



FE CIVIL EXAM 03

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Problems

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1. Find the area under the curve $y = x^2$ from $x = 0$ to $x = 2$.

(A) $\frac{8}{3}$

(B) $\frac{7}{3}$

(C) $\frac{11}{6}$

(D) $\frac{9}{11}$

2. For the function $f(x) = x^4 - 3x^3 + x - 2$, find its second derivative

(A) $12x^2 - 18x$

(B) $12x^2 - 9x$

(C) $24x^2 - 18x$

(D) $24x^2 - 9x$

3. Evaluate the cross product $\vec{A} \times \vec{B}$ if $\vec{A} = \hat{i} + \hat{j}$ and $\vec{B} = \hat{j} + \hat{k}$

(A) $\hat{i} - \hat{k}$

(B) $\hat{i} - \hat{j} + \hat{k}$

(C) $\hat{i} + \hat{k}$

(D) $-\hat{i} - \hat{k}$

4. For a function $f(x) = e^x \sin x$, find its derivative.

(A) $e^x(\cos x + \sin x)$

(B) $e^x(\cos x - \sin x)$

(C) $e^x(\cos x)$

(D) $e^x(\sin x)$

5. For a function $f(x) = -2x^2 + 4x + 1$, identify the maximum value.

(A) 0

(B) $\sqrt{5}$

(C) 3

(D) $2\sqrt{2}$

6. Evaluate the definite integral $\int_1^2 (3x^2 - 2x + 1)dx$.

(A) 6

(B) $\frac{10}{3}$

(C) 2

(D) 5

7. Calculate the derivative of $f(x) = \ln(x^2 + 1)$.

(A) $\frac{2x}{x^2+1}$

(B) $\frac{1}{x^2+1}$

(C) $\frac{2}{x^2+1}$

(D) $\frac{x}{x^2+1}$

8. For the following data of a linear regression analysis:

X	Y
1	2
2	3
3	5
4	6
5	8

Find the slope (m) of the regression line $\bar{Y} = m\bar{X} + b$

- A) 1.3
- B) 1.5
- C) 1.2
- D) 1.6

9. An engineering team records the weights (in pounds) of concrete blocks as follows: 500, 510, 530, 540, and 520. What is the 90% confidence interval for the true mean weight of the blocks, assuming the population follows a normal distribution?

- (A) (505.53, 519.47)
- (B) (505.53, 529.47)
- (C) (504.93, 535.07)
- (D) (510.53, 519.47)

10. Evaluate the limit, $\lim_{x \rightarrow \infty} \frac{3x^2+2}{2x^2+5x+3}$

- (A) 1
- (B) ∞
- (C) 0
- (D) $\frac{3}{2}$

11. In a professional liability claim, what is the role of expert witnesses?

- (A) To provide financial compensation
- (B) To offer technical expertise and opinions
- (C) To draft the initial contract
- (D) To represent the parties in court

12. Which of the following is an example of a professional liability issue?

- (A) An engineer failing to renew their professional license
- (B) An engineer being late to a project meeting
- (C) An engineer's design error causing structural failure
- (D) An engineer accepting a new job offer

13. What is the primary purpose of having a professional liability clause in an engineering contract?

- (A) To outline project timelines
- (B) To specify payment terms
- (C) To allocate responsibility for errors and omissions
- (D) To describe project deliverables

14. Which of the following actions could lead to a professional liability claim against an engineer?

- (A) Volunteering for a community project
- (B) Publishing a technical paper
- (C) Ignoring safety standards in a project design
- (D) Attending a professional conference

15. An engineer can reduce their professional liability risk by:

- (A) Avoiding all high-profile projects

- (B) Maintaining thorough and accurate documentation
- (C) Delegating all tasks to subordinates
- (D) Working without professional liability insurance

16. A civil engineering firm is considering a project to construct a new bridge. The initial cost of the project is estimated to be \$10 million. The project is expected to have an annual maintenance cost of \$500,000 and to generate toll revenue of \$1.5 million per year over a lifespan of 30 years. The firm uses a discount rate of 8% to evaluate projects. Assume there is no salvage value at the end of the bridge's lifespan and that the cash flows are constant over time. Calculate the Net Present Value (NPV) of the project.

- (A) \$1, 257, 300
- (B) \$4, 257, 300
- (C) \$-5, 342, 000
- (D) \$-250,000

17. What is the effective annual rate (EAR) if the nominal interest rate is 12% compounded quarterly?

- (A) 11.36 %
- (B) 12.55 %
- (C) 1.68 %
- (D) 32.75 %

18. A wind turbine costs \$150,000 and generates annual revenue of \$20,000 from electricity sales. The maintenance cost is \$5,000 annually. Calculate the Return on Investment (ROI) after 15 years.

- A) 40%
- B) 45%
- C) 50%
- D) 55%

19. Which of the following is considered a fixed cost?

- (A) Direct labor cost
- (B) Material cost
- (C) Depreciation expense
- (D) Variable overhead cost

20. A project has fixed costs of \$12,000, and its variable costs per unit are \$30. If the project's revenue per unit is \$50, what is the project's break-even volume in units?

- (A) 400 units
- (B) 600 units
- (C) 800 units
- (D) 1,000 units

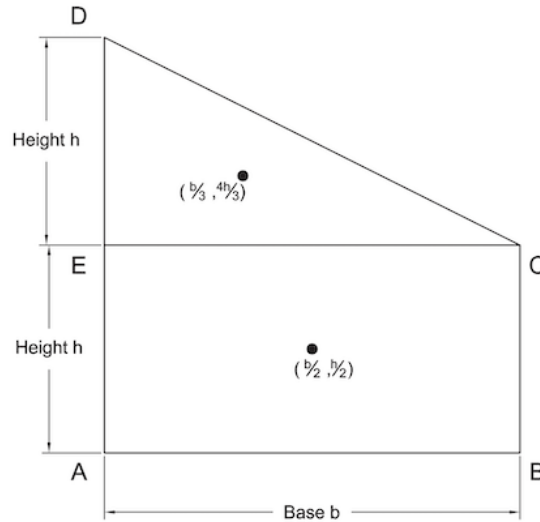
21. An investor is analyzing two stocks, X and Y, with the following probabilities and returns:

Stock	Return (%)	Probability
X	10	0.5
	5	0.5
Y	12	0.3
	4	0.7

Which stock has a higher expected return, and by how much?

- A) Stock X by 1.1%
- B) Stock Y by 0.6%
- C) Both have the same expected return
- D) Stock X by 0.8%

22. The middle point of a shape made up of a rectangle (base b , height h) and a right triangle (base b , height h) put on top of the rectangle is:



(A) $\frac{b}{2}, \frac{7h}{9}$

(B) $\frac{b}{3}, \frac{h}{9}$

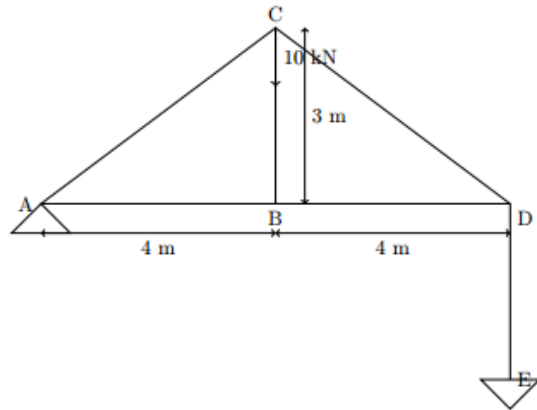
(C) $\frac{4b}{9}, \frac{7h}{9}$

(D) $1, 7h$

23. Consider a truss structure ABCDE as illustrated below. The truss is supported by a pin support at A and a roller support at E. A vertical load of 10 kN is applied at joint C. Members AB and BD are horizontal, while members AC and CD are inclined. The lengths of the members are as follows:

- $AB = BD = 4 \text{ m}$
- $AC = CD = 5 \text{ m}$

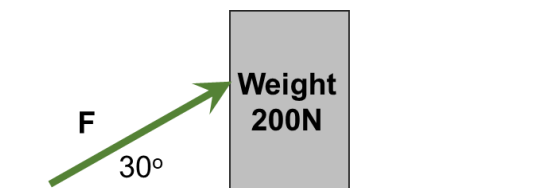
Determine the force in member CD using the method of joints. Indicate whether these members are in tension or compression.



- (A) 8.33 (Tension)
- (B) 7.55 (Compression)
- (C) 8.33 (Compression)
- (D) 16.67 (Tension)

24. A block weighing 200 N rests on a horizontal surface. The coefficient of static friction is 0.55. What is the smallest force that must be applied at an angle of 30° above the horizontal to initiate motion?

- A) 65.01 N
- B) 96.4 N
- C) 186.1 N
- D) 125.5 N



25. Find the center point of the area under the curve $y = x^2$ from $x = 0$ to $x = a$ along the x-axis.

(A) $\bar{x} = \frac{a}{4}, \bar{y} = \frac{3a^2}{10}$

(B) $\bar{x} = \frac{1a}{4}, \bar{y} = \frac{3a^3}{10}$

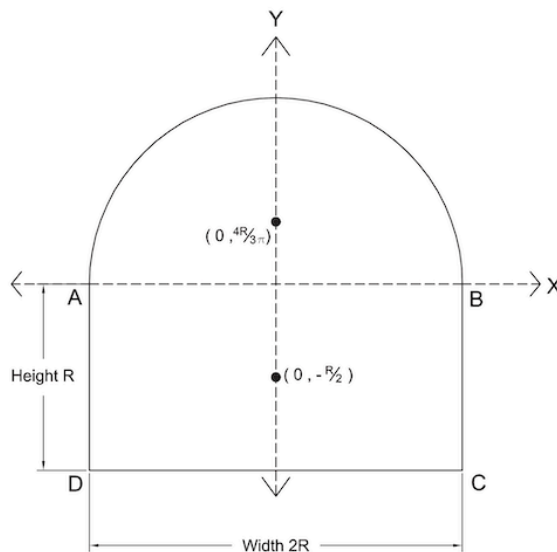
(C) $\bar{x} = \frac{3a}{4}, \bar{y} = \frac{3a^2}{10}$

(D) $\bar{x} = \frac{1}{4}, \bar{y} = \frac{11a^3}{3}$

26. A composite area is made up of two shapes:

1. A semicircle of radius R with its diameter on the x-axis and centered at the origin.
2. A rectangle with width $2R$ and height R positioned directly below the semicircle, sharing the same width and aligned with the semicircle.

Identify the y-coordinate of the centroid of this composite area.



$$(A) \quad -\frac{2R}{3\pi+12}$$

$$(B) \quad \frac{2R}{3\pi+12}$$

$$(C) \quad -\frac{R}{3\pi+4}$$

$$(D) \quad -\frac{2R}{3\pi}$$

27. For a square area with a base of b and a height of h , the first moment of area about the y -axis is:

$$(A) \frac{b^2}{2} h$$

$$(B) \frac{b^2}{2h}$$

$$(C) \frac{b^2}{2}$$

$$(D) bh^2$$

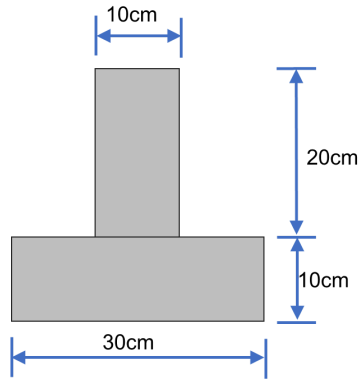
28. A T-shaped cross-section consists of a vertical stem with dimensions 10 cm by 20 cm and a horizontal flange with dimensions 30 cm by 10 cm. Determine the moment of inertia of the T-shaped section from the bottom of the flange.

$$A) 2.6 \times 10^4 \text{ cm}^4$$

$$B) 3.6 \times 10^4 \text{ cm}^4$$

$$C) 6.6 \times 10^4 \text{ cm}^4$$

$$D) 9.6 \times 10^4 \text{ cm}^4$$



29. For a triangle with base b lying along the x -axis and height h extending upward, calculate the first moment of area about the x -axis.

(A) $\frac{bh^2}{2}$

(B) $\frac{bh^2}{6}$

(C) $\frac{b^2h}{2}$

(D) bh^2

30. The angle of acceleration of a wheel is always 2 rad/s^2 . If the angle of movement starts at 3 rad/s , what is the angle of movement after 4 seconds?

(A) 40 rad

(B) 28 rad

(C) 32 rad

(D) 24 rad

31. There is a particle moving in a straight line at a speed of 10 meters per second and an acceleration of -2 m/s^2 . After how long the particle stops moving?

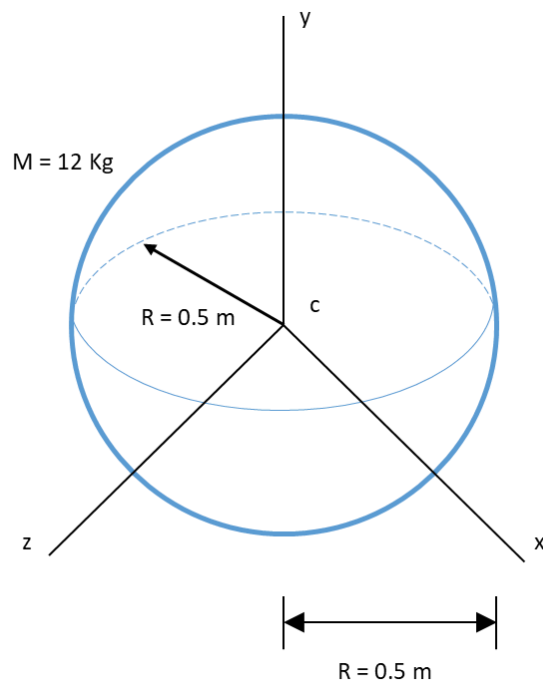
(A) 11 seconds

- (B) 2.5 seconds
- (C) 5 seconds
- (D) 26 seconds

32. At an angle of 30° to the horizontal, a projectile is sent off at a speed of 20m/s. How high the missile go prior to it stops?

- (A) 5m
- (B) 10m
- (C) 15m
- (D) 20m

33. A solid sphere of radius $R = 0.5$ m and mass $M=12$ kg is rotating about an arbitrary axis that passes through its center. What is the radius of gyration k of the sphere?



- (A) 0.316 m

- (B) 0.416 m
- (C) 0.456 m
- (D) 0.506 m

34. A 10 kg block is pushed across a frictionless surface with a constant force of 60 N. If the block starts from rest, what is the velocity of the block after 5 seconds?

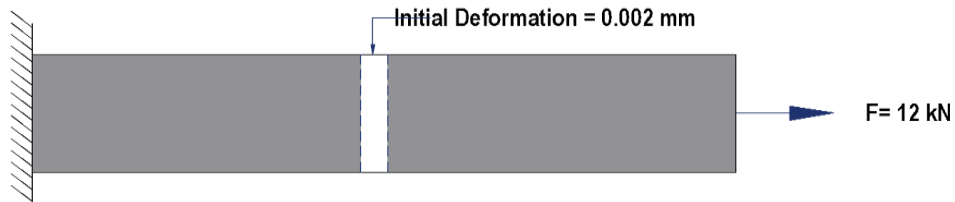


- (A) 25 m/s
- (B) 30 m/s
- (C) 35 m/s
- (D) 40 m/s

35. A steel rod with a diameter of $d=20$ mm, modulus of elasticity $E = 210$ GPa, and length of $L = 2$ m is subjected to a tensile load $F = 50$ kN. Calculate the elongation of the rod.

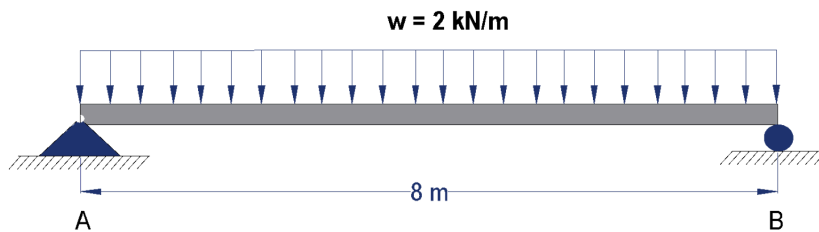
- (A) 0.1 mm
- (B) 2.2 mm
- (C) 0.57 mm
- (D) 1.51 mm

36. A steel rod having 3 meters length and cross section of 150mm x 200mm has already elongated by 0.002 mm. Furthermore, a load of 12 kN is applied to the steel rod. Find the total elongation in the steel?. ($E=200 \times 10^3$ MPa)



- (A) 0.008 mm
- (B) 0.002 mm
- (C) 0.006 mm
- (D) 0.004 mm

37. A uniformly distributed load of 2kN/m applied on a simply supported beam having length of 8 meters, causing a deflection of $80/EI$. How much additional deflection is allowed in beam under elastic range?



- (A) $26.67/EI$
- (B) $773.67/EI$
- (C) $100/EI$
- (D) $853.67/EI$

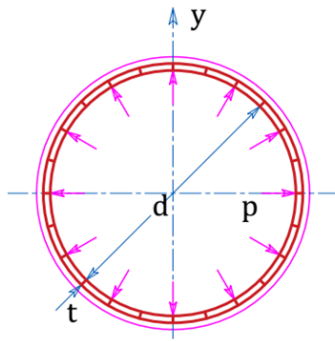
38. A 500 Nm torque is applied to a 50 mm diameter circular shaft. Ascertain the shaft's maximum shear stress. ($J = \pi d^4/32$, the polar moment of inertia)

- (A) 16.3 MPa
- (B) 20.4 MPa

(C) 130 MPa

(D) 14.1 MPa

39. The wall thickness of a 1.22 meters-diameter spherical tank is 15.8 mm. Calculate the allowable internal pressure if the stress is limited to 55.158 MPa.



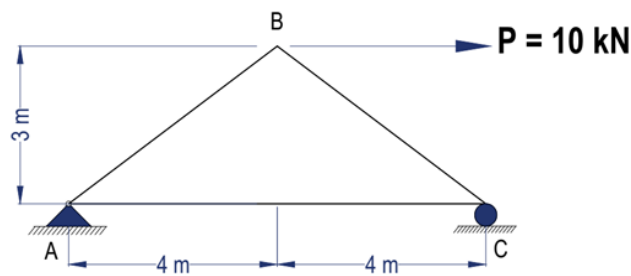
(A) 3.02 MPa

(B) 1.87 MPa

(C) 2.85 MPa

(D) 1.06 MPa

40. A horizontal force of $P = 10$ kN applied on a joint B in a structure. What is the moment at point A?



(A) 30 kN-m

- (B) 40 kN-m
- (C) 0 kN-m
- (D) 50 kN-m

41. A steel rod with a diameter of $d=30$ mm, a yield stress of $\sigma_y = 250$ MPa, and a length of $L = 1$ m is subjected to a load $F = 300$ kN. Determine if the rod undergoes plastic deformation.

- (A) Yes
- (B) No
- (C) Cant determined
- (D) None of the above

42. Calculate the engineering stress, true stress, and percent elongation for a steel specimen with an initial length of 200 mm and a diameter of 10 mm subjected to a tensile load of 40 kN, which elongates to 210 mm before fracture.

- (A) 125.36 MPa, 557.65 MPa, 2%
- (B) 750.23 MPa, 525.65 MPa, 6%
- (C) 509.30 MPa, 534.77 MPa, 5%
- (D) 550.20 MPa, 300.33 MPa, 1%

43. A steel specimen with an original cross-sectional area of 100 mm^2 undergoes a tensile load of 300 kN. After necking, the area reduces to 60 mm^2 . Calculate the true stress and compare it to the engineering stress at the point of necking.



- (A) True stress is higher than engineering stress.
- (B) True stress is lower than engineering stress.
- (C) True stress and engineering stress are equal.

(D) Both true stress and engineering stress are the same at the point of necking

44. A concrete cylinder with a diameter of 150 mm and height of 300 mm is subjected to a compressive load of 600 kN, causing it to shorten by 2 mm. Calculate the engineering stress, engineering strain, and modulus of elasticity.

(A) 339.52 MPa, 0.0075, 6.10 GPa

(B) 33.91 MPa, 0.0067, 5.06 GPa

(C) 465.36 MPa, 0.0067, 1.03 GPa

(D) 33.91 MPa, 0.0050, 7.09 GPa

45. Determine the amount of each component in a 1-ton asphalt mix given the following proportions(Bitumen, coarse aggregate, Fine aggregate):

- Bitumen: 5%
- Coarse aggregate: 45%
- Fine aggregate: 50%

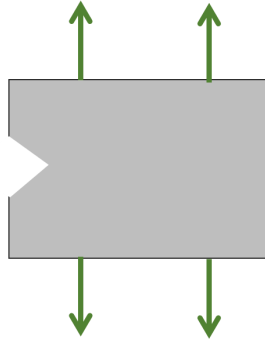
(A) 40 kg, 50 kg, 60 kg

(B) 50 kg, 525 kg, 751 kg

(C) 40 kg, 450 kg, 973 kg

(D) 50 kg, 450 kg, 500 kg

46. A crack in an asphalt pavement grows from an initial length of 4 mm to 8 mm under stress. If the fracture toughness is $0.9 \text{ MPa}\sqrt{\text{m}}$, find the critical stress (σ) required for further crack propagation.



- A) 3.18 MPa
- B) 4.12 MPa
- C) 5.16 MPa
- D) 6.95 MPa

47. A metal alloy has an ASTM grain size number of 8. What is the approximate average grain diameter?

- A. 0.022 mm
- B. 0.055 mm
- C. 0.1 mm
- D. 0.2 mm

48. An inclined manometer contains oil (density = 850 kg/m^3). If the inclined length of the oil column is 0.2 meters at an angle of 45 degrees, calculate the pressure difference.

- (A) 1.179 kPa
- (B) 0.177 kPa
- (C) 0.007 kPa
- (D) 2.350 kPa

49. A U-tube manometer contains mercury (density 13600 kg/m^3) and water (density 1000 kg/m^3). The height of the water column in one arm is 40 cm,

and the height of the mercury column is 10 cm. What is the pressure difference (in kPa) between the two points connected to the manometer?

- A. 9.42 kPa
- B. 12.6 kPa
- C. 15.4 kPa
- D. 17.2 kPa

50. Calculate the capillary rise in a tube of radius 0.001 m for mercury with a surface tension of 0.485 N/m and a contact angle of 140° .

- (A) -0.0005 m
- (B) -0.0093 m
- (C) -0.0077 m
- (D) -0.0056 m

51. A Venturi meter is installed in a horizontal pipeline to measure the flow rate of a gas. The diameter of the pipe is 200 mm, and the diameter at the throat is 80 mm. The pressure difference between the inlet and the throat is 40 kPa. Calculate the flow rate of the gas if the density is 1.5 kg/m^3 .

- (A) $1.17 \text{ m}^3/\text{s}$
- (B) $1.05 \text{ m}^3/\text{s}$
- (C) $2.36 \text{ m}^3/\text{s}$
- (D) $0.16 \text{ m}^3/\text{s}$

52. Calculate the pressure at a point in a pipe where the velocity is 3 m/s and the height is 10 m, given that the pressure at a reference point is 200 kPa, the velocity is 1 m/s, and the height is 5 m.

- (A) 147.15 KPa
- (B) 186.36 KPa
- (C) 225.25 KPa
- (D) 96.500 KPa

53. A 10 cm diameter jet of water (density = 1000 kg/m^3) strikes a flat plate normally at a velocity of 15 m/s. If the jet is completely stopped by the plate and deflected, what is the force exerted by the water on the plate?

- A. 1767 N
- B. 2454 N
- C. 2956 N
- D. 3255 N

54. A non-Newtonian fluid has a consistency index $K = 0.2 \text{ Pa}\cdot\text{s}^n$ and a flow behavior index $n = 0.8$. If the shear rate is 50 s^{-1} , calculate the shear stress exerted by the fluid.

- (A) 4.57 Pa
- (B) 1.74 Pa
- (C) 9.35 Pa
- (D) 7.27 Pa

55. Compute the area using Simpson's rule for $y = [2, 5, 8, 11]$ with intervals of 2 m.

- (A) 48.35 m^2
- (B) 44.05 m^2
- (C) 32.67 m^2
- (D) 95.36 m^2

56. Determine the area of a triangle with vertices at (0, 0), (5, 0), and (2, 4) using the area by coordinates method.

- (A) 11 units^2
- (B) 19 units^2
- (C) 10 units^2
- (D) 23 units^2

57. Convert the Cartesian coordinates ($x = 7, y = -7$) to polar coordinates

(A) $r = 5\sqrt{2}, \theta = 135^\circ$

(B) $r = 7\sqrt{2}, \theta = 315^\circ$

(C) $r = 3\sqrt{2}, \theta = 317^\circ$

(D) $r = 7\sqrt{7}, \theta = 295^\circ$

58. Calculate the volume of a pyramid with a rectangular base of dimensions 6 m by 8 m and a height of 12 m.

(A) 100 m^3

(B) 392 m^3

(C) 192 m^3

(D) 75 m^3

59. Calculate the area of a quadrilateral with vertices at (1, 2), (3, 5), (6, 5), (5, 2) using the area by coordinates method.

(A) 19.6 units^2

(B) 10.5 units^2

(C) 25.5 units^2

(D) 13.0 units^2

60. A point $P(400, 250)$ undergoes the following transformations in sequence:

- Translated by $(-150, +100)$
- Rotated counterclockwise by 30° about the origin

What are the new coordinates of the point after both transformations?

A. $(41.5, 428.1)$

B. $(51.5, 178.1)$

C. (651.3, 228.1)

D. (301.3, 378.1)

61. Calculate the volume of earth between two cross-sections with areas of 50 m^2 and 80 m^2 , spaced 100 m apart using the Average End Area Method.

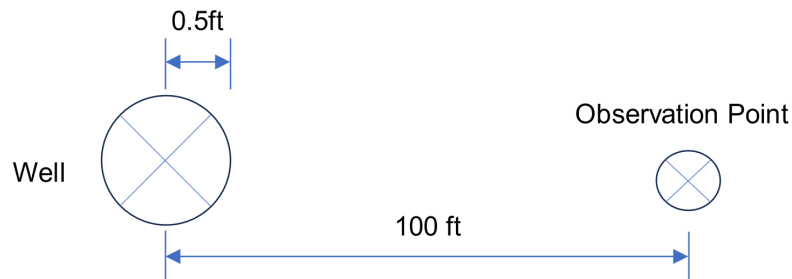
(A) 6203 m^3

(B) 7800 m^3

(C) 9350 m^3

(D) 6500 m^3

62. A well is drilled into an unconfined aquifer with a hydraulic conductivity of $K = 0.001 \text{ ft/sec}$. The radius of the well is 0.5 ft, and the distance to the observation point is 100 ft. The water surface height above the bottom of the aquifer is 40 ft at the well perimeter and 50 ft at the observation point. What is the flow rate Q of water drawn from the well in ft^3/sec ?



(A) $0.53 \text{ ft}^3/\text{sec}$

(B) $5.3 \text{ ft}^3/\text{sec}$

(C) $0.13 \text{ ft}^3/\text{sec}$

(D) $0.23 \text{ ft}^3/\text{sec}$

63. A reservoir with a water surface area of 5000 m^2 is filled with water at a rate of $0.1 \text{ m}^3/\text{s}$. Calculate the increase in water depth after 2 hours.

(A) 0.015 m

- (B) 0.206 m
- (C) 0.186 m
- (D) 0.144 m

64. A pipeline carrying water has a diameter of 0.3 m at section A and 0.2 m at section B. The velocity at section A is 3.5 m/s. Assuming steady, incompressible flow, what is the velocity at section B?

- A. 7.875 m/s
- B. 5.245 m/s
- C. 3.275 m/s
- D. 6.568 m/s

65. Calculate the hydraulic grade line (HGL) for a pipe with an initial pressure head of 30 m, velocity head of 2 m, and an elevation of 10 m.

- (A) 39 m
- (B) 42 m
- (C) 37 m
- (D) 18 m

66. Calculate the storage capacity of a dam reservoir if the inflow is 300 m³/s, the outflow is 100 m³/s, and the water level increases by 2 meters over a surface area of 150 hectares in 8 hours.

- (A) 1.49 m
- (B) 3.84 m
- (C) 2.96 m
- (D) 7.64 m

67. A flood having discharge of 1161600 cfs is passing through a reservoir with a speed of 88 ft/sec. If the area of the reservoir is 220ft x 60ft and 10ft x 20 ft gates are installed on a reservoir cross section. How many gates will be required to control the flood?

- A. 50
- B. 55
- C. 100
- D. 66

68. A pipe with a diameter of 0.25 m and length of 150 m transports water with a flow rate of $0.02 \text{ m}^3/\text{s}$. The Hazen-Williams coefficient is 110. Calculate the head loss using the Hazen-Williams equation.

- (A) 0.603 m
- (B) 0.164 m
- (C) 0.015 m
- (D) 0.002 m

69. In the context of water distribution systems, what is the primary function of a hydraulic grade line (HGL)?

- (A) To indicate the velocity of water in the pipes.
- (B) To measure the amount of water consumed by end users.
- (C) To represent the energy available to move water through the system
- (D) To control the chemical composition of the water.

70. A confined aquifer is pumped at a steady state, and the following data are observed:

Transmissivity (T): $250 \text{ ft}^2/\text{day}$

Piezometric surface heights: $h_1 = 10 \text{ ft}$, $h_2 = 20 \text{ ft}$

Radial distances: $r_1 = 20 \text{ ft}$, $r_2 = 200 \text{ ft}$

Using the Thiem Equation, calculate the flow rate (Q) of water.

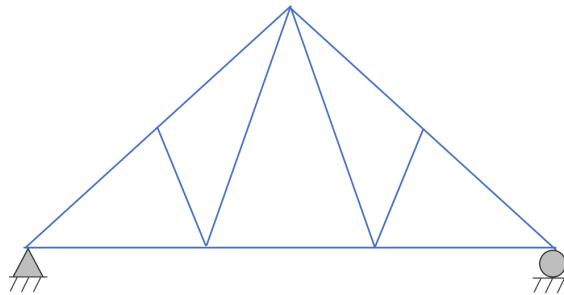
- A) $2,818.42 \text{ ft}^3/\text{day}$
- B) $4,818.42 \text{ ft}^3/\text{day}$
- C) $6,818.42 \text{ ft}^3/\text{day}$

D) 8,818.42 ft³/day

71. A water sample has a BOD₅ of 200 mg/L and a COD of 500 mg/L. What does this indicate about the nature of the water?

- A. The water contains a significant amount of biologically degradable organic matter.
- B. The water has a high fraction of non-biodegradable organic compounds.
- C. The BOD/COD ratio suggests rapid biological decomposition.
- D. The sample does not contain any toxic organic compounds.

72. A truss is supported by a roller and a pinned support. Determine the external and internal determinacy of the truss.



- (A) Externally Determinate, Internally determinate
- (B) Externally Indeterminate (1 degree), Internally Determinate
- (C) Externally Determinate, Internally Indeterminate (2 degrees)
- (D) Externally Indeterminate (1 degree), Internally Indeterminate (1 degree)

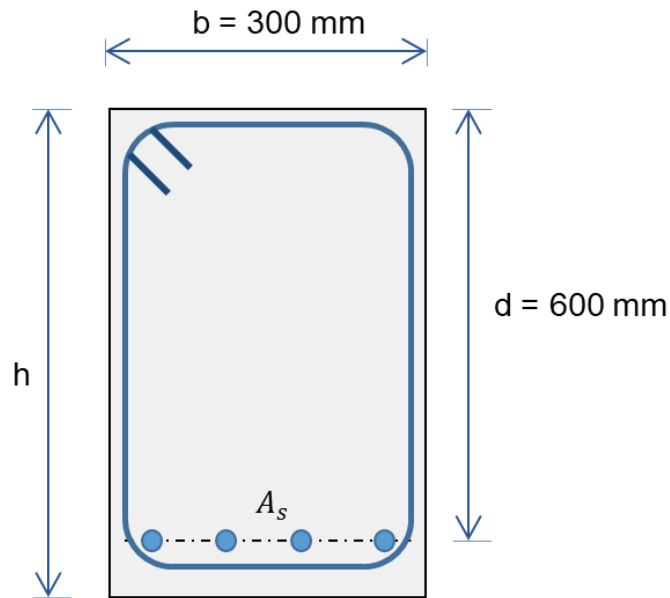
73. For a reinforced concrete column with a cross sectional area of 4000 mm² and a concrete strength of 35 MPa. The column has 4% longitudinal reinforcement with a yield strength of 420 MPa. The resistance factor is 0.65, what is the axial load capacity ?

- (A) 121.03 kN
- (B) 225.3 kN
- (C) 741.5 kN
- (D) 98.63 kN

74. In the analysis of beams, what is the significance of the bending moment diagram?

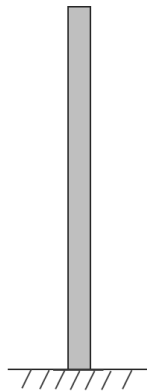
- (A) It shows the variation of shear force along the length of the beam.
- (B) It indicates the internal moment distribution that helps in designing the beam for bending resistance.
- (C) It provides the axial force distribution in the beam.
- (D) It is used to calculate the deflection of the beam under load.

75. A reinforced concrete beam has a width (b) of 300 mm and an effective depth (d) of 600 mm. The nominal shear strength (V_c) of the concrete is 90 kN. If the shear force (V_u) is 150 kN and the yield strength (f_y) of the stirrups is 420 MPa, calculate the required spacing (s) of the stirrups with a cross-sectional area (A_v) of 150 mm^2 .



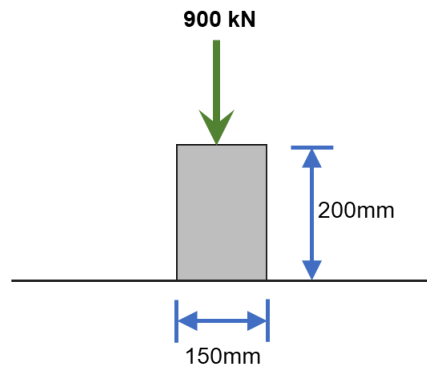
- A. 630 mm
- B. 400 mm
- C. 300 mm
- D. 230 mm

76. A 2.5 m long column with a circular cross-section has a radius of gyration (r) of 50 mm. The column is fixed at one end and free at the other. What is the slenderness ratio of the column?



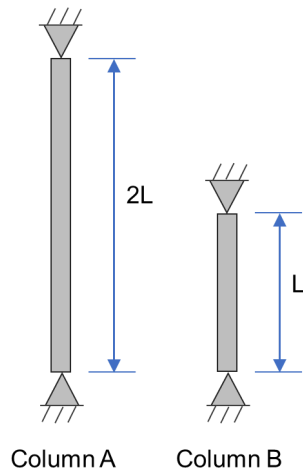
- (A) 10
- (B) 0.05
- (C) 75
- (D) 100

77. A rectangular steel column with a width of 150 mm and a depth of 250 mm supports an axial compressive force of 900 kN. If the factor of safety (FS) is 1.8, determine the required yield strength of the material.



- (A) 24.3 MPa
- (B) 43.2 MPa
- (C) 48.5 MPa
- (D) 52.4MPa

78. Two steel columns, A and B, have the same material properties and cross-sectional shape, but column A is twice as long as column B. Both columns are pinned at both ends. What is the ratio of the critical buckling load of column A to that of column B?

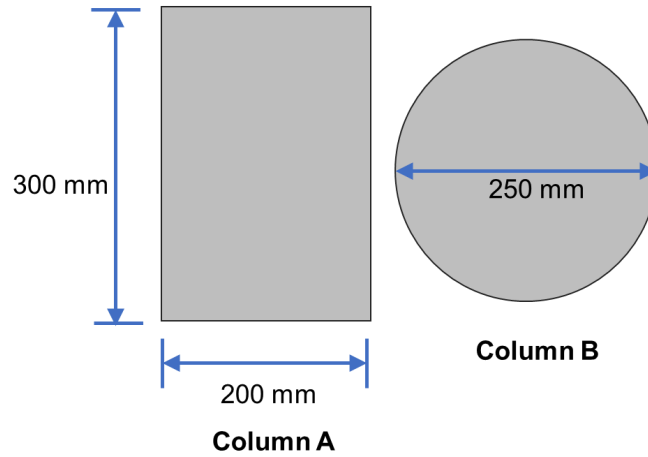


- A) 1:4
- B) 1:2
- C) 2:1
- D) 4:1

79. Two steel columns (same length and boundary conditions) have different cross-sections:

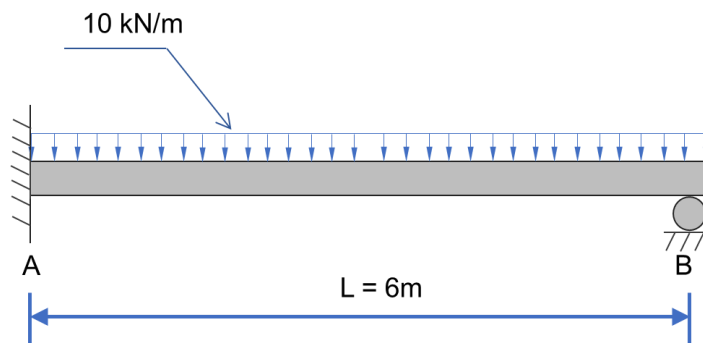
- Column A: Rectangular cross-section, $b = 200 \text{ mm}$, $h = 300 \text{ mm}$
- Column B: Circular cross-section, diameter = 250 mm

Which column will buckle first, assuming both have the same material properties?



- (A) Column A (Rectangular)
- (B) Column B (Circular)
- (C) Both buckles simultaneously
- (D) Cannot be determined without load values

80. A propped cantilever beam of length $L = 6\text{ m}$ is subjected to a uniformly distributed load $w = 10\text{ kN/m}$. The beam is fixed at one end and simply supported at the other. Using the superposition method, determine the reaction force at the simply supported end.



- (A) 15 kN
- (B) 18.75 kN
- (C) 22.5 kN

(D) 30 kN

81. What is the key difference between a statically determinate and a statically indeterminate frame?

- (A) Determinate frames have only axial forces while indeterminate frames have bending moments.
- (B) Determinate frames can be solved using only equilibrium equations, while indeterminate frames require additional compatibility conditions.
- (C) Determinate frames are always stable, while indeterminate frames are always unstable.
- (D) Determinate frames do not deform under load, while indeterminate frames do.

82. According to Rankine's Earth Pressure Theory, what is the active earth pressure coefficient K_a for a soil with an internal friction angle $\phi = 30^\circ$?

- (A) 0.333
- (B) 0.5
- (C) 0.667
- (D) 1.0

83. In an unsaturated soil, if the pore air pressure is 30 kPa and the pore water pressure is 20 kPa, with a total stress of 150 kPa, what is the effective stress?

- (A) 120 kPa
- (B) 130 kPa
- (C) 90 kPa
- (D) 100 kPa

84. If a retaining wall is designed to withstand an active earth pressure of 100 kPa, what would be the at-rest earth pressure σ_{ho} assuming a coefficient of earth pressure at rest $K_0 = 0.5$?

- (A) 50 kPa
- (B) 100 kPa
- (C) 150 kPa
- (D) 200 kPa

85. Given a flow net for seepage under a dam with 4 flow channels and 8 equipotential drops, if the head difference is 10 m, calculate the seepage per unit width assuming permeability $k = 2 \times 10^{-4}$ m/s.

- (A) 2.5×10^{-3} m³/s
- (B) 5.0×10^{-4} m³/s
- (C) 1.0×10^{-3} m³/s
- (D) 2.0×10^{-3} m³/s

86. A retaining wall is subjected to a uniform surcharge load of 10 kPa. What is the horizontal pressure on the wall due to this surcharge? Assume that the coefficient of lateral earth pressure at rest, K_0 , is 0.5.

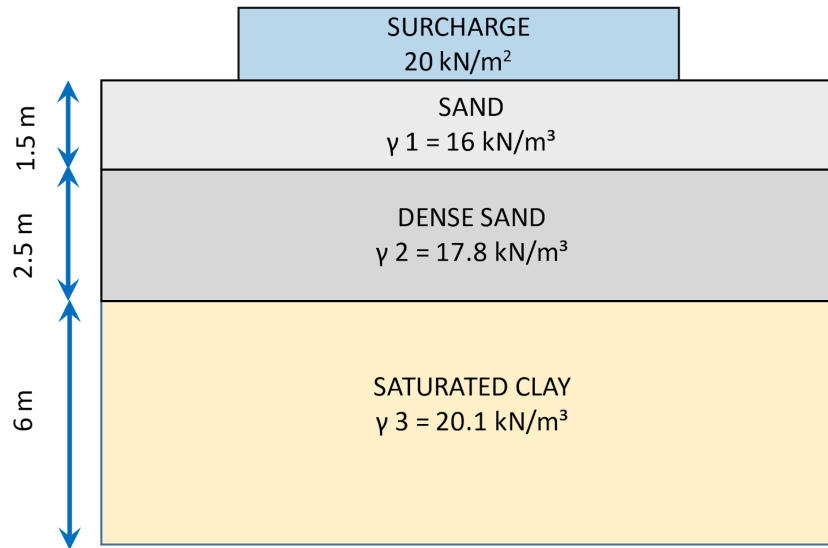
- (A) 2 kPa
- (B) 5 kPa
- (C) 10 kPa
- (D) 20 kPa

87. Calculate the consolidation settlement (S_c) for a clay layer 5 m thick, with a compression index (C_c) of 0.3, initial void ratio (e_0) of 1.2, and an increase in effective stress from 100 kPa to 200 kPa.

- (A) 100 mm
- (B) 205 mm
- (C) 150 mm
- (D) 175 mm

88. A soil profile consists of 1.5m of sand with a unit weight of 16 kN/m³, 2.5 m of dense sand with a unit weight of 17.8 kN/m³ and 6 m of saturated clay

with a unit weight of 20.1 kN/m^3 . The water table is at the interface of the dense sand and clay layers. A surcharge of 20 kN/m^2 is applied at the surface. Determine the effective vertical stress (σ') at the bottom of the clay layer.



- A. 132.9 kN/m^2
- B. 138.2 kN/m^2
- C. 145.8 kN/m^2
- D. 150.2 kN/m^2

89. A saturated soil sample has a void ratio of 0.85 and a specific gravity of 2.70 . Determine the submerged unit weight of the soil in kN/m^3 .

- A. 8.12 kN/m^3
- B. 9.01 kN/m^3
- C. 11.48 kN/m^3
- D. 12.35 kN/m^3

90. A saturated sand layer has a unit weight $\gamma_{\text{sat}} = 19.5 \text{ kN/m}^3$. The water table is at the surface, and the underlying soil is impermeable. The seepage exit gradient is observed to be 0.85 in a field test. Determine the factor of safety (FS_s) against seepage liquefaction for this sand layer.

- A. 0.86
- B. 1.16
- C. 1.24
- D. 1.31

91. Using Coulomb's Earth Pressure Theory, what is the active earth pressure coefficient K_a for a retaining wall with an internal friction angle $\phi = 35^\circ$ and a wall friction angle $\delta = 20^\circ$?

- (A) 0.271
- (B) 0.327
- (C) 0.377
- (D) 0.450

92. Calculate the overturning moment at the base of a 6 m high retaining wall due to active earth pressure. The wall retains a soil with a unit weight of 20 kN/m^3 and an internal friction angle of 35° .

- (A) 616.5 kNm/m
- (B) 324 kNm/m
- (C) 432 kNm/m
- (D) 194.4 kNm/m

93. Calculate the superelevation (e) required for a curve with a radius of 250 m and a design speed of 60 km/h. Assume the side friction factor (f) is 0.12.

- (A) -0.05
- (B) 0.06

(C) -0.07

(D) 0.08

94. A city has two zones, A and B. The number of trips generated from zone A is 600, and from zone B is 800. The travel time between the two zones is 30 minutes. The gravity model is used with an inverse-square function for travel impedance:

$$T_{AB} = \frac{kP_A P_B}{t^2}$$

Where $k=0.1$. Find the estimated trips between A and B.

A. 53

B. 43

C. 60

D. 40

95. Calculate the external distance (E) for a horizontal curve with a radius (R) of 500 m and a central angle (Δ) of 60 degrees.

(A) 77.35 m

(B) 75.55 m

(C) 90.10 m

(D) 105.2 m

96. The mechanistic-empirical pavement design method primarily relies on which two types of analysis?

(A) Statistical and probabilistic

(B) Empirical and mechanistic

(C) Deterministic and stochastic

(D) Analytical and numerical

97. Which layer in a flexible pavement system is designed to provide structural support and distribute loads?

- (A) Subgrade
- (B) Subbase
- (C) Base course
- (D) Surface course

98. Calculate the required thickness of a concrete pavement slab using the AASHTO design method for a traffic load of 3,000,000 ESALs, considering a modulus of rupture of 650 psi and a k-value (modulus of subgrade reaction) of 100 pci.

- (A) 1152 mm
- (B) 664.36 mm
- (C) 258.69 mm
- (D) 300.03 mm

99. For a flexible pavement, what will be the structural number (SN)? If the pavement layer properties are:

Surface course: $D_1 = 100$ mm, $a_1 = 0.44$

Base course: $D_2 = 150$ mm, $a_2 = 0.14$, $m_2 = 0.85$

Subbase: $D_3 = 200$ mm, $a_3 = 0.10$, $m_3 = 0.80$

- A. 7.79
- B. 5.65
- C. 9.86
- D. 3.06

100. Using the gravity model, calculate the trip distribution between two zones with a friction factor of 0.5, a trip production of 200, and a trip attraction of 300.

- (A) 10000
- (B) 15000
- (C) 20000
- (D) 30000

101. Determine the required thickness of an asphalt pavement surface course given a design traffic load of 5,000,000 ESALs, using the AASHTO design method. Assume the following parameters:

- Reliability level: 95%
- Standard deviation: 0.45
- Serviceability loss: 2.5
- Resilient modulus of the subgrade: 7,000 psi
- Layer coefficient for the surface course: $a_1 = 0.44$

- (A) 236.13 mm
- (B) 155.225 mm
- (C) 200.00 mm
- (D) 253.13 mm

102. A contractor is estimating the cost of placing 5,000 square feet of concrete sidewalk. The cost of concrete is \$100 per cubic yard, and the thickness of the sidewalk is 4 inches. Calculate the total cost of the concrete required for the sidewalk.

- (A) \$6,173
- (B) \$7,522
- (C) \$8,030
- (D) \$9,500

103. A contractor is estimating the cost of a retaining wall project. The wall has a height of 12 feet, a length of 100 feet, and a thickness of 1 foot. The cost of concrete is \$90 per cubic yard. Additionally, the cost of rebar is \$1,200 per ton, with rebar required at a rate of 150 pounds per cubic yard of concrete. Calculate the total cost of materials.

- (A) \$3,600
- (B) \$4,800
- (C) \$6,000
- (D) \$7,995

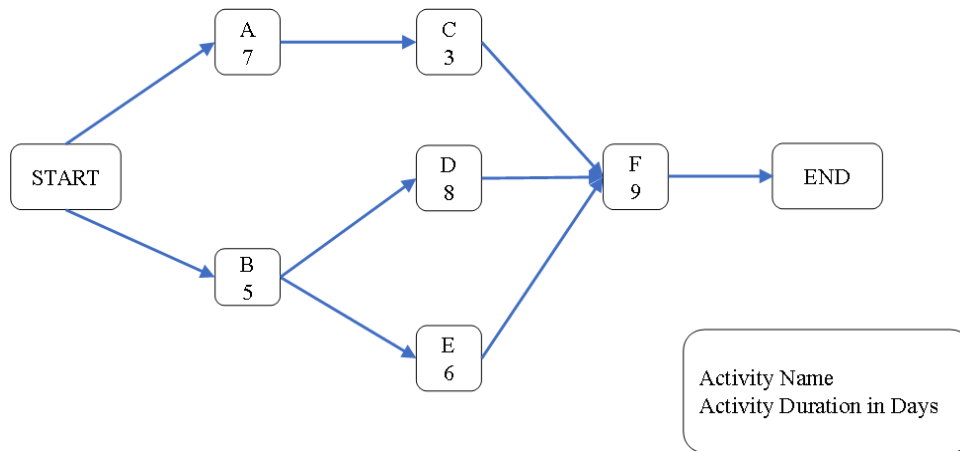
104. A construction project requires the installation of 2,500 linear feet of sewer line. The cost of pipe materials is \$10 per linear foot, and the installation cost is \$25 per linear foot. Additionally, the project includes a fixed cost of \$15,000 for mobilization and permits. Calculate the total project cost.

- (A) \$97,500
- (B) \$102,500
- (C) \$112,500
- (D) \$125,000

105. A contractor is considering two types of cranes for a construction project. Crane A has a fixed cost of \$10,000 and an operating cost of \$250 per hour. Crane B has a fixed cost of \$12,000 and an operating cost of \$200 per hour. For a project duration of 80 hours, determine which crane is more cost-effective and calculate the total cost.

- (A) Crane A; \$30,000
- (B) Crane A; \$32,000
- (C) Crane B; \$30,000
- (D) Crane B; \$28,000

106. A construction project consists of six activities (A to F) with the following relationships and durations (in days) as shown in activity-on-node diagram. Calculate the minimum number of days to finish the project.



- A. 22 Days
- B. 20 Days
- C. 19 Days
- D. 16 Days

107. A bridge construction project consists of three work packages. The budget and actual cost for each work package at the end of a progress review are given below:

Work Package	BCWP (\$)	ACWP (\$)
Foundation	120,000	140,000
Superstructure	250,000	230,000
Finishing	100,000	110,000

Calculate the overall Cost Variance (CV) for the project.

BCWS = Budgeted cost of work scheduled (Planned)

ACWP = Actual cost of work performed (Actual)

BCWP = Budgeted cost of work performed (Earned)

- A. \$-10,000
- B. \$-20,000

C. \$+10,000

D. \$+20,000

108. A government agency uses the following criteria to evaluate bids:

Cost (50%)

Experience (30%)

Project Timeline (20%)

Three contractors submit bids and receive scores as follows:

Contractor	Cost	Experience	Timeline
A	85	90	80
B	80	85	75
C	75	95	90

Which contractor has the highest weighted score?

A) A

B) B

C) C

D) Tie between A and C

109. A detail view of a staircase shows each step has a rise of 7 inches and a run of 11 inches. Calculate the total horizontal distance covered by 12 steps.

(A) 9 feet

(B) 10 feet

(C) 11 feet

(D) 12 feet

110. A parking lot with 90-degree (perpendicular) parking is redesigned to use 60-degree angled parking. If the original layout had 50 spaces, how many additional spaces can be added assuming the same total area?

A. 5 spaces

- B. 8 spaces
- C. 10 spaces
- D. 12 spaces

Solutions

[Click here for Problems](#)

1. Problem

Correct Answer: (A) $\frac{8}{3}$

Explanation: To find the area under the curve $y = x^2$ from $x = 0$ to $x = 2$, evaluate the definite integral:

$$A = \int_0^2 x^2 dx$$

$$\int x^2 dx = \frac{x^{2+1}}{2+1} = \frac{x^3}{3}$$

$$\left[\frac{x^3}{3} \right]_0^2 = \frac{2^3}{3} - \frac{0^3}{3} = \frac{8}{3} - 0 = \frac{8}{3}$$

2. Problem

Correct Answer: (A) $12x^2 - 18x$

Explanation: Differentiate $f(x)$ with respect to x to get the first derivative:

$$f'(x) = \frac{d}{dx}[x^4] - \frac{d}{dx}[3x^3] + \frac{d}{dx}[x] - \frac{d}{dx}[2]$$

$$\frac{d}{dx}[x^4] = 4x^3$$

$$\frac{d}{dx}[x^4] = 4x^3 \frac{d}{dx}[3x^3] = 3 \cdot 3x^2 = 9x^2 \frac{d}{dx}[x] = 1 \frac{d}{dx}[2] = 0$$

$$f'(x) = 4x^3 - 9x^2 + 1$$

$$f''(x) = \frac{d}{dx}[4x^3] - \frac{d}{dx}[9x^2] + \frac{d}{dx}[1]$$

$$\frac{d}{dx}[4x^3] = 4 \cdot 3x^2 = 12x^2 \quad \frac{d}{dx}[9x^2] = 9 \cdot 2x = 18x \quad \frac{d}{dx}[1] = 0$$

$$f''(x) = 12x^2 - 18x$$

3. Problem

Correct Answer: $(B) = \hat{i} - \hat{j} + \hat{k}$

Explanation: use the determinant method for cross products.

$$\vec{A} = \hat{i} + \hat{j} = (1, 1, 0) \quad \vec{B} = \hat{j} + \hat{k} = (0, 1, 1)$$

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 0 \\ 0 & 1 & 1 \end{vmatrix}$$

$$\vec{A} \times \vec{B} = \hat{i}(1 \cdot 1 - 0 \cdot 1) - \hat{j}(1 \cdot 1 - 0 \cdot 0) + \hat{k}(1 \cdot 1 - 1 \cdot 0)$$

$$\vec{A} \times \vec{B} = \hat{i}(1 \cdot 1 - 0 \cdot 1) - \hat{j}(1 \cdot 1 - 0 \cdot 0) + \hat{k}(1 \cdot 1 - 1 \cdot 0)$$

$$= \hat{i}(1) - \hat{j}(1) + \hat{k}(1)$$

$$= \hat{i} - \hat{j} + \hat{k}$$

4. Problem

Correct Answer: (A) $e^x(\cos x + \sin x)$

Explanation: By product rule:

$$f'(x) = u'(x)v(x) + u(x)v'(x)$$

In this case, $u(x) = e^x$ and $v(x) = \sin x$.

$$u'(x) = \frac{d}{dx}[e^x] = e^x; \quad v'(x) = \frac{d}{dx}[\sin x] = \cos x$$

Substituting the values,

$$u'(x) = e^x, u(x) = e^x, v(x) = \sin x, \text{ and } v'(x) = \cos x :$$

$$f'(x) = e^x \sin x + e^x \cos x$$

$$f'(x) = e^x (\sin x + \cos x)$$

5. Problem

Correct Answer: (C) 3

Explanation: To find the maximum value of the function

$f(x) = -2x^2 + 4x + 1$, first find the derivative and set it to zero to find critical points:

$$f'(x) = -4x + 4$$

$$-4x + 4 = 0 \Rightarrow x = 1$$

We then evaluate the function at this critical point:

$$f(1) = -2(1)^2 + 4(1) + 1 = -2 + 4 + 1 = 3$$

6. Problem

Correct Answer: (D) 5

Explanation: To evaluate the definite integral $\int_1^2 (3x^2 - 2x + 1) dx$, find the antiderivative and then apply the Fundamental Theorem of Calculus:

$$\int (3x^2 - 2x + 1) dx = \left[x^3 - x^2 + x \right]_1^2 = (8 - 4 + 2) - (1 - 1 + 1) = 5$$

7. Problem

Correct Answer: (A) $\frac{2x}{x^2+1}$

Explanation: To find the derivative of $f(x) = \ln(x^2 + 1)$, use the chain rule:

$$\frac{d}{dx} [f(g(x))] = f'(g(x)) \cdot g'(x)$$

$$\frac{d}{du} [\ln(u)] = \frac{1}{u}$$

$$\frac{d}{dx} [x^2 + 1] = 2x$$

$$\frac{d}{dx} [\ln \ln (x^2 + 1)] = \frac{1}{x^2+1} \cdot 2x$$

$$\frac{d}{dx} [\ln \ln (x^2 + 1)] = \frac{2x}{x^2+1}$$

8. Problem

Correct Answer: B) 1.5

Explanation: To find the slope, we use the formula for the slope m:

$$m = \frac{n\sum XY - (\sum X \sum Y)}{n\sum X^2 - (\sum X)^2}$$

Where $n = 5$, $\sum X = 15$, $\sum Y = 24$, $\sum XY = 87$, and $\sum X^2 = 55$.

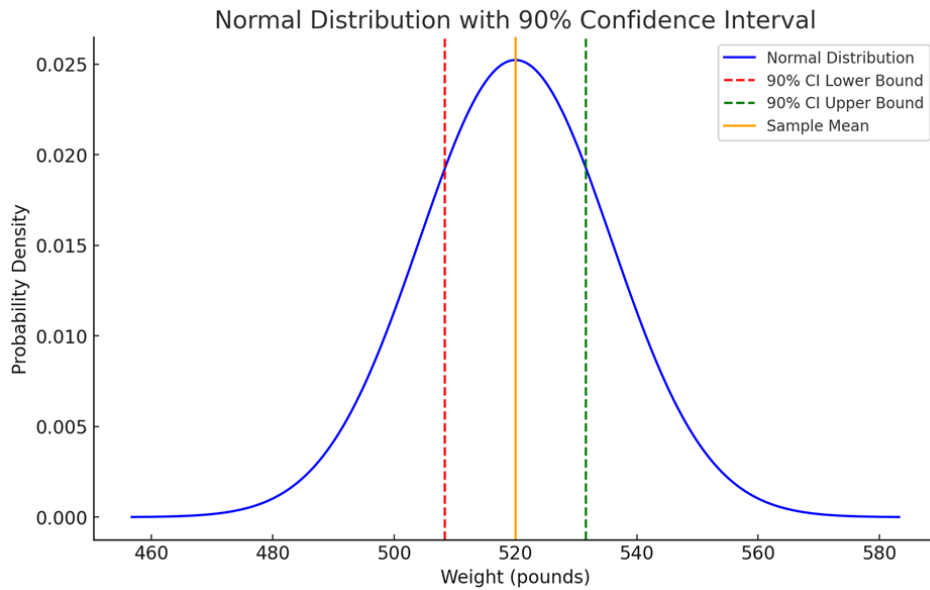
$$m = \frac{5(87) - (15)(24)}{5(55) - (15)^2} = 1.5$$

Hence, the slope of the regression line is 1.5

9. Problem

Correct Answer: C) (504.93, 535.07)

Explanation:



To calculate the 90% confidence interval for the mean, use the formula:

$$s = \bar{x} \pm t_{\alpha/2} \cdot \frac{s}{\sqrt{n}}$$

Step 1:

$$\text{Mean, } \bar{x} = \frac{500+510+530+540+520}{5} = 520$$

Step 2:

$$SD, s = \sqrt{\frac{(500-520)^2 + (510-520)^2 + (530-520)^2 + (540-520)^2 + (520-520)^2}{5-1}}$$

$$s = 15.81$$

Step 3: Look up the t-value for a 90% confidence level and 4 degrees of freedom, for $\alpha/2 = (1 - 0.90) / 2 = 0.05$.

From the t- table, $t_{\alpha/2} \approx 2.132$.

Step 4: Calculate the margin of error:

$$ME = 2.132 \cdot \frac{15.81}{\sqrt{5}} = 15.07$$

Step 5. Calculate the confidence interval:

$$CI = 520 \pm 15.07$$

$$CI = (504.93, 535.07)$$

10. Problem

Correct Answer: (D) $\frac{3}{2}$

Explanation:

Identify the highest power of x in the numerator and the denominator. The highest power of x in both the numerator and the denominator is x^2 .

Divide every term in the numerator and the denominator by x^2 .

$$\frac{3x^2+2}{2x^2+5x+3} = \frac{\frac{3x^2}{x^2} + \frac{2}{x^2}}{\frac{2x^2}{x^2} + \frac{5x}{x^2} + \frac{3}{x^2}} = \frac{3 + \frac{2}{x^2}}{2 + \frac{5}{x} + \frac{3}{x^2}}$$

$$\frac{2}{x^2} \rightarrow 0 \text{ as } x \rightarrow \infty \quad \frac{5}{x} \rightarrow 0 \text{ as } x \rightarrow \infty \quad \frac{3}{x^2} \rightarrow 0 \text{ as } x \rightarrow \infty$$

Simplify,

$$\lim_{x \rightarrow \infty} \frac{3 + \frac{2}{x^2}}{2 + \frac{5}{x} + \frac{3}{x^2}} = \frac{3+0}{2+0+0} = \frac{3}{2}$$

11. Problem

Answer: B) To offer technical expertise and opinions

Explanation: Expert witnesses provide technical expertise and opinions to help the court understand complex engineering issues in liability cases.

12. Problem

Answer: C) An engineer's design error causing structural failure

Explanation: Professional liability issues arise from errors, omissions, or negligence in professional services that result in harm or damages.

13. Problem

Answer: C) To allocate responsibility for errors and omissions

Explanation: A professional liability clause outlines the responsibilities and liabilities of parties involved regarding errors and omissions in professional services.

14. Problem

Answer: C) Ignoring safety standards in a project design

Explanation: Ignoring safety standards can result in design flaws that may lead to accidents or failures, potentially resulting in liability claims.

15. Problem

Answer: B) Maintaining thorough and accurate documentation

Explanation: Accurate documentation helps demonstrate due diligence and can be crucial in defending against liability claims.

16. Problem

Correct Answer: (A) \$1, 257, 300

Explanation: To solve this problem, we need to calculate the Net Present Value (NPV) of the project. The NPV is the difference between the present value of cash inflows and the present value of cash outflows over the project's lifespan.

Step 1: Calculate the Present Value of Cash Inflows

The annual toll revenue is \$1.5 million, and it will be received for 30 years. The present value of an annuity can be calculated using the formula:

$$P V_{\text{inflows}} = R \times 1 - (1 + r)^{-n} / r$$

where:

- R is the annual revenue (\$1.5 million)
- r is the discount rate (8% or 0.08)
- n is the lifespan of the project (30 years)

Substituting the values:

$$P V_{\text{inflows}} = 1,500,000 \times 1 - (1 + 0.08)^{-30} / 0.08$$

$$P V_{\text{inflows}} = 1,500,000 \times 1 - (1.08)^{-30} / 0.08$$

$$P V_{\text{inflows}} = 1,500,000 \times 11.2573$$

$$P V_{\text{inflows}} = 16,885,950$$

Step 2: Calculate the Present Value of Cash Outflows

The project has two types of cash outflows: the initial construction cost and the annual maintenance cost.

Initial Construction Cost: The initial cost is \$10 million. Since this cost is incurred at the beginning, its present value is simply:

$$P V_{\text{initial cost}} = 10,000,000$$

Annual Maintenance Cost: The annual maintenance cost is \$500,000, and it will be paid for 30 years. The present value of this annuity can be calculated using the same annuity formula as above:

$$P V_{\text{maintenance}} = 500,000 \times 1 - (1 + 0.08)^{-30} / 0.08$$

$$P V_{\text{maintenance}} = 500,000 \times 11.2573$$

$$P V_{\text{maintenance}} = 5,628,650$$

Total Present Value of Cash Outflows: The total present value of the cash outflows is the sum of the initial cost and the present value of the maintenance costs:

$$P V_{\text{outflows}} = P V_{\text{initial cost}} + P V_{\text{maintenance}}$$

$$P V_{\text{outflows}} = 10,000,000 + 5,628,650$$

$$P V_{\text{outflows}} = 15,628,650$$

Step 3: Calculate the Net Present Value (NPV)

The NPV is calculated by subtracting the present value of cash outflows from the present value of cash inflows:

$$NPV = P V_{\text{inflows}} - P V_{\text{outflows}}$$

$$NPV = 16,885,950 - 15,628,650$$

$$NPV = 1,257,300$$

17. Problem

Correct Answer: (B) 12.55%

Explanation: The effective annual rate EAR is calculated using the formula:

$$EAR = \left(1 + \frac{i}{m}\right)^m - 1$$

where i is the nominal interest rate, and m is the number of compounding periods per year.

Step 1: Identify the values: $i = 0.12$, $m = 4$.

Step 2: Plug the values into the formula:

$$EAR = \left(1 + \frac{0.12}{4}\right)^4 - 1$$

$$EAR = (1.03)^4 - 1$$

$$EAR = 0.1255$$

Convert to percentage:

$$EAR = 12.55 \%$$

18. Problem

Correct Answer: C) 50%

Return on Investment (ROI):

$$ROI = \frac{\text{Total Net Revenue} - \text{Initial Cost}}{\text{Initial Cost}} \times 100$$

Total Net Revenue = Net Annual Revenue $\times$ No. of years

Total Net Revenue = (Annual Revenue – Annual Maintenance Costs) $\times$ 15

Total Net Revenue = (20,000 – 5,000) $\times$ 15 = 225,000

Substituting in the ROI:

$$ROI = \frac{225,000 - 150,000}{150,000} \times 100 = 50\%$$

19. Problem

Correct Answer: (C) Depreciation expense.

Explanation: Fixed costs are expenses that do not change with the level of production or sales. Depreciation expense is an example of a fixed cost as it remains constant regardless of the production volume.

20. Problem

Correct Answer: (B) 600 units

Explanation: Break-even volume (BEV) is calculated as

BEV = Fixed Costs / (Revenue per Unit - Variable Cost per Unit).

Here, $BEV = \$12,000 / (\$50 - \$30) = 600$ units.

21. Problem

Correct Answer: A) Stock X by 1.1%

Calculate expected return for each stock.

For Stock X:

$$E(X) = (10 \times 0.5) + (5 \times 0.5) = 5 + 2.5 = 7.5\%$$

For Stock Y:

$$E(Y) = (12 \times 0.3) + (4 \times 0.7) = 3.6 + 2.8 = 6.4\%$$

Compare expected returns.

$$E(X) - E(Y) = 7.5\% - 6.4\% = 1.1\%$$

22. Problem

Correct Answer: (C) $\frac{4b}{9}$, $\frac{7h}{9}$

Explanation: Calculate individual areas:

$$\text{Rectangle: } A_1 = b \times h = bh \quad \text{Triangle: } A_2 = \frac{1}{2}b \times h = \frac{bh}{2}$$

Calculate individual centroid y-coordinates:

$$\text{Rectangle: } \bar{y}_1 = \frac{h}{2} \quad \text{Triangle: } \bar{y}_2 = h + \frac{h}{3} = \frac{4h}{3}$$

The centroid of a composite shape is found by calculating the area-weighted average of the centroids of the individual shapes. For the rectangle:

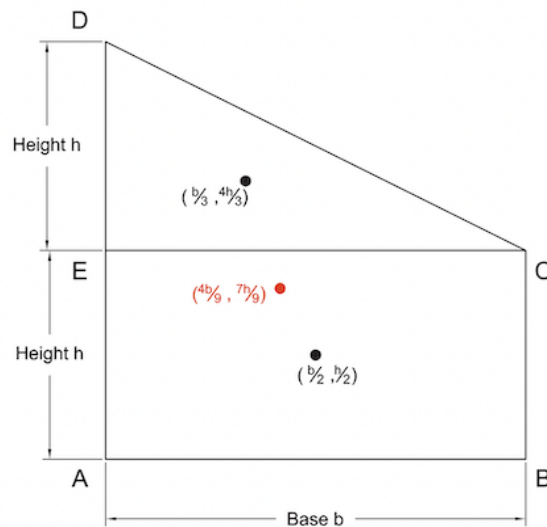
$$\begin{aligned} \bar{y} &= \frac{A_1 \bar{y}_1 + A_2 \bar{y}_2}{A_1 + A_2} = \frac{bh \cdot \frac{h}{2} + \frac{1}{2}bh \cdot \frac{4h}{3}}{bh + \frac{1}{2}bh} = \frac{\frac{bh^2}{2} + \frac{2bh^2}{3}}{\frac{3bh}{2}} = \frac{\frac{3bh^2}{6} + \frac{4bh^2}{6}}{\frac{3bh}{2}} \\ &= \frac{\frac{7bh^2}{6}}{\frac{3bh}{2}} = \frac{7h}{9} \end{aligned}$$

Calculate individual centroid x coordinates:

Rectangle $x_1 = \frac{b}{2}$ Triangle: $x_2 = \frac{b}{3}$

$$\bar{x} = \frac{A_1 x_1 + A_2 x_2}{A_1 + A_2} \rightarrow \frac{bh \cdot \frac{b}{2} + \frac{bh}{2} \cdot \frac{b}{3}}{bh + \frac{1}{2}bh} \rightarrow \frac{\frac{4}{6}b^2 h}{\frac{3bh}{2}} \rightarrow \frac{4}{9}b$$

Thus, centroid of the figure is $(\frac{4}{9}b, \frac{7}{9}h)$



23. Problem

Correct Answer: (C) 8.33 kN (Compression)

Explanation: To solve this problem, we will use the method of joints to determine the forces in members AC and CD.

We will start by analyzing the equilibrium at joint C.

Step 1: Joint C Analysis

At joint C, we have three members: BC, CD, and AC. The load applied at C is 10 kN vertically downward. Vertical member BC is a zero force member in

the truss so we only have to calculate forces in the inclined members for equilibrium at joint C.

We can resolve the forces into their horizontal and vertical components.

Let, F_{AC} and F_{CD} be the forces in members AC and CD, respectively

Sum of vertical forces at joint C: $F_{AC} \sin \theta + F_{CD} \sin \theta = 10 \text{ kN}$

Sum of horizontal forces at joint C: $F_{AC} \cos \theta - F_{CD} \cos \theta = 0$

Where θ is the angle of inclination of members AC and CD with the horizontal. From the given dimensions,

$$F_{AC} \left(\frac{3}{5} \right) + F_{CD} \left(\frac{3}{5} \right) = 10$$

$$F_{AC} \left(\frac{4}{5} \right) - F_{CD} \left(\frac{4}{5} \right) = 0$$

Step 2: Solve the Equations

From the horizontal equilibrium equation:

$$F_{AC} \cos \theta = F_{CD} \cos \theta \Rightarrow F_{AC} = F_{CD}$$

Substituting $F_{AC} = F_{CD}$ into the vertical equilibrium equation:

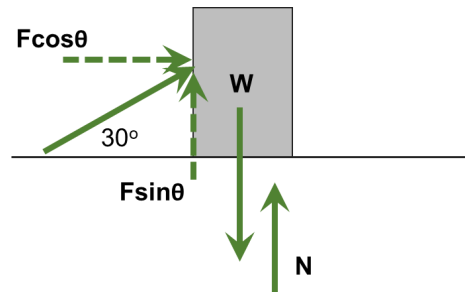
$$2F_{AC} \left(\frac{3}{5} \right) = 10$$

$$F_{AC} = \frac{10 \times 5}{6}$$

$$F_{AC} = 8.33 \text{ kN (Compression)}$$

24. Problem

Correct Answer: B) 96.4 N



To solve this problem, we must account for both the horizontal component of the applied force and the change in the normal force due to the vertical component of the applied force.

Normal force:

When a force F is applied at an angle of 30° , the vertical component of this force reduces the normal force, i.e.,

$$N = W - F \sin \theta$$

Force of static friction:

The force of static friction is:

$$F_s = \mu_s \cdot N = \mu_s \cdot (W - F \sin \theta)$$

Substituting the values:

$$F_s = 0.55 \times (200 - F \sin 30^\circ)$$

Since, $\sin 30^\circ = 0.5$:

$$F_s = 0.55 \times (200 - 0.5F)$$

Horizontal component of the applied force must overcome the static friction:

$$F \cos 30^\circ = F_s$$

Using $\cos 30^\circ = 0.866$, we can substitute for F_s :

$$F \times 0.866 = 0.55 \times (200 - 0.5F)$$

Now, solve for F :

$$0.866 F = 110 - 0.275 F$$

$$0.866 F + 0.275 F = 110$$

$$1.141 F = 110$$

$$F = 110/1.141 = 96.4 \text{ N}$$

Thus, the minimum force required to initiate motion is approximately 96.4 N

25. Problem

Correct Answer: (C) $\bar{x} = \frac{3a}{4}, \bar{y} = \frac{3a^2}{10}$

Explanation: The x-coordinate of the centroid for the region under the curve $y = f(x)$ from $x = a$ to $x = b$ is given by:

$$\bar{x} = \frac{1}{A} \int_a^b x f(x) dx$$

The y-coordinate of the centroid is given by:

$$\bar{y} = \frac{1}{A} \int_a^b \frac{f(x)^2}{2} dx$$

Where A is the area under the curve; $A = a^3/3$

$$\bar{x} = \frac{1}{A} \int_0^a x(x^2) dx = \frac{1}{\frac{a^3}{3}} \int_0^a x^3 dx = \frac{3}{a^3} \left[\frac{x^4}{4} \right]_0^a = \frac{3}{a^3} \cdot \frac{a^4}{4} = \frac{3a}{4}$$

$$\bar{y} = \frac{1}{A} \int_0^a \frac{(x^2)^2}{2} dx = \frac{1}{\frac{a^3}{3}} \int_0^a \frac{x^4}{2} dx = \frac{3}{a^3} \left[\frac{x^5}{10} \right]_0^a = \frac{3}{a^3} \cdot \frac{a^5}{10} = \frac{3a^2}{10}$$

The centroid $(\bar{x}, \bar{y})$ of the area under the curve $y = x^2$ from $x = 0$ to $x = a$ is:

$$\bar{x} = \frac{3a}{4}, \bar{y} = \frac{3a^2}{10}$$

26. Problem

Correct Answer: (A) $-\frac{2R}{3\pi + 12}$

Explanation:

$$\text{Area of the semicircle:} = \frac{1}{2}\pi R^2$$

$$\text{Area of the rectangle:} = 2R \cdot R = 2R^2$$

Using the formula for the centroid of a composite area:

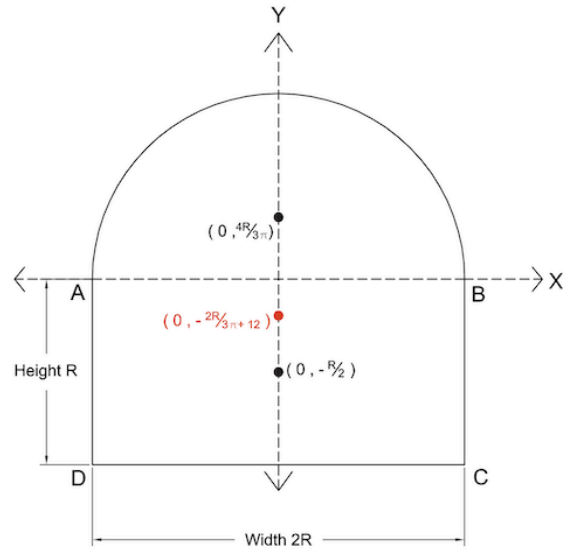
$$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}$$

$$\bar{y} = \frac{\frac{1}{2}\pi R^2 \cdot \frac{4R}{3\pi} + 2R^2 \cdot \left(-\frac{R}{2}\right)}{\frac{1}{2}\pi R^2 + 2R^2}$$

$$\bar{y} = \frac{\frac{2R^3}{3} - R^3}{R^2\left(\frac{\pi}{2} + 2\right)}$$

$$\bar{y} = \frac{\frac{2R^3}{3} - \frac{3R^3}{3}}{R^2\left(\frac{\pi}{2} + 2\right)}$$

$$\bar{y} = \frac{\frac{-R^3}{3}}{R^2\left(\frac{\pi}{2} + 2\right)} \rightarrow \bar{y} = \frac{-R}{3\left(\frac{\pi}{2} + 2\right)} \rightarrow \bar{y} = \frac{-2R}{3\pi + 12}$$



27. Problem

Correct Answer: (A) $Q_y = \frac{b^2}{2}h$

Explanation: The first moment of area about the y-axis is given by:

$$Q_y = \int_A x dA$$

The first moment of area about the y-axis for a rectangle can be calculated as follows:

$$Q_y = \int_0^h \int_0^b x dx dy$$

$$Q_y = \int_0^h \frac{b^2}{2} dy$$

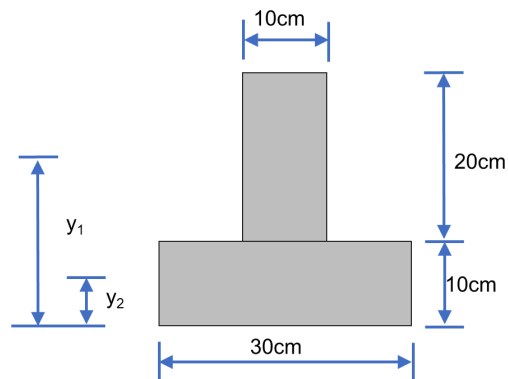
$$Q_y = \frac{b^2}{2} \int_0^h dy$$

$$Q_y = \frac{b^2}{2} [y]_0^h$$

$$Q_y = \frac{b^2}{2} h$$

28. Problem

Correct Answer: D) $9.6 \times 10^4 \text{ cm}^4$



Centroid Calculation

Vertical stem:

- Area (A_1) = $10 \times 20 = 200 \text{ cm}^2$
- Centroid of the stem from the bottom of flange (y_1) = $10 + (20 / 2)$
= 20 cm

Horizontal flange:

- Area (A_2) = $30 \times 10 = 300 \text{ cm}^2$
- Centroid of the flange from the bottom of flange (y_2) = $10 / 2 = 5 \text{ cm}$

Composite centroid (y):

$$y = \frac{(200 \times 20) + (300 \times 5)}{200 + 300} = \frac{4000 + 1500}{500} = 11 \text{ cm}$$

Moment of Inertia about Centroidal Axis

Using the parallel axis theorem,

$$I_t = I_{flange} + I_{stem}$$

$$I_{flange} = I_f + A_f d_f^2 = \frac{30 \times 10^3}{12} + (300 \times 5^2) = 10,000 \text{ cm}^4$$

$$I_{stem} = I_s + A_s d_s^2 = \frac{10 \times 20^3}{12} + (200 \times 20^2) = 86,666 \text{ cm}^4$$

Substituting values, $I_t = 13300 + 22866 = 36167 \text{ cm}^4 = 9.6 \times 10^4 \text{ cm}^4$

29. Problem

Correct Answer: (B) $\frac{bh^2}{6}$

Explanation: The first moment of area about the x-axis is given by:

$Q_x = \int_A y dA$ where y is the distance from the x-axis to the differential area element dA and A is the area of the triangle.

$$A = \frac{1}{2}bh$$

Since the centroid $\bar{y}$ is located at $\frac{h}{3}$ from the base, the first moment of area

$$Q_x = A \times \bar{y} = \frac{1}{2}bh \times \frac{h}{3} = \frac{bh^2}{6}$$

30. Problem

Correct Answer: (B) 28 rad

Explanation:

$$\theta = \omega_0 t + \frac{1}{2} \alpha t^2 = 3 \times 4 + \frac{1}{2} \times 2 \times 4^2$$

$$= 28 \text{ rad}$$

31. Problem

Correct Answer: (C) 5 seconds

Explanation:

$$t = \frac{v-u}{a}$$

$$t = \frac{0-10}{-2}$$

$$T = 5 \text{ seconds}$$

32. Problem

Correct Answer: (B) 10 m

Explanation:

$$H = \frac{v_0^2 \sin^2 \theta}{2g} = \frac{20^2 \sin^2 30^\circ}{2 \times 9.81} = 10 \text{ m}$$

33. Problem

Correct Answer: A) 0.316 m

The radius of gyration is defined as:

$$r^2 = \frac{2}{5} R^2$$

$$r^2 = \frac{2}{5} (0.5)^2$$

$$r = \sqrt{\frac{2}{5} (0.5)^2}$$

$$k = 0.316 \text{ m}$$

34. Problem

Correct Answer: B) 30 m/s

From Newton's Second Law:

$$F = ma, a = F/m$$

$$a = 60 / 10 = 6 \text{ m/s}^2$$

Now, use the kinematic equation to find velocity after 5 seconds:

$$v = u + at$$

Where $u = 0 \text{ m/s}$ (since the block starts from rest), $a = 6 \text{ m/s}^2$, $t = 5 \text{ sec}$.

$$v = 0 + 6 \times 5 = 30 \text{ m/s}$$

35. Problem

Correct Answer: (D) 1.51 mm

Explanation: Calculate elongation:

$$\delta = \frac{FL}{AE} \rightarrow A = \pi \left(\frac{d}{2} \right)^2 = \pi \left(\frac{20}{2} \right)^2 = 314.16 \text{ mm}^2 \rightarrow \delta = \frac{50 \times 10^3 \times 2 \times 10^3}{314.16 \times 210 \times 10^3} = 1.51 \text{ mm}$$

36. Problem

Correct Answer: A) 0.008 mm

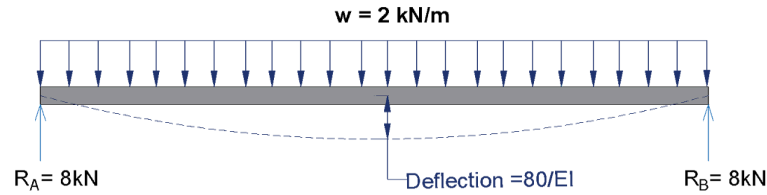
$$\delta = \frac{PL}{AE}$$

$$= \frac{12000 \times 3000}{30000 \times 200 \times 10^3} = 0.006 \text{ mm}$$

$$\text{Total Deflection} = \delta_{init} + \delta = 0.002 + 0.006 = 0.008 \text{ mm}$$

37. Problem

Correct Answer: A) 26.67/EI



$$v_{max} = \frac{5wL^4}{384EI}$$

$$= \frac{5 \times 2 \times (8)^4}{384 \times EI} = \frac{106.6}{EI}$$

$$\text{Additional Permissible deflection in a beam} = \frac{106.6 - 80}{EI} = \frac{26.67}{EI}$$

38. Problem

Correct Answer: (B) 20.4 MPa

Explanation:

$$J = \frac{\pi d^4}{32} = \frac{\pi (0.05)^4}{32} = 6.136 \times 10^{-7} m^4 \rightarrow \tau_{max} = \frac{Tr}{J} = \frac{500 Nm \times 0.025 m}{6.136 \times 10^{-7} m^4} = 20.4 MPa$$

39. Problem

Correct Answer: C) 2.85 MPa

The internal pressure for a spherical wall cylinder is given by;

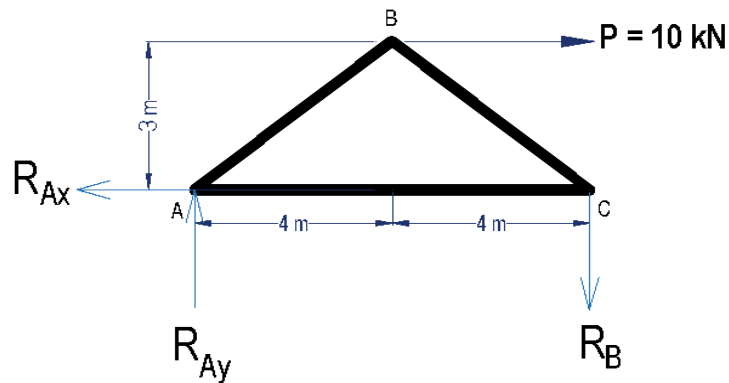
$$\sigma = \frac{P \times d}{4t}$$

$$P = \frac{4t\sigma}{d}$$

$$P = \frac{4 \times 55.158 \times 0.0158}{1.22} = 2.85 MPa$$

40. Problem

Correct Answer: C) 0 kN-m



The support is pin-connection, the moment must not be resisted at point A.
So, moment will be zero.

41. Problem

Correct Answer: (A) Yes

Explanation: Calculate stress:

$$\sigma = F/A$$

$$A = \pi \left(\frac{d}{2} \right)^2 = \pi \left(\frac{30}{2} \right)^2 = 706.86 \text{ mm}^2 \rightarrow \sigma = \frac{300 \times 10^3}{706.86} = 424.4 \text{ MPa}$$

Compare with yield stress:

$$\sigma > \sigma_y \Rightarrow \text{Plastic deformation}$$

42. Problem

Correct Answer: (C) 509.30 MPa, 534.77 MPa, 5%

Explanation:

Initial length (L_0) = 200 mm

Initial diameter (d_0)=100 mm

Applied load (F)= 40,000N

Final length (L_f)= 210 mm

$$A_0 = \pi \left(\frac{d_0}{2} \right)^2 = \pi (50 \text{ mm})^2 = 2500\pi \text{ mm}^2 \approx 7854 \text{ mm}^2$$

$$\sigma_{eng} = \frac{F}{A_0} = \frac{40,000 \text{ N}}{7854 \text{ mm}^2} \approx 509.30 \text{ MPa}$$

$$\sigma_{true} = \sigma_{eng} \left(\frac{L_f}{L_0} \right) = 509.30 \text{ MPa} \left(\frac{210 \text{ mm}}{200 \text{ mm}} \right) = 509.30 \text{ MPa} \times 1.05$$

$$\approx 534.77 \text{ MPa}$$

$$\% \epsilon = \left(\frac{L_f - L_0}{L_0} \right) \times 100 = \left(\frac{210 \text{ mm} - 200 \text{ mm}}{200 \text{ mm}} \right) \times 100 = \left(\frac{10 \text{ mm}}{200 \text{ mm}} \right) \times 100$$

$$= 5\%$$

43. Problem

Correct Answer: A) True stress is higher than the engineering stress.

Engineering Stress:

Engineering stress (σ_e) = Force (F) / Original Area (A_0)

$$\sigma_e = 300 \text{ kN} / 100 \text{ mm}^2$$

$$\sigma_e = 3000 \text{ N/mm}^2 = 3000 \text{ MPa}$$

True Stress:

True stress (σ_t) = Force (F) / Instantaneous Area (A_i)

$$\sigma_t = 300 \text{ kN} / 60 \text{ mm}^2$$

$$\sigma_t = 5000 \text{ N/mm}^2 = 5000 \text{ MPa}$$

Comparison:

True stress (5000 MPa) is significantly higher than the engineering stress (3000 MPa) at the point of necking.

44. Problem

Correct Answer: (B) 33.91 MPa, 0.0067, 5.06 GPa

Explanation:

$$\text{Engineering stress} = \frac{600 \times 10^3}{\pi \left(\frac{150}{2}\right)^2} = 33.91 \text{ MPa}, \text{ Engineering strain} = \frac{2}{300} = 0.0067$$

$$\text{Modulus of elasticity} = \frac{\text{Stress}}{\text{Strain}} = \frac{33.91 \times 10^6}{0.0067} = 5.06 \text{ GPa}$$

45. Problem

Correct Answer: (D) 50 kg, 450 kg, 500 kg

Explanation: (1 ton = 1000 kg)

$$\text{Bitumen} = 0.05 \times 1000 = 50 \text{ kg}$$

$$\text{Coarse aggregate} = 0.45 \times 1000 = 450 \text{ kg}$$

$$\text{Fine aggregate} = 0.50 \times 1000 = 500 \text{ kg}$$

46. Problem

Correct Answer: C) 5.16 MPa

Fracture mechanics formula:

$$K_{1C} = Y\sigma\sqrt{\pi a_c}$$

For external crack, $Y = 1.1$

$$\sigma = \frac{K_{1C}}{Y\sqrt{\pi a}}$$

final cracking length $a = 8\text{mm}$:

$$\sigma = \frac{0.9}{1.1\sqrt{\pi \times 8 \times 10^{-3}}} = 5.16\text{MPa}$$

47. Problem

Correct Answer: A) 0.022 mm

$$N_{(0.0645 \text{ mm}^2)} = 2^{(n-1)}$$

$$N_{(0.0645 \text{ mm}^2)} = 2^{(8-1)} = 128 \text{ grains}$$

Now, we know that there are 128 grains in an area of 0.0645 mm^2 .

The approximate average grain diameter d is given by:

$$d = \frac{1}{\sqrt{\frac{N}{A}}} = \frac{1}{\sqrt{\frac{128}{0.0645}}} = 0.022 \text{ mm}$$

or the following solution for the grain diameter:

To find the average grain area, we divide the total area by the number of grains:

$$\text{Average grain area} = 0.0645 \text{ mm}^2 / 128 \text{ grains} \approx 0.000504 \text{ mm}^2/\text{grain}$$

Assuming the grains are approximately circular, we can find the average grain diameter (d) by relating the area of a circle to the average grain area:

$$\text{Area} = \pi (d/2)^2$$

$$0.000504 \text{ mm}^2 = \pi (d/2)^2$$

Solving for d :

$$d^2 = (4 * 0.000504 \text{ mm}^2) / \pi$$

$$d = \sqrt{0.000642} \approx 0.022 \text{ mm}$$

48. Problem

Correct Answer: (A) 1.179 kPa

Explanation:

$$h_v = h \sin \theta$$

$$h_v = 0.2 \text{ m} \times \sin 45^\circ$$

$$h_v = 0.1414 \text{ m}$$

$$\Delta P = \rho g h_v$$

Where, ΔP = Pressure Difference, ρ = Density, h_v = Height difference

$$\Delta P = 850 \text{ kg/m}^3 \times 9.81 \text{ m/s}^2 \times 0.1414 \text{ m}$$

$$\Delta P = 1.179 \text{ kPa}$$

49. Problem

Correct Answer: A) 9.42 kPa

Pressure due to water column:

$$P_{\text{water}} = \rho_{\text{water}} * g * h_{\text{water}} = (1000)(9.81)(0.4) = 3924 \text{ Pa}$$

Pressure due to mercury column:

$$P_{\text{mercury}} = \rho_{\text{mercury}} * g * h_{\text{mercury}} = (13600)(9.81)(0.1) = 13341.6 \text{ Pa}$$

Pressure difference:

$$\Delta P = P_{\text{mercury}} - P_{\text{water}} = 13341.6 - 3924 = 9417.6 \text{ Pa} = 9.42 \text{ kPa}$$

50. Problem

Correct Answer: (D) -0.0056 m

Explanation:

$$\text{Capillary rise} = \frac{2\sigma \cos \theta}{\rho g r}$$

Where, θ = contact angle; σ = Surface tension of water; ρ = density

$$= \frac{2 \times 0.485 \text{ N/m} \times \cos 140}{13546 \text{ kg/m}^3 \times 9.81 \text{ m/s}^2 \times 0.001 \text{ m}}$$

$$= -0.0056 \text{ m}$$

51. Problem

Correct Answer: (A) $1.17 \text{ m}^3/\text{s}$

Explanation:

The formula derived from the combination of the continuity equation and Bernoulli's equation applied to the flow through a Venturi meter is:

$$Q = C_d A_2 \sqrt{\frac{2\Delta P}{\rho \left(1 - \left(\frac{A_2}{A_1}\right)^2\right)}}$$

It expresses the flow rate Q in terms of the areas at the inlet and the throat, the pressure difference, and the density of the fluid.

$$A_1 = \frac{\pi D_1^2}{4} = \frac{\pi (0.2)^2}{4} = \frac{\pi \cdot 0.04}{4} = 0.01\pi \text{ m}^2 \approx 0.0314 \text{ m}^2$$

$$A_2 = \frac{\pi D_2^2}{4} = \frac{\pi (0.08)^2}{4} = \frac{\pi \cdot 0.0064}{4} = 0.0016\pi \text{ m}^2 \approx 0.005 \text{ m}^2$$

$$\left(\frac{A_2}{A_1}\right)^2 = \left(\frac{0.005}{0.0314}\right)^2 \approx (0.159)^2 \approx 0.0253$$

$$Q = 0.005 \sqrt{\frac{2 \cdot 40,000}{1.5 \cdot (1 - 0.0253)}}$$

$$Q = 0.005 \cdot 233.92 \approx 1.17 \text{ m}^3/\text{s}$$

52. Problem

Correct Answer: (A) 147.15 KPa

Explanation: As per Bernoulli's equation,

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + h_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_2$$

Where, P=Pressure at point; V=Velocity at point; ρ = The density of the fluid;
h=height above a reference level at point.

$\frac{P}{\rho g}$ = Pressure head; $\frac{V_{1,2}^2}{2g}$ = Velocity head, h= elevation head

$$\frac{200000}{1000 \times 9.81} + \frac{1^2}{2 \times 9.81} + 5 = \frac{P_2}{1000 \times 9.81} + \frac{3^2}{2 \times 9.81} + 10$$

$$20.39 + 0.05 + 5 = \frac{P_2}{9810} + 0.46 + 10$$

$$25.44 = \frac{P_2}{9810} + 10.46 \rightarrow 15 = \frac{P_2}{9810} \rightarrow P_2 = 147150 \text{ Pa} \leftrightarrow P_2 = 147.15 \text{ kPa}$$

53. Problem

Correct Answer: A) 1767 N

Applying the Impulse-Momentum Principle:

$$F = \rho Q (V_{\text{in}} - V_{\text{out}})$$

$$Q = AV$$

Cross-sectional area:

$$A = \pi (0.1)^2 / 4 = 0.00785 \text{ m}^2$$

$$Q = AV = (0.00785)(15) = 0.1178 \text{ m}^3/\text{s}$$

Since the jet is completely stopped: $V_{\text{out}} = 0 \text{ m/s}$

$$F = (0.1178)(1000)(15 - 0) = 1767 \text{ N}$$

54. Problem

Correct Answer: (A) 4.57 Pa

Explanation: $\tau = K\left(\frac{dv}{dy}\right)^n = 0.2 \text{ Pa} \times (50s^{-1})^{0.8} = 4.57 \text{ Pa}$

Where,

τ : Shear stress (Pa)

K: Consistency index (Pa·s)

$\frac{dv}{dy}$: *Shear rate*

n: Flow behavior index (dimensionless)

55. Problem

Correct Answer: (C) 32.67 m^2

Explanation:

$$A = \frac{h}{3} \left(y_0 + 4 \sum_{\text{odd } i=1}^{n-1} y_i + 2 \sum_{\text{even } i=2}^{n-2} y_i + y_n \right)$$

$$h = 2 \text{ m}$$

$$A = 2/3 (2 + 4(5) + 2(8) + 11)$$

$$A = 2/3 \times 49$$

$$A = 32.67 \text{ m}^2$$

56. Problem

Correct Answer: (C) 10 units^2

Explanation:

$$A = \frac{1}{2} |x_1 y_2 + x_2 y_3 + x_3 y_1 - (y_1 x_2 + y_2 x_3 + y_3 x_1)|$$

$$A = \frac{1}{2} |0 \cdot 0 + 5 \cdot 4 + 2 \cdot 0 - (0 \cdot 5 + 0 \cdot 2 + 4 \cdot 0)|$$

$$A = \frac{1}{2} \times 20 \rightarrow A = 10 \text{ units}^2$$

57. Problem

Correct Answer: (B) $r = 7\sqrt{2}$, $\theta = 315^\circ$

Explanation:

$$r = \sqrt{x^2 + y^2} = \sqrt{7^2 + (-7)^2} = \sqrt{98} \rightarrow r = 7\sqrt{2}$$

$$\theta = \tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{-7}{7}\right)$$

$$\theta = \tan^{-1}(-1) = -45^\circ \rightarrow 360^\circ - 45^\circ = 315^\circ$$

58. Problem

Correct Answer: (C) 192 m^3

Explanation:

$$A = 6 \times 8$$

$$A = 48 \text{ m}^2$$

$$V = \frac{1}{3} \times A \times h$$

$$V = \frac{1}{3} \times 48 \times 12$$

$$V = \frac{1}{3} \times 576$$

$$V = 192 \text{ m}^3$$

59. Problem

Correct Answer: (B) 10.5 units^2

Explanation:

$$A = \frac{1}{2} |x_1 y_2 + x_2 y_3 + x_3 y_4 + x_4 y_1 - (y_1 x_2 + y_2 x_3 + y_3 x_4 + y_4 x_1)|$$

$$A = \frac{1}{2} |1 \cdot 5 + 3 \cdot 5 + 6 \cdot 2 + 5 \cdot 2 - (2 \cdot 3 + 5 \cdot 6 + 5 \cdot 5 + 2 \cdot 1)|$$

$$A = \frac{1}{2} | - 21 | \rightarrow A = 10.5 \text{ units}^2$$

60. Problem

Correct Answer: A) (41.5, 428.1)

Apply Translation

$$x' = 400 - 150 = 250$$

$$y' = 250 + 100 = 350$$

Apply Rotation (30° Counterclockwise)

Rotation transformation equations:

$$x'' = x' \cos \theta - y' \sin \theta$$

$$y'' = x' \sin \theta + y' \cos \theta$$

For $\theta = 30^\circ$,

$$\cos 30^\circ = 0.866, \sin 30^\circ = 0.5$$

$$x'' = (250 \times 0.866) - (350 \times 0.5) = 41.5$$

$$y'' = (250 \times 0.5) + (350 \times 0.866) = 428.1$$

Thus, the closest correct answer is (41.5, 428.1)

61. Problem

Correct Answer: (D) 6500 m³

Explanation:

$$V = [(A_1 + A_2)/2] \times L$$

$$V = [(50 + 80) / 2] \times 100$$

$$V = 65 \times 100$$

$$V = 6500 \text{ m}^3$$

62. Problem

Correct Answer: A) $0.53 \text{ ft}^3/\text{sec}$

Using the Dupuit's formula:

$$Q = \frac{\pi K(h_2^2 - h_1^2)}{\ln\left(\frac{r_2}{r_1}\right)}$$

$$Q = \frac{3.14 \times 0.001(50^2 - 40^2)}{\ln\left(\frac{100}{0.5}\right)}$$

$$Q = 0.53 \text{ ft}^3/\text{sec}$$

63. Problem

Correct Answer: (D) 0.144 m

Explanation:

$$V = Q \times t, Q = 0.1 \text{ m}^3/\text{s}, t = 2 \times 3600, V = 0.1 \times 7200 = 720 \text{ m}^3$$

$$\Delta h = \frac{V}{A}, A = 5000 \text{ m}^2 \rightarrow \Delta h = \frac{720}{5000} = 0.144 \text{ m}$$

64. Problem

Correct Answer: A) 7.875 m/s

Using the continuity equation:

$$Q = A_1 V_1 = A_2 V_2$$

$$\frac{\pi 0.3^2}{4} \times 3.5 = \frac{\pi 0.2^2}{4} \times V_2$$

$$V_2 = 7.875 \text{ m/s}$$

65. Problem

Correct Answer: (B) 42 m

Explanation:

$$HGL = z + \frac{P}{\rho g} + \frac{v^2}{2g}$$

$$z = 10m \rightarrow \frac{P}{\rho g} = 30m \rightarrow \frac{v^2}{2g} = 2m$$

$$HGL = 10 + 30 + 2 = 42m$$

66. Problem

Correct Answer: (B) 3.84 m

Explanation:

$$Q_{in} = 300m^3/s$$

$$Q_{out} = 100m^3/s$$

$$\Delta h = 2m$$

$$A = 150 \times 10^4 m^2$$

$$t = 8 \times 3600s$$

$$V_{in} = Q_{in} \times t$$

$$V_{in} = 300 \times 28800$$

$$V_{in} = 8640000m^3$$

$$V_{out} = Q_{out} \times t$$

$$V_{out} = 100 \times 28800$$

$$V_{out} = 2880000m^3$$

$$\Delta V = V_{in} - V_{out}$$

$$\Delta V = 8640000 - 2880000$$

$$\Delta V = 5760000m^3$$

$$\Delta h_{calc} = \frac{\Delta V}{A}$$

$$\Delta h_{calc} = \frac{5760000}{150 \times 10^4}$$

$$\Delta h_{calc} = \frac{5760000}{1500000}$$

$$\Delta h_{calc} = 3.84m$$

67. Problem

Correct Answer: D) 66

$$Q = 1161600 \text{ cfs}$$

$$\text{Velocity of flood} = 88 \text{ ft/sec}$$

$$\text{Area of one gate; } A_g = 10 \times 20 = 200 \text{ ft}^2$$

$$\text{Discharge control by 1 gate} = 200 \times 88 = 17600 \text{ cfs}$$

$$\text{No. of gates required} = \frac{Q}{Q_g} = \frac{1161600}{17600} = 66$$

68. Problem

Correct Answer: (B) 0.164 m

Explanation:

$$h_f = \frac{10.67 L Q^{1.85}}{C^{1.85} D^{4.87}}, L = 150 \text{ m}, Q = 0.02 \text{ m}^3/\text{s}, C = 110, D = 0.25 \text{ m}$$

$$h_f = \frac{10.67 \times 150 \times (0.02)^{1.85}}{(110)^{1.85} \times (0.25)^{4.87}} = \frac{10.67 \times 150 \times 0.000719}{5978.28 \times 0.0011} = 0.164 \text{ m}$$

69. Problem

Correct Answer: (C) To represent the energy available to move water through the system.

Explanation: The hydraulic grade line (HGL) represents the energy available to move water through the system. It is a graphical representation of the pressure head and elevation head along a pipeline. The HGL is essential for designing and analyzing water distribution systems, as it helps ensure that sufficient pressure is maintained to deliver water to all consumers, especially at peak demand times

70. Problem

Correct Answer: (C) 6,818.42 ft³/day

Using Thiem equation:

$$Q = \frac{2\pi T(h_2 - h_1)}{\ln\left(\frac{r_2}{r_1}\right)}$$

$$Q = \frac{2 \times 3.14 \times 250 \times (20 - 10)}{\ln\left(\frac{200}{20}\right)}$$

$$Q = 6,818.42 \frac{ft^3}{day}$$

71. Problem

Correct Answer: B) The water has a high fraction of non-biodegradable organic compounds.

The BOD/COD ratio is an indicator of biodegradability.

A ratio of BOD/COD > 0.5 suggests high biodegradability, while a BOD/COD < 0.4 suggests the presence of significant non-biodegradable organics.

Here,

$$\text{BOD/COD} = 200 / 500 = 0.4$$

This suggests that the water has a significant fraction of non-biodegradable organic compounds.

72. Problem

Correct Answer: A) Externally determinate, internally determinate

External Determinacy:

The number of external reactions R is: R = 2 (Pinned) + 1 (Roller) = 3

The condition for external determinacy is: R = 3

The structure is externally determinate.

Internal Determinacy:

The equation for internal determinacy is:

$$m + R = 2j$$

$$11 + 3 = 2(7) \quad \Rightarrow \quad 14 = 14$$

Since $m + R = 2j$, the truss is internally determinate.

73. Problem

Correct Answer: (A) 121.03 kN

Explanation:

$$\text{Axial load capacity: } P_n = 0.85f'_c A_g + A_s f_y$$

$$A_s = 0.04 \times 4000 = 160 \text{ mm}^2$$

$$P_n = 0.85 \times 35 \times 4000 + 160 \times 420 = 119000 + 67200 = 186200 \text{ N}$$

$$= 186.2 \text{ kN}$$

$$\text{Design axial load capacity: } \phi P_n = 0.65 \times 186.2 = 121.03 \text{ kN}$$

74. Problem

Correct Answer: (B)

Explanation: It indicates the internal moment distribution that helps in designing the beam for bending resistance.

75. Problem

Correct Answer: C) 300 mm

Calculate the Shear Force to be Resisted by Stirrups

$$V_s = V_u - V_c$$

$$V_s = 150 \text{ kN} - 90 \text{ kN} = 60 \text{ kN}$$

Calculate the Required Spacing of the Stirrups

The shear strength provided by the shear reinforcement (V_s) is given by:

$$V_s = A_v f_y d / s$$

Rearranging to solve for the spacing (s):

$$s = A_v f_y d / V_s$$

$$s = 150 \times 10^{-6} \text{ m}^2 \times 420 \times 10^6 \text{ N/m}^2 \times 0.6 \text{ m} / (60 \times 10^3 \text{ N})$$

$$s = 630 \text{ mm}$$

Check against maximum spacing limits:

According to design codes, the maximum spacing of stirrups should not exceed $d/2$ or 600 mm, whichever is smaller. Here:

$$d/2 = 600/2 = 300 \text{ mm}$$

Therefore, the maximum allowable spacing is 300 mm

76. Problem

Correct Answer: D) 100

The slenderness ratio is given by:

$$\text{slenderness ratio} = \frac{L_{eff}}{r}$$

Since the column is fixed-free, the effective length factor is: $K = 2.0$

So, the effective length is:

$$L_{eff} = K \times L = 2.0 \times 2500 = 5000 \text{ mm}$$

Now, calculating slenderness ratio:

$$\text{slenderness ratio} = \frac{5000}{50} = 100$$

77. Problem

Correct Answer: B) 43.2 MPa

Calculate the Allowable Stress:

$$\text{Allowable Stress} = \text{Yield Strength} / \text{Factor of Safety}$$

Calculate the Actual Stress:

$$\text{Actual Stress} = \text{Axial Force} / \text{Cross-sectional Area}$$

- Cross-sectional Area = width * depth = 150 mm * 250 mm = 37,500 mm² = 0.0375 m²

$$\text{Actual Stress} = 900,000 \text{ N} / 0.0375 \text{ m}^2 = 24 \times 10^6 \text{ Pa} = 24 \text{ MPa}$$

Relate Allowable Stress to Yield Strength:

$$\text{Allowable Stress} = \text{Actual Stress}$$

$$\text{Yield Strength} / \text{Factor of Safety} = 24 \text{ MPa}$$

Solve for Yield Strength:

$$\text{Yield Strength} = \text{Actual Stress} * \text{Factor of Safety}$$

$$\text{Yield Strength} = 24 \text{ MPa} * 1.8 = 43.2 \text{ MPa}$$

Therefore, the required yield strength of the steel is 43.2 MPa.

78. Problem

Correct Answer: A) 1:4

Euler's formula for buckling load:

$$P_{cr} = \frac{\pi^2 EI}{L^2}$$

Since both columns have the same E and I, the critical load is inversely proportional to the square of the length:

$$\frac{P_{cr,A}}{P_{cr,B}} = \frac{L_B^2}{L_A^2}$$

Given $L_A = 2L_B$:

$$\frac{P_{cr,A}}{P_{cr,B}} = \frac{L_B^2}{(2L_B)^2} = \frac{1}{4}$$

79. Problem

Correct Answer: B) Column B (circular)

Buckling resistance depends on moment of inertia (I), which is:

Column A:

$$I_{x-rect} = \frac{bh^3}{12}, \quad I_{y-rect} = \frac{hb^3}{12}$$

$$I_{x-rect} = \frac{bh^3}{12} = \frac{200 \times 300^3}{12} = 4.5 \times 10^8 \text{ mm}^4$$

$$I_{y-rect} = \frac{hb^3}{12} = \frac{300 \times 200^3}{12} = 2.0 \times 10^8 \text{ mm}^4$$

Column B:

$$I_{circle} = \frac{\pi d^4}{64} = \frac{\pi \times 250^4}{64} = 1.9 \times 10^8 \text{ mm}^4$$

Column B (circular cross-section) will buckle first because it has a smaller moment of inertia compared to Column A (rectangular cross-section).

80. Problem

Correct Answer: C). 22.5 kN

The deflection at the simply supported end due to w is:

$$\Delta_w = wL^4/8EI$$

The deflection at the simply supported end due to R_B is:

$$\Delta_{RB} = R_B L^3/3EI$$

For compatibility, the net deflection at the simply supported end must be zero:

$$\Delta_w + \Delta_{RB} = 0$$
$$\frac{wL^4}{8EI} + \frac{R_B L^3}{3EI} = 0$$

Solve for R_B :

$$R_B = -\frac{3wL}{8} = -\frac{3(10)(6)}{8} = -22.5 \text{ kN}$$

81. Problem

Correct Answer: (B)

Explanation: Determinate frames can be solved using only equilibrium equations, while indeterminate frames require additional compatibility conditions.

82. Problem

Correct Answer: (A) 0.333

Explanation:

$$K_a = \tan^2\left(45^\circ - \frac{\phi}{2}\right) = \tan^2\left(45^\circ - \frac{30^\circ}{2}\right) = \tan^2(30^\circ) = \left(\frac{1}{\sqrt{3}}\right)^2 = 0.333$$

83. Problem

Correct Answer: (D) 100 kPa

Explanation:

For unsaturated soils, the effective stress can be computed as:

$$\text{Effective Stress} = \text{Total Stress} - (U_a + U_w)$$

$$\text{Effective Stress} = 150 \text{ kPa} - (30 \text{ kPa} + 20 \text{ kPa}) = 100 \text{ kPa}$$

84. Problem

Correct Answer: (C) 150 kPa

Explanation:

In an active state, the horizontal stress is: $\sigma_{h,act} = K_a \sigma_v$ where K_a is Rankine's or Coulomb's active earth pressure coefficient.

Given $\sigma_{h,act} = 100\text{kPa}$, then $\sigma_v = \frac{100}{K_a}$

In the at-rest condition (no wall movement), the horizontal stress is

$$\sigma_{h,0} = K_0 \sigma_v \Rightarrow \sigma_{h,0} = 0.5 \times \frac{100}{K_a} = \frac{50}{K_a}$$

For $\phi = 30^\circ$, Rankine's formula gives: $K_a = \frac{1 - \sin 30^\circ}{1 + \sin 30^\circ} = \frac{1 - 0.5}{1 + 0.5} = 0.3333$

$$\sigma_{h0} = \frac{50}{0.3333} = 150 \text{ kPa}$$

85. Problem

Correct Answer: (C) $1.0 \times 10^{-3} \text{ m}^3/\text{s}$

Explanation: $q = k \frac{H \times N_f}{N_d}$

$$q = 2 \times 10^{-4} \text{ m/s} \times \frac{10\text{m} \times 4}{8} = 1 \times 10^{-3} \text{ m}^3/\text{s}$$

86. Problem

Correct Answer: (B) 5 kPa

Explanation: The horizontal pressure due to the surcharge load is given by:

$$\sigma_h = K_0 \times q \rightarrow K_0 = 0.5, q = 10\text{kPa} \rightarrow \sigma_h = 0.5 \times 10 = 5\text{kPa}$$

87. Problem

Correct Answer: (B) 205mm

Explanation: Consolidation settlement (S_c) is given by:

$$S_c = \frac{C_c H}{1 + e_0} \log\left(\frac{\sigma_f}{\sigma_i}\right)$$

Where:

- H = thickness of the clay layer
- C_c = compression index
- e_0 = initial void ratio
- σ_f = final effective stress
- σ_i = initial effective stress

$$S_c = \frac{0.3 \times 5}{1 + 1.2} \log\left(\frac{200}{100}\right)$$

$$S_c = \frac{1.5}{2.2} \log(2) = 0.6818 \times 0.301 = 0.205m = 205mm$$

88. Problem

Correct Answer: D) 150.2 kN/m²

Total vertical stress at z = 10 m is:

$$\sigma = S + (\gamma_1 \times H_1) + (\gamma_2 \times H_2) + (\gamma_3 \times H_3)$$

Substituting values:

$$\sigma = 20 + (16 \times 1.5) + (17.8 \times 2.5) + (20.1 \times 6)$$

$$\sigma = 20 + 24 + 44.5 + 120.6$$

$$\sigma = 209.1 \text{ kN/m}^2$$

Pore water pressure is given by:

$$u = \gamma_w \times H_3$$

$$u = 9.81 \times 6$$

$$u = 58.86 \text{ kN/m}^2$$

Effective vertical stress is:

$$\sigma' = \sigma - u$$

Substituting values:

$$\sigma' = 209.1 - 58.86$$

$$\sigma' = 150.2 \text{ kN/m}^2$$

89. Problem

Correct Answer: B) 9.01 kN/m^3

The formula for saturated unit weight is:

$$\gamma_{sat} = \frac{(G_s + e)}{1 + e} \gamma_w$$

Substituting given values:

$$\gamma_{sat} = \frac{2.70 + 0.85}{1 + 0.85} \times 9.81$$

$$\gamma_{sat} = \frac{3.55}{1.85} \times 9.81$$

$$\gamma_{sat} = 1.9189 \times 9.81$$

$$\gamma_{sat} = 18.82 \text{ kN/m}^3$$

The submerged unit weight is given by:

$$\gamma' = \gamma_{sat} - \gamma_w$$

Substituting values:

$$\gamma' = 18.82 - 9.81$$

$$\gamma' = 9.01 \text{ kN/m}^3$$

90. Problem

Correct Answer: B) 1.16

The critical hydraulic gradient is:

$$i_c = \frac{\gamma_{sat} - \gamma_w}{\gamma_w}$$

$$i_c = \frac{19.5 - 9.81}{9.81}$$

$$i_c = \frac{9.69}{9.81}$$

$$i_c = 0.987$$

The factor of safety against seepage liquefaction is:

$$FS_s = \frac{i_c}{i_e}$$

Substituting values:

$$FS_s = \frac{0.987}{0.85}$$

$$FS_s = 1.16$$

91. Problem

Correct Answer: (B) 0.327

Explanation:

$$K_a = \frac{\cos(\phi-\delta)}{\cos(\delta) \cdot \cos(\theta+\delta)} \cdot \frac{1}{\sqrt{1+\sin(\phi)\sin(\delta)}} = \frac{\cos(35^\circ-20^\circ)}{\cos(20^\circ) \cdot \cos(0^\circ+20^\circ)} \cdot \frac{1}{\sqrt{1+\sin(35^\circ)\sin(20^\circ)}} =$$

$$= \frac{\cos(15^\circ)}{\cos(20^\circ) \cdot \cos(20^\circ)} \cdot \frac{1}{\sqrt{1+\sin(35^\circ)\sin(20^\circ)}} = \frac{0.966}{0.94 \cdot 0.94} \cdot \frac{1}{\sqrt{1+0.5736 \cdot 0.342}} = 0.327$$

92. Problem

Correct Answer: (D) 194.4 kNm/m

Explanation: First, calculate the active earth pressure coefficient K_a :

$$K_a = \frac{1 - \sin\phi}{1 + \sin\phi}, \phi = 35^\circ$$

$$K_a = \frac{1 - \sin 35^\circ}{1 + \sin 35^\circ} = \frac{1 - 0.574}{1 + 0.574} = \frac{0.426}{1.574} \approx 0.27$$

The active earth pressure at the base of the wall is:

$$\sigma_a = \frac{1}{2} K_a \gamma H^2$$

$$\sigma_a = \frac{1}{2} \times 20 \times 0.27 \times 6^2 = 0.5 \times 20 \times 0.27 \times 36 = 0.5 \times 194.4$$

$$= 97.2 \text{ kPa}$$

The overturning moment at the base is:

$$M_o = P_a \times \frac{H}{3} = 97.2 \times 2 = 194.4 \text{ kNm/m}$$

93. Problem

Correct Answer: (C) - 0.007

Explanation: $e + f = \frac{V^2}{127R} = \frac{(60)^2}{127 \times 250} = \frac{3600}{31750} = 0.113$

Given $f = 0.12$,

$$e = 0.113 - 0.12 = -0.007$$

The negative value indicates that the provided friction factor ($f=0.12$) exceeds the required lateral force for the given speed and radius. This implies that no superelevation is necessary under these conditions. In practical highway design, this situation is rare and might suggest reviewing the friction factor or speed assumptions to ensure they align with realistic scenarios.

94. Problem

Correct Answer: A) 53

$$P_A = 600$$

$$P_B = 800$$

$$t = 30 \text{ minutes}$$

$$k = 0.1$$

$$T_{AB} = 0.1 \times \frac{600 \times 800}{30^2} = 53.33 \approx 53$$

95. Problem

Correct Answer: (A) 77.35 m

Explanation:

$$E = R \left(\sec\left(\frac{\Delta}{2}\right) - 1 \right) = 500 \left(\sec\left(\frac{60}{2}\right) - 1 \right) = 500 (\sec(30) - 1) = 500 \times 0.1547 = 77.35m$$

96. Problem

Correct Answer: (B) Empirical and mechanistic.

Explanation: The mechanistic-empirical pavement design method combines mechanistic (structural analysis) and empirical (performance data) approaches to predict pavement behavior.

97. Problem

Correct Answer: (C) Base course

Explanation: The base course in a flexible pavement system is designed to provide structural support and distribute loads to the subgrade.

98. Problem

Correct Answer: (B) 664.36 mm

Explanation: Using the AASHTO design equation for rigid pavements,

$$D = \left(\frac{W_{18}}{0.9 \cdot 0.75 \cdot f'_c \cdot \sqrt{k}} \right)^{0.5}$$

Where:

- $W_{18} = 3,000,000$ ESALs

- $f'_c = 650$ psi

- $k = 100$ pci

$$D = \left(\frac{3,000,000}{0.9 \cdot 0.75 \cdot 650 \cdot \sqrt{100}} \right)^{0.5} = \left(\frac{3,000,000}{0.9 \cdot 0.75 \cdot 650 \cdot 10} \right)^{0.5} D = \left(\frac{3,000,000}{4387.5} \right)^{0.5} = 26.14 \text{ inches} = 664.36 \text{ mm}$$

99. Problem

Correct Answer: D) 3.06

Solution:

$$SN = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3$$

Surface course: $D_1 = 100/25.4 = 3.94$ inches

Base course: $D_2 = 150/25.4 = 5.91$ inches

Subbase: $D_3 = 200 \text{ mm}/25.4 = 7.87$ inches

$$SN = (0.44 \cdot 3.94) + (0.14 \cdot 5.91 \cdot 0.85) + (0.10 \cdot 7.87 \cdot 0.80) = 3.06$$

100. Problem

Correct Answer: (D) 30000

Explanation: The gravity model for trip distribution is given by:

$$T_{ij} = \frac{P_i A_j F_{ij}}{\sum_k A_k F_{ik}}$$

For simplicity, assuming only one attraction zone:

$$T_{ij} = P_i A_j F_{ij} = 200 \times 300 \times 0.5 = 30000$$

101. Problem

Correct Answer: (A) 236.13 mm

Explanation: Using the AASHTO design equation for flexible pavements,

$$\log_{10}(W_{18}) = Z_R \cdot S_0 + 9.36 \cdot \log_{10}(SN + 1) - 0.20 + \log_{10}\left(\frac{4.2 - 1.5}{0.40}\right) + 2.32 \cdot \log_{10}(M_R) - 8.07$$

Where:

- $W_{18} = 5,000,000$ ESALs
- $Z_R = -1.645$ (for 95% reliability)
- $S_0 = 0.45$

-SN = Structural number

- MR = Resilient modulus of subgrade

Assuming a resilient modulus MR of 7,000 psi,

$$\log_{10}(5,000,000) = -1.645 - 0.45 + 9.36 - \log_{10}(SN + 1) - 0.20 + 1.5 + 2.32 \cdot \log_{10}(7,000) - 8.07$$

$$6.70 = -0.74025 + 9.36 \cdot \log_{10}(SN + 1) - 0.20 + 1.5 + 7.478 - 8.07$$

$$5.73225 = 9.36 \cdot \log_{10}(SN + 1) \rightarrow \log_{10}(SN + 1) = \frac{5.73225}{9.36} = 0.612 \rightarrow SN + 1 = 10^{0.612} = 4.1$$

Assuming a base course and subbase with known thicknesses and moduli,
let's consider the thickness required for the surface course to achieve
the structural number:

$$4.1 = a_1 \cdot D_1 + a_2 \cdot D_2 + a_3 \cdot D_3$$

Assuming typical layer coefficients for asphalt surface course $a_1 = 0.44$:

$$D_1 = \frac{4.1}{0.44} = 9.32 \text{ inches} = 236.13 \text{ mm}$$

102. Problem

Correct Answer: (A) \$6,173

Explanation: Volume in cubic feet = Area $\times$ Thickness = 5,000 square feet $\times$
4/12 feet = 1,666.67 cubic feet

$$\text{Volume in cubic yards} = \frac{1,666.67 \text{ cubic feet}}{27} = 61.73 \text{ cubic yards}$$

Total cost = 61.73 cubic yards $\times$ \$100/cubic yard = \$6,173

103. Problem

Correct Answer: (D) \$7,995.60

Explanation: Volume in cubic feet = Height × Length × Thickness

$$= 12 \text{ feet} \times 100 \text{ feet} \times 1 \text{ foot} = 1,200 \text{ cubic feet}$$

$$\text{Volume in cubic yards} = \frac{1,200 \text{ cubic feet}}{27} = 44.44 \text{ cubic yards}$$

$$\text{Cost of concrete} = 44.44 \text{ cubic yards} \times \$90/\text{cubic yard} = \$3,999.60$$

$$\text{Weight of rebar} = 44.44 \text{ cubic yards} \times \frac{150 \text{ pounds}}{2,000 \text{ pounds per ton}} = 3.33 \text{ tons}$$

$$\text{Cost of rebar} = 3.33 \text{ tons} \times \$1,200/\text{ton} = \$3,996$$

$$\begin{aligned} \text{Total cost of materials} &= \text{Cost of concrete} + \text{Cost of rebar} \\ &= \$3,999.60 + \$3,996 = \$7,995.60 \end{aligned}$$

104. Problem

Correct Answer: (B) \$102,500

Explanation: Cost of pipe materials = 2,500 linear feet × \$10/linear foot

$$= \$25,000$$

$$\text{Installation cost} = 2,500 \text{ linear feet} \times \$25/\text{linear foot} = \$62,500$$

Total project cost = Cost of pipe materials + Installation cost + Fixed cost

$$= \$25,000 + \$62,500 + \$15,000 = \$102,500$$

105. Problem

Correct Answer: (D) Crane B; \$28,000

Explanation: Total cost for Crane A = Fixed cost + (Operating cost per hour × Duration)

$$= \$10,000 + (\$250/\text{hour} \times 80 \text{ hours}) = \$30,000$$

Total cost for Crane B = Fixed cost + (Operating cost per hour × Duration)

$$= \$12,000 + (\$200/\text{hour} \times 80 \text{ hours}) = \$28,000$$

Crane B is more cost-effective with a total cost of \$28,000.

106. Problem

Correct Answer: C) 19 Days

We have the following possible path as shown in the network diagram:

Path A → C → F → End

Path B → D → F → End

Path B → E → F → End

Determining the project duration of each path:

Path A → C → F → End = 7 + 3 + 9 = 19 days

Path B → D → F → End = 5 + 8 + 9 = 22 days

Path B → E → F → End = 5 + 6 + 9 = 20 days

107. Problem

Correct Answer: A) -10,000 \$

Total BCWP = 120,000 + 250,000 + 100,000 = 470,000 \$

Total ACWP = 140,000 + 230,000 + 110,000 = 480,000 \$

$$CV = BCWP - ACWP$$

$$CV = 470,000 - 480,000 = \$ - 10,000$$

108. Problem

Correct Answer: A) A

Calculate weighted scores:

$$A: (85 \times 0.5) + (90 \times 0.3) + (80 \times 0.2) = 85.5$$

$$B: (80 \times 0.5) + (85 \times 0.3) + (75 \times 0.2) = 80.5$$

$$C: (75 \times 0.5) + (95 \times 0.3) + (90 \times 0.2) = 84$$

Highest Score: A

109. Problem

Correct Answer: (C) 11 feet

Explanation:

Total run = Number of steps $\times$ Run per step = 12×11 inches = 132 inches

$$\textit{Total run in feet} = \frac{132 \text{ inches}}{12 \text{ inches per foot}} = 11 \text{ feet}$$

110. Problem

Correct Answer: B) 8 spaces

Space Efficiency Comparison:

90-degree parking $\rightarrow$ 50 spaces

60-degree parking increases space efficiency by $\sim 15\%$

New Number of Spaces:

$$50 \times 1.15 = 57.5 \approx 58 \text{ spaces}$$

Additional Spaces:

$$58 - 50 = 8 \text{ spaces}$$