in the plane of the wall. Out-of-plane loading is not its primary function.
52. B — A negative net present worth at the MARR means costs exceed benefits, so the project should be rejected. The project fails to meet the minimum return. Positive NPW is required for acceptance.
53. C — Third angle = 180° − (40° + 75°) = 65°. The interior angles of a triangle always sum to 180°. Subtracting the two known angles gives the third.
54. B — A satellite in circular orbit is held in by a centripetal force supplied by gravity, directed toward Earth's center. This continuous inward force produces centripetal acceleration. Orbital motion is free fall around the planet.
55. B — Pascal's law states that pressure applied to a confined fluid is transmitted equally and undiminished in all directions. This principle underlies hydraulic jacks and presses. A small input force can generate a large output force.
56. C — An SPT blow count of N = 50 in sand indicates a very dense material. Higher blow counts reflect greater density and strength. This influences foundation bearing capacity and settlement.
57. C — Reciprocal leveling cancels curvature and refraction errors by taking equal-length sights in both directions across an obstacle. Averaging the two results removes the systematic error. It is used across rivers and valleys.
58. B — The MARR is the lowest acceptable rate of return an investment must earn to be worthwhile. It reflects the cost of capital and risk. Projects below it are rejected.
59. A — $x^2 \cdot x^3 = x^{(2+3)} = x^5$. Multiplying powers of the same base adds the exponents. This is a basic law of exponents.
60. D — Lateral bracing of the compression flange prevents lateral-torsional buckling, in which the flange displaces sideways and the section twists. Adequate bracing increases the beam's flexural capacity. Unbraced compression flanges are vulnerable.
61. A — Traffic-calming devices such as speed humps are intended to reduce vehicle speeds in residential and pedestrian areas. They physically discourage speeding. Improved safety, not capacity, is their goal.
62. C — The available net positive suction head must exceed the required value to prevent cavitation at the pump inlet. Cavitation forms damaging vapor bubbles when pressure drops to the vapor pressure. Maintaining adequate NPSH protects the pump.

63. C — A geotechnical investigation characterizes subsurface soil and rock conditions for foundation and earthwork design. Borings, sampling, and testing reveal stratigraphy and properties. This informs safe, economical design.
64. A — Over the same period, the project with greater present worth of net benefits is the more economically attractive. Present worth captures the time-adjusted value of all cash flows. The largest positive value is preferred.
65. B — P(ace) = 4/52 = 1/13. There are four aces in a 52-card deck. Reducing the fraction gives one in thirteen.
66. B — Impulse equals the area under the force-versus-time curve, equal to the change in momentum. A force acting over time changes a body's momentum. Longer or larger forces deliver greater impulse.
67. D — A truss loaded only at its joints carries axial force in each member, with no bending or shear. The pin-joint idealization makes members two-force elements. This assumption underlies truss analysis.
68. C — For a very wide rectangular channel, the hydraulic radius approaches the flow depth, since the wetted perimeter is dominated by the wide bottom. The side contributions become negligible. This simplifies wide-channel flow calculations.
69. A — A dewatering system lowers the groundwater table to keep an excavation dry and stable. It removes water faster than it seeps in. This prevents flooding and bottom instability during construction.
70. C — Depreciation is the systematic allocation of an asset's cost over its useful life. It is an accounting and tax concept, not a cash outflow. It reduces taxable income through the depreciation schedule.
71. B — A closed traverse returning to its start permits checking both angular closure and positional (coordinate) closure. Comparing computed and known values reveals errors. This built-in check is a key advantage of closed traverses.
72. A — The quadratic formula gives $x = [-b \pm \sqrt{(b^2 - 4ac)}]/(2a)$. The discriminant under the radical determines the nature of the roots. It solves any quadratic equation.
73. D — A merge of two streams into one creates a bottleneck where combined demand may exceed downstream capacity. This is a common site of recurring congestion. Queues form when demand outpaces capacity.
74. C — The plastic moment Mp is reached when the entire cross-section has yielded, forming a plastic hinge. This exceeds the yield moment, where only the extreme fiber yields. Plastic design uses this full capacity.
75. A — An ideal fluid is assumed inviscid and incompressible, with no friction losses. This simplification underlies Bernoulli's equation. Real fluids deviate due to viscosity.
76. A — The angle of repose of a granular material closely approximates its angle of internal friction. Both reflect the frictional resistance between particles. A steeper repose angle indicates higher friction.
77. D — When an alternative produces no revenue, it is judged on least equivalent cost (cost minimization). The lowest-cost option that meets requirements is selected. This applies to service projects with only expenses.
78. A — The interior angles of any quadrilateral sum to 360°, found from $(n - 2) \times 180°$ with $n = 4$. Dividing a quadrilateral into two triangles confirms this. It holds regardless of shape.
79. D — $\alpha = T/I = 10/2 = 5$ rad/s². Angular acceleration equals torque divided by moment of inertia, the rotational form of Newton's second law. A larger inertia would resist angular acceleration.

80. C — Stirrups resist diagonal tension, the inclined cracking caused by shear in a concrete beam. They cross potential shear cracks to carry the tension. Longitudinal bars handle flexure separately.
81. B — An orifice or venturi meter creates a flow constriction and infers discharge from the resulting pressure drop. The constriction accelerates the flow, lowering pressure measurably. Bernoulli and continuity relate the drop to flow rate.
82. B — Relative density characterizes the compactness state of granular cohesionless soils between their loosest and densest conditions. It does not apply to clays, which use consistency indices. It strongly affects strength and settlement.
83. A — A capital expenditure provides benefits over multiple years and is capitalized and depreciated. An operating expense is consumed within the period. This distinction governs accounting treatment.
84. D — Earth curvature makes a distant rod reading appear too high, so a downward correction is applied. The effect grows with sight distance. Refraction partially offsets it, and balanced sights cancel both.
85. C — The derivative of any constant is zero, since a constant does not change with the variable. Its rate of change is nil. This is a foundational differentiation rule.
86. D — $h = v^2/(2g) = 10^2/(2 \times 9.81) = 100/19.62 = 5.1$ m. At maximum height the vertical velocity is zero. Mass does not affect the height in free flight.
87. B — Cantilever tip deflection under an end load is $\delta = PL^3/(3EI)$, proportional to L^3. The cube dependence makes length dominate deflection. Doubling the length increases deflection eightfold.
88. D — The discharge coefficient corrects ideal orifice flow for contraction (vena contracta) and friction losses. Real flow is less than the theoretical value. The coefficient is applied to obtain actual discharge.
89. D — A laterally loaded pile resists load mainly through passive soil resistance mobilized along its embedded length. The soil pushes back as the pile tries to deflect. End bearing and skin friction resist axial, not lateral, loads.
90. A — Approximate real rate = market rate − inflation = 9% − 4% = 5%. This subtraction estimates the inflation-adjusted return. The exact Fisher value is close, about 4.8%.
91. C — A circle of radius r centered at the origin is $x^2 + y^2 = r^2$. It expresses all points at distance r from the center. This is the standard form for an origin-centered circle.
92. C — A signal warrant analysis determines whether a traffic signal is justified at an intersection, based on volume, crash, and other criteria. Meeting a warrant supports installation. It prevents unwarranted signals that could worsen operations.
93. A — Creep is the gradual increase in concrete strain under sustained load over time. It causes long-term deflection and prestress loss. It is distinct from the instantaneous elastic strain.
94. D — For laminar pipe flow, the Darcy friction factor is $f = 64/Re$. It depends only on Reynolds number, not roughness. This relation holds below the laminar limit of about Re = 2,000.
95. B — A high-plasticity (expansive) clay undergoes large volume change with moisture, swelling when wet and shrinking when dry. This movement can damage foundations and pavements. Such soils require special design measures.
96. A — Sunk costs are excluded entirely from a decision analysis because they are unrecoverable and unaffected by the choice. Only future cash flows are relevant. Including them biases the decision.
97. C — A block remains at rest until the applied force exceeds the maximum static friction force, $\mu_s N$. Beyond that threshold, motion begins and kinetic friction takes over. Static friction is generally larger than kinetic.

98. A — Mean = (1 + 2 + 3 + 4 + 5)/5 = 15/5 = 3. The arithmetic mean sums the values and divides by their count. For evenly spaced data, it equals the middle value.
99. D — Bearing stress equals the load divided by the projected area, which is the bolt diameter times the plate thickness. This measures the contact pressure between bolt and plate. It is distinct from the bolt's shear area.
100. B — Water hammer results from a rapid change in flow velocity, such as a sudden valve closure, producing a pressure surge. The abrupt momentum change sends a pressure wave through the pipe. Slow valve operation mitigates it.
101. B — The 85th-percentile speed is commonly used to set posted speed limits, representing the speed below which most drivers travel. It reflects the speed reasonable drivers find comfortable. Limits set near it improve compliance.
102. D — Primary consolidation is complete when the excess pore water pressure from loading has fully dissipated. At that point the added stress is carried entirely by the soil skeleton. The process is slow in low-permeability clays.
103. B — The rule of 72 estimates the time for an investment to double by dividing 72 by the interest rate. It is a quick mental approximation of compound-growth doubling time. Higher rates shorten the doubling period.
104. D — The Pythagorean identity $\sin^2\theta + \cos^2\theta = 1$ holds for all angles. It follows from the unit circle definition. It is used throughout trigonometry and integration.
105. A — A force applied through the centroid produces uniform axial stress with no bending. Without eccentricity, there is no moment to cause flexure. This is the assumption for pure axial members.
106. B — Specific gravity compares a substance's density to that of water at a reference temperature. It is a dimensionless ratio. Values above 1.0 indicate a substance denser than water.
107. A — A simply supported beam becomes a collapse mechanism when enough plastic hinges form to permit free rotation. For this beam, a single midspan hinge creates the mechanism. This defines the plastic collapse load.
108. C — In Terzaghi's bearing capacity equation, Nc multiplies the cohesion term. Nq applies to surcharge and $N\gamma$ to the soil-weight term. Each factor captures a distinct strength contribution.
109. C — An annuity due has payments at the beginning of each period, unlike an ordinary annuity, which pays at the end. The earlier timing increases its present and future value. Rent and lease payments are common examples.
110. B — An engineer must refuse to certify work that violates an applicable safety code, consistent with holding public safety paramount. Client pressure does not justify approving noncompliant work. Certifying it would breach both ethical and legal duties.