



FE CIVIL EXAM 01

Table of Contents

Problems.....	2
Solutions.....	44

Problems

[Click here for Solutions](#)

1. From the following select the equation of a line passing through the points (1, 2) and (3, 6) ?

(A) $y = 2x + 1$

(B) $y = 2x$

(C) $y = 2x + 2$

(D) $y = x + 2$

2. A civil engineer collects the following set of data representing the compressive strength (in MPa) of concrete samples:

45,50,55,60,65

What is the sample variance of this data set?

(A) 50

(B) 62.5

(C) 100

(D) 125

3. Select the correct equation for a line that is perpendicular to the line $2x+3y=6$ and passes through the point (1, -1).

(A) $3x - 2y = 5$

(B) $2x - 3y = 5$

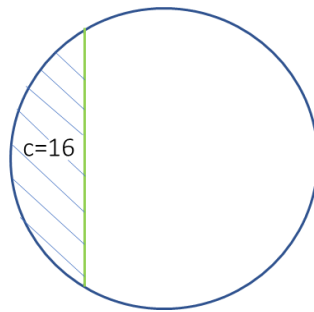
(C) $3x + 2y = 1$

(D) $2x + 3y = 1$

4. What is the equation of the hyperbola centered at (2, -1) with a transverse axis length of 8 and a conjugate axis length of 6?

- (A) $\frac{(x-2)^2}{16} - \frac{(y+1)^2}{9} = 1$
- (B) $\frac{(x-2)^2}{9} - \frac{(y+1)^2}{16} = 1$
- (C) $\frac{(x-2)^2}{25} - \frac{(y+1)^2}{9} = 1$
- (D) $\frac{(x-2)^2}{16} - \frac{(y+1)^2}{25} = 1$

5. What is the area of a circular segment formed by a chord of 16 m in a circle with a radius of 10 m?



- (A) 40.12 m²
- (B) 44.43 m²
- (C) 48.25 m²
- (D) 52.10 m²

6. Determine the critical points of the function $f(x) = x^3 - 3x^2 + 2x$.

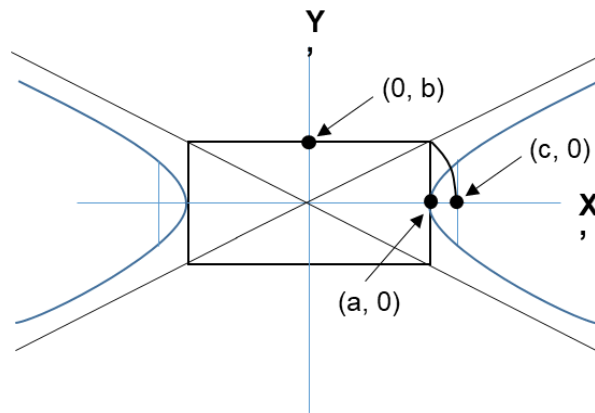
- (A) $x = 1 + \frac{\sqrt{3}}{3}$ and $x = 1 - \frac{\sqrt{3}}{3}$
- (B) $x = 1$ and $x = 0$
- (C) $x = 1$ and $x = -1$
- (D) $x = \frac{\sqrt{3}}{3}$ and $x = -\frac{\sqrt{3}}{3}$

7. For a circle $x^2 + y^2 = 25$, which is the equation of the tangent line at the point $(3, 4)$?

- (A) $3x + 4y = 25$
- (B) $3x + 4y = 5$
- (C) $4x - 3y = 25$
- (D) $4x + 3y = 25$

8. For the hyperbola represented as $\frac{x^2}{16} - \frac{y^2}{9} = 1$

What is its eccentricity and the distance between its foci?



- (A) $e = 5/4$, distance = 10
- (B) $e = 5/4$, distance = 8
- (C) $e = 3/2$, distance = 10
- (D) $e = 3/2$, distance = 8

9. If an engineer makes an error in their design that leads to a building collapse, what type of liability are they most likely facing?

- (A) Criminal liability
- (B) Strict liability
- (C) Professional liability

(D) Vicarious liability

10. Which of the following societies is known for its focus on civil engineering and its standards for professional practice?

(A) IEEE

(B) ASCE

(C) NSPE

(D) AIChE

11. Which of the following best describes a situation where an engineer should not sign and seal documents?

(A) When the project is nearing completion

(B) When they have not been in responsible charge of the work

(C) When they have met all the project requirements

(D) When they are familiar with the work done

12. What should an engineer do if they discover a potential hazard in a project they are working on?

(A) Keep it confidential to avoid panic

(B) Report the hazard to their supervisor and take steps to mitigate it

(C) Ignore it if it is not part of their direct responsibility

(D) Inform the media to alert the public

13. Which statement correctly describes a similarity between the ASCE and NSPE codes of ethics?

(A) Both emphasize the importance of financial gain in engineering decisions.

(B) Both stress the need for public welfare and safety in engineering practice.

- (C) Both prioritize the interests of private corporations over public interests.
- (D) Both codes do not address issues of environmental impact.

14. Which term describes a professional's failure to meet the standard of care, resulting in harm or damage?

- (A) Risk assessment
- (B) Negligence
- (C) Risk management
- (D) Liability

15. A civil engineering firm is considering purchasing a piece of equipment for \$50,000. The equipment is expected to generate annual savings of \$15,000 for 5 years. Assuming no salvage value and no tax implications, what is the internal rate of return (IRR)?

- (A) 15.2 %
- (B) 16.5 %
- (C) 17.8 %
- (D) 18.4 %

16. You plan to buy a car for \$25,000 in 4 years. How much should you invest now at an interest rate of 5% compounded annually to have enough money?

- (A) \$22,563
- (B) \$21,367
- (C) \$20,567
- (D) \$23,150

17. A civil engineer is evaluating two project options. Project A has a 60% chance of yielding a profit of \$200,000 and a 40% chance of incurring a loss of \$100,000. Project B has a 70% chance of yielding a profit of \$150,000 and a 30% chance of incurring a loss of \$50,000. Which project should the engineer choose based on expected monetary value (EMV)?

- (A) Project A
- (B) Project B
- (C) Projects have equal EMV
- (D) Neither project should be chosen

18. You are planning to retire in 20 years and wish to have \$1,000,000 at that time. If you can invest in an account that earns 7% annually. How much do you need to invest annually to reach your goal?

- (A) \$19,520.25
- (B) \$24,393
- (C) \$21,632.45
- (D) \$23,042

19. A civil engineer plans to invest \$12,000 today in a project that promises to return \$20,000 after 7 years. What is the annual rate of return on this investment?

- (A) 6.25 %
- (B) 7.43 %
- (C) 8.17 %
- (D) 9.0 %

20. Find the resultant of the following force system:

Forces:

$$F_1 = 20\text{N at } 0^\circ,$$

$$F_2 = 20\text{N at } 180^\circ$$



$$F_2 = 20\text{N at } 180^\circ \quad F_1 = 20\text{N at } 0^\circ$$

- (A) 40N at 0°

(B) 20N at 90°

(C) 0N

(D) 20N at 0°

21. A square thread screw jack can move 5000 N. The screw's pitch is 5 mm, and its average width is 25 mm. It is 0.15 times more likely for the screw and the nut to rub against each other. How much force does it take to lift the weight?

(A) 18.75 Nm

(B) 9.82 Nm

(C) 47.35 Nm

(D) 13.49 Nm

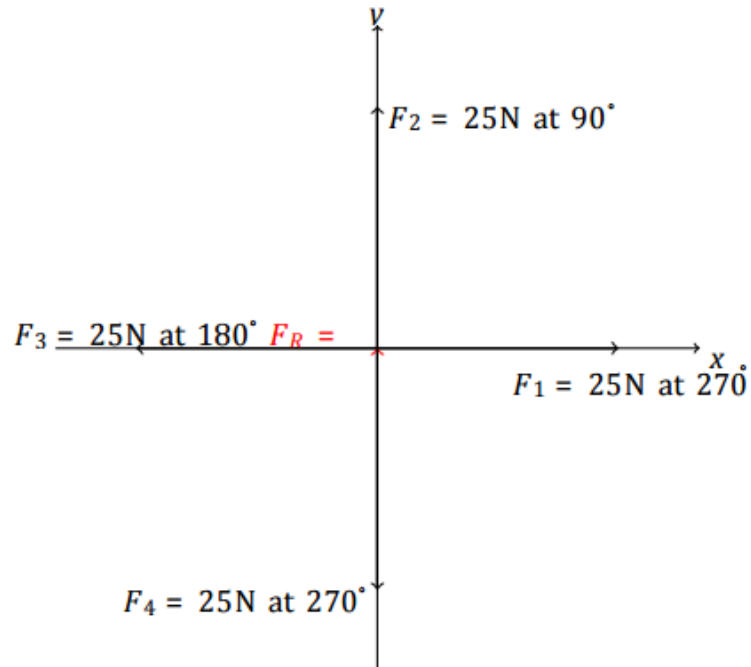
22. Determine the resultant force for the system:

$$F_1 = 25\text{N at } 0^\circ,$$

$$F_2 = 25\text{N at } 90^\circ,$$

$$F_3 = 25\text{N at } 180^\circ,$$

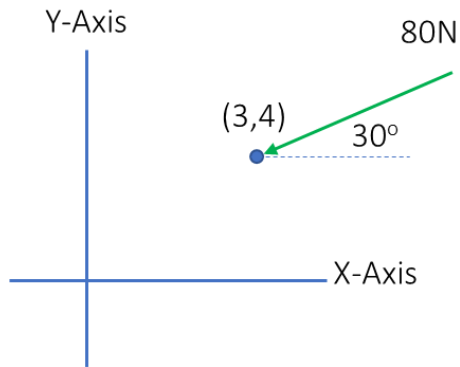
$$F_4 = 25\text{N at } 270^\circ$$



- (A) 35.36N at 135°
- (B) 50N at 45°
- (C) 25N at 90°
- (D) 0 N

23. A force of 80 N is applied at a point P(3,4) and acts at an angle of 30° from the x-axis. Which of the following is most nearly the moment of the force about the origin?

- A) 160 N·m
- B) 240 N·m
- C) 320 N·m
- D) 400 N·m



24. The resultant of two forces, each of magnitude 10 N, acting at an angle of 120° to each other, is:

- (A) 10 N
- (B) 20 N
- (C) 103 N
- (D) 5 N

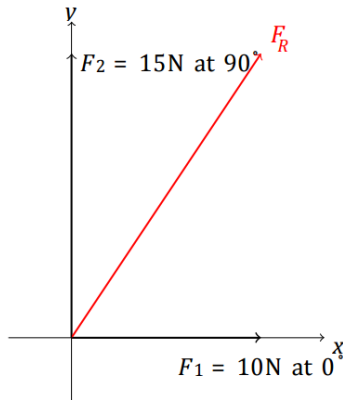
25. Which of the following represents the correct resultant force vector for the following force system?

Forces:

$$F_1 = 10\text{N at } 0^\circ,$$

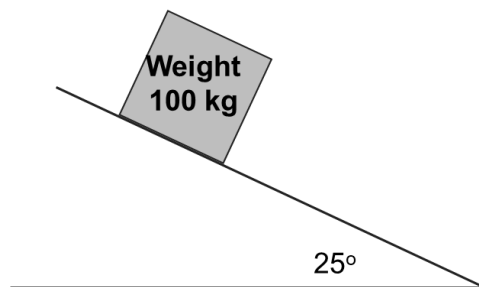
$$F_2 = 15\text{N at } 90^\circ$$

- (A) 15N at 53.13°
- (B) 18.03N at 56.31°
- (C) 25N at 45°
- (D) 17.32N at 30°



26. A 100 kg box is placed on an inclined plane with an angle of 25° to the horizontal. The coefficient of static friction between the box and the plane is 0.4. What is the minimum force required parallel to the incline to prevent the box from sliding down? (Assume $g = 9.81 \text{ m/s}^2$)

- A) 59 N
- B) -59 N
- C) 769 N
- D) 1303 N

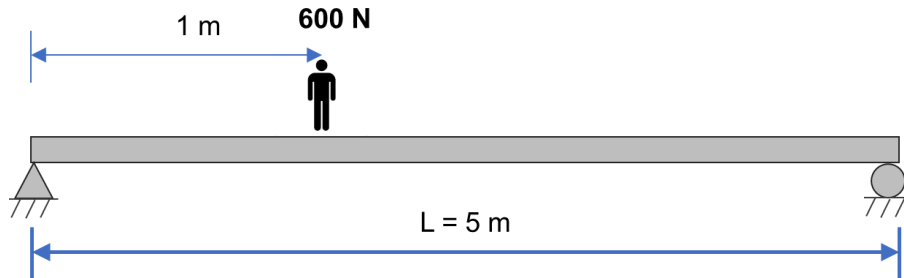


27. A 5-meter uniform plank of weight 300 N is supported at its ends. A person weighing 600 N stands 1 meter from the left support. What is the reaction force at the left support?

- A) 300 N
- B) 450 N

C) 600 N

D) 630 N



28. At an angle of 45° to the horizontal, a projectile is sent off at a speed of 30 m/s . What is the long-range of the bullet?

(A) 27 m

(B) 120 m

(C) 90 m

(D) $2\sqrt{2}\text{ m}$

29. A particle follows a path described by $x = 3t^2$ and $y = 2t^3$. Determine its velocity vector at $t = 2$ seconds.

(A) $12\mathbf{i} + 24\mathbf{j}$

(B) $12\mathbf{i} + 16\mathbf{j}$

(C) $6\mathbf{i} + 24\mathbf{j}$

(D) $6\mathbf{i} + 12\mathbf{j}$

30. Despite the presence of a frictional force of 20 N , a 10 kg block is sliding down on a 45° inclined plane. Determine the net acceleration of the block.

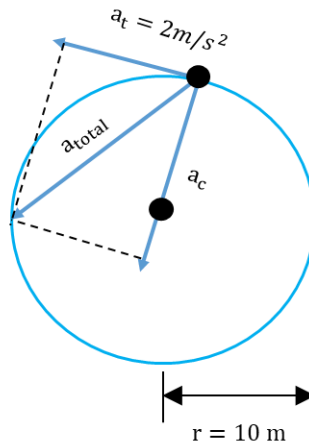
(A) 3 m/s^2

(B) 4 m/s^2

(C) 5 m/s^2

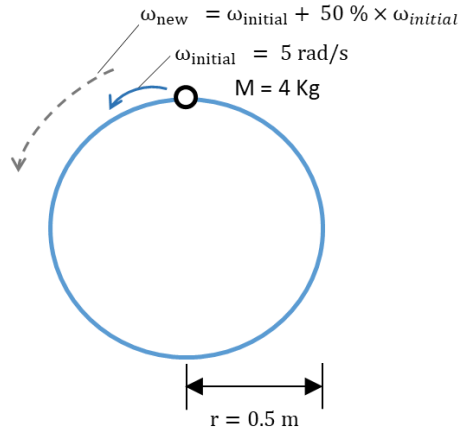
(D) 6 m/s^2

31. A particle moves along a circular path of radius 10 m with a constant tangential acceleration of 2 m/s^2 . If the particle starts from rest, what will be the magnitude of its total acceleration after 5 s ?



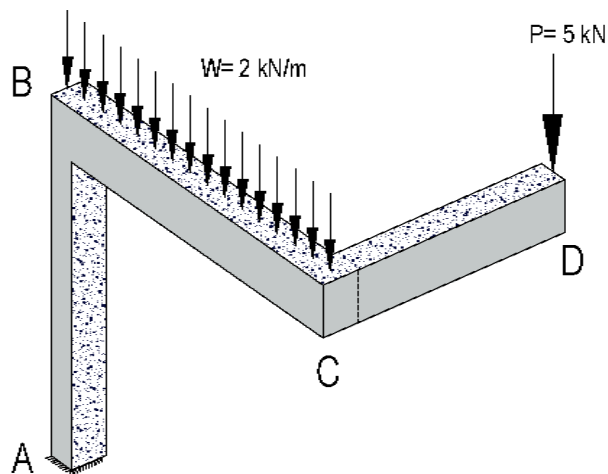
- (A) 8.5 m/s^2
- (B) 9.8 m/s^2
- (C) 10.2 m/s^2
- (D) 11.5 m/s^2

32. A particle of mass 4 kg is rotating in a circular path of radius 0.5 m with an angular velocity of 5 rad/s . If the moment of inertia of the particle about the center is increased by 50% , what will be the new angular momentum of the particle?



- (A) $4.5 \text{ kg}\cdot\text{m}^2/\text{s}$
- (B) $5.0 \text{ kg}\cdot\text{m}^2/\text{s}$
- (C) $7.5 \text{ kg}\cdot\text{m}^2/\text{s}$
- (D) $8.0 \text{ kg}\cdot\text{m}^2/\text{s}$

33. A point load of 5kN at point D and uniformly distributed load at member BC were applied. Assume the stiffness of member AB is infinite. The bending moment will be;



- (A) Maximum at Point D

- (B) Maximum at Point C
- (C) Maximum at Point B
- (D) Bending moment at all points will be the same

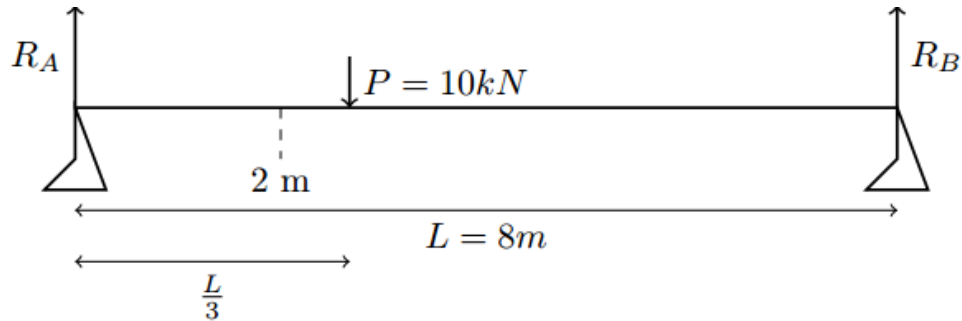
34. Three stresses are applied to a rectangular element: $\sigma_x = 80$ MPa, $\sigma_y = 40$ MPa, and $\tau_{xy} = 30$ MPa. To what principal plane is the angle of rotation equal to?

- (A) 13.3°
- (B) 26.6°
- (C) 28°
- (D) 45°

35. A rectangular aluminum beam with a width of $b = 100$ mm, height $h = 200$ mm, and length $L = 4$ m is subjected to a bending moment $M = 50$ kNm. The yield stress of the aluminum is $\sigma_y = 250$ MPa. Determine if the beam yields under the applied moment. If it yields, calculate the plastic moment capacity.

- (A) Does not yield
- (B) Plastic moment capacity 50 kNm
- (C) Plastic moment capacity 62.5 kNm
- (D) Plastic moment capacity 75 kNm

36. For a simply supported beam with a span of $L = 8$ m and a concentrated load $P = 10$ kN at $L/3$ from left support, calculate the shear force at a distance $x = 2$ m from the left support.



- (A) 6.66 kN
- (B) 5 kN
- (C) 10 kN
- (D) 15.44 kN

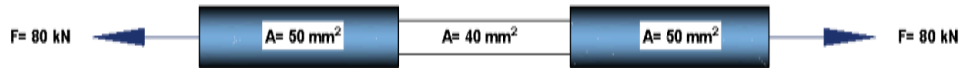
37. A cantilever beam made of steel with a length of $L = 2\text{ m}$, width $b = 100\text{ mm}$, and height $h = 200\text{ mm}$ is subjected to a point load $P = 100\text{ kN}$ at its free end. The yield stress of the steel is $\sigma_y = 250\text{ MPa}$ and the modulus of elasticity $E = 210\text{ GPa}$. Calculate the deflection at the free end and determine if the beam yields.

- (A) Deflection 19.03 mm, Yielding
- (B) Deflection 4.76 mm, No yielding
- (C) Deflection 2.38 mm, Yielding
- (D) Deflection 4.76 mm, Yielding

38. Using the von Mises yield criterion, ascertain if a material with a 300 MPa yield strength will yield under the following stress states: $\sigma_x = 200\text{ MPa}$, $\sigma_y = 100\text{ MPa}$, and $\tau_{xy} = 50\text{ MPa}$.

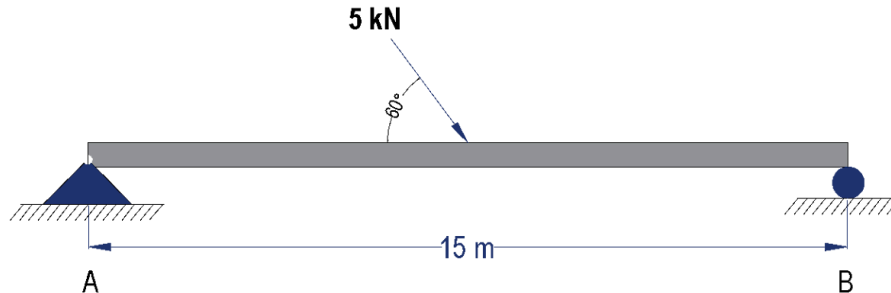
- (A) It will not yield
- (B) Remains the same
- (C) It will yield
- (D) None of the above

39. A steel rod with a cross-sectional area of $A = 40 \text{ mm}^2$ at center and $A = 50 \text{ mm}^2$ at the end subjected to a tensile force of $F = 80 \text{ kN}$. Calculate the critical axial stress in the rod.



- (A) 2 GPa
- (B) 1.6 GPa
- (C) 3 GPa
- (D) 4 GPa

40. An inclined point load of 5 kN applied at the mid span of simply supported beam having length of 15 meters. Assume the modulus of rigidity is constant. The maximum deflection due to the applied load is;



- (A) $175.78/EI$
- (B) $304.46/EI$
- (C) $560.5/EI$
- (D) $360.98/EI$

41. For a given concrete mix with the following proportions:

- Cement: 1 part

- Fine aggregate: 2 parts
- Coarse aggregate: 4 parts
- Water-cement ratio: 0.45
- Density of concrete: 2400 kg/m^3

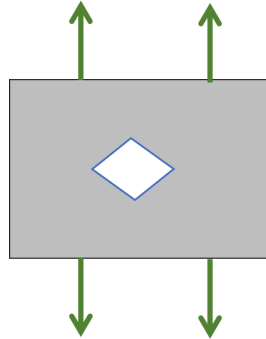
Calculate the required amount of each component (fine aggregate, coarse aggregate, and water) for 1 cubic meter of concrete.

- (A) 80.25 kg, 25.57 kg, 52 kg
- (B) 141.4 kg, 180 kg, 44.3 kg
- (C) 991.4 kg, 582.9 kg, 100 kg
- (D) 644.3 kg, 1288.6 kg, 144.9 kg

42. A cylindrical specimen of brass with an initial diameter of 20 mm and length of 250 mm is subjected to a tensile force causing the diameter to reduce to 18 mm and the length to increase to 260 mm. Calculate the true strain.

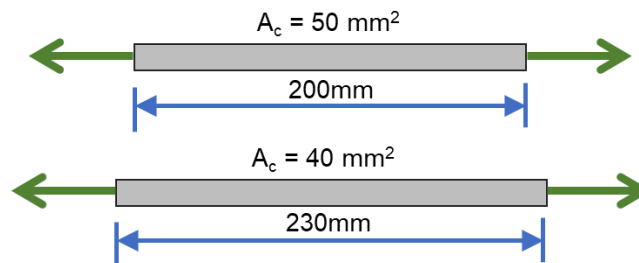
- (A) 0.1500
- (B) 0.0450
- (C) 0.0392
- (D) 0.0315

43. A concrete specimen has an initial crack of 5 mm and is subjected to stress conditions where fracture toughness (K_{IC}) is $1.2 \text{ MPa}\sqrt{\text{m}}$. If the applied stress is 8 MPa, determine the critical crack length for failure.



- (A) 10.2 mm
- (B) 8.1 mm
- (C) 7.2 mm
- (D) 5.3 mm

44. A metal specimen has an initial length of 200 mm and after the test, the final length is measured to be 230 mm. The initial cross-sectional area is 50 mm², and the final area is 40 mm². Calculate the percent elongation and percent reduction in area.



- (A) Elongation: 15%, Reduction in Area: 20%
- (B) Elongation: 15%, Reduction in Area: 10%
- (C) Elongation: 20%, Reduction in Area: 15%
- (D) Elongation: 25%, Reduction in Area: 30%

45. A wooden beam with a rectangular cross-section of 100 mm by 200 mm is subjected to a bending test. The beam bends until a deflection of 20 mm is

observed under a load of 15 kN. Calculate the stress and strain if the modulus of elasticity for wood is 10 GPa.

- (A) 12.35 MPa, 0.00556
- (B) 7.51 MPa, 0.00754
- (C) 0.75 MPa, 0.00702
- (D) 19.68 MPa, 0.001968

46. A copper specimen has an initial diameter of 12 mm and an initial length of 150 mm. After deformation, the diameter reduces to 10 mm and the length increases to 165 mm. Calculate true strain and engineering strain.

- (A) 0.0005, 0.2
- (B) 0.0010, 0.05
- (C) 0.0953, 0.1
- (D) 0.9250, 0.3

47. A Pitot tube is used to measure the velocity of air (density = 1.2 kg/m^3) in a duct. The pressure difference between the stagnation point and the static point is 100 Pa. Calculate the velocity of air in the duct.

- (A) 11.91 m/s
- (B) 12.91 m/s
- (C) 7.25 m/s
- (D) 17.39 m/s

48. Calculate the kinematic viscosity of an oil with a dynamic viscosity of 0.1 Pa·s and a density of 900 kg/m^3 .

- (A) $3.83 \times 10^{-5} \text{ m}^2/\text{s}$
- (B) $1.55 \times 10^{-4} \text{ m}^2/\text{s}$
- (C) $1.11 \times 10^{-4} \text{ m}^2/\text{s}$
- (D) $7.11 \times 10^{-2} \text{ m}^2/\text{s}$

49. An ultrasonic flow meter is used to measure the flow rate of a liquid in a pipe. The length of the path of the ultrasonic signal is 1.2 meters, and the time difference between the upstream and downstream signals is 0.03 seconds. Calculate the velocity of the liquid if the velocity of sound in the liquid is 1480 m/s.

- (A) 13.67 m/s
- (B) 17.5 m/s
- (C) 18.5 m/s
- (D) 3.2 m/s

50. A flow nozzle is installed in a pipeline to measure the flow rate of water. The diameter of the pipe is 250 mm, and the diameter of the nozzle is 150 mm. The pressure drop across the nozzle is 60 kPa. Calculate the flow rate of water through the pipe

- (A) $0.007 \text{ m}^3/\text{s}$
- (B) $0.127 \text{ m}^3/\text{s}$
- (C) $0.057 \text{ m}^3/\text{s}$
- (D) $0.203 \text{ m}^3/\text{s}$

51. A tank contains two immiscible liquids: oil (density = 800 kg/m^3) and water (density = 1000 kg/m^3). The oil layer is 2 meters thick, and the water layer is 3 meters thick. What is the pressure at the bottom of the tank? (Assume atmospheric pressure = 101.3 kPa and $g = 9.81 \text{ m/s}^2$).



- (A) 115.03 kPa
- (B) 116.99 kPa
- (C) 146.42 kPa
- (D) 160.94 kPa

52. A Venturi meter is installed in a horizontal pipe carrying water. The diameter of the pipe is 200 mm, and the diameter at the throat is 100 mm. The pressure difference between the inlet and the throat is 50 kPa. Calculate the flow rate of water through the pipe.

- (A) $0.081 \text{ m}^3/\text{s}$
- (B) $0.0175 \text{ m}^3/\text{s}$
- (C) $0.0735 \text{ m}^3/\text{s}$
- (D) $0.115 \text{ m}^3/\text{s}$

53. A fluid with a dynamic viscosity of $0.01 \text{ Pa}\cdot\text{s}$ flows between two parallel plates separated by 0.001 m . The top plate moves at 0.1 m/s . Calculate the shear stress.

- (A) 6 Pa
- (B) 1 Pa
- (C) 5 Pa
- (D) 9 Pa

54. A turbine flow meter is used to measure the flow rate of a fluid in a pipeline. The flow rate is found to be $0.05 \text{ m}^3/\text{s}$, and the diameter of the pipe is 100 mm. Calculate the Reynolds number if the density of the fluid is 900 kg/m^3 and the viscosity is $0.05 \text{ Pa}\cdot\text{s}$.

- (A) 13560
- (B) 11500
- (C) 10250
- (D) 11466

55. Convert the UTM coordinates ($X = 500000 \text{ m}$, $Y = 4649776.224 \text{ m}$) to geographic coordinates assuming the central meridian is 99° W and scale factor is 0.9996.

- (A) $\lambda = -48.32^\circ$
- (B) $\lambda = 36.21^\circ$
- (C) $\lambda = -92.99^\circ$
- (D) $\lambda = -89.99^\circ$

56. Convert the geographic coordinates (latitude 35° N , longitude 120° W) to state plane coordinates assuming the central meridian is 123° W and scale factor is 0.9996.

- (A) 12829183.0 m
- (B) 523123.25 m
- (C) undefined
- (D) None of the above

57. Compute the area using the trapezoidal rule for $y = [1, 4, 9, 16]$ with intervals of 3 m

- (A) 66 m^2
- (B) 53.2 m^2
- (C) 11.9 m^2

(D) 64.5 m^2

58. A leveling survey was conducted between two points A and B. The instrument was set up at two different positions. The following readings were recorded:

Instrument Position 1:

Back Sight on A = 2.435 m; Fore Sight on B = 1.865 m

Instrument Position 2:

Back Sight on B = 2.210 m; Fore Sight on C = 1.670 m

If the elevation of point A is 100.000 m, determine the elevation of point C.

(A) 10.110 m

(B) 1110.110 m

(C) 101.110 m

(D) 1011.10 m

59. Determine the area of a pentagon with vertices at (0, 0), (2, 4), (4, 3), (3,1), (1, 2) using the area by coordinates method.

(A) 5 units²

(B) 7 units²

(C) 9 units²

(D) 32 units²

60. Determine the distance between two points with coordinates (latitude 36° N , longitude 121° W) and (latitude 36° N , longitude 123° W) using the Haversine formula.

(A) 321.62 km

(B) 111.2 km

- (C) 186.3 km
- (D) 179.32 km

61. Calculate the Froude number for water flowing in a rectangular channel with a depth of 2 m and velocity of 4 m/s.

- (A) 0.230
- (B) 1
- (C) 0.903
- (D) 0

62. Calculate the specific energy of water in an open channel with a depth of 2 m and velocity of 3 m/s.

- (A) 2.300 m
- (B) 2.459 m
- (C) 1.709 m
- (D) 3.360 m

63. Calculate the flow rate through a pipe with a diameter of 0.4 m if the pressure drop is 10 kPa over a length of 100 m. Assume the water temperature is 20°C and the dynamic viscosity is 0.001 Pa·s

- (A) $0.2512 \text{ m}^3/\text{s}$
- (B) $0.5823 \text{ m}^3/\text{s}$
- (C) $0.5957 \text{ m}^3/\text{s}$
- (D) $0.2385 \text{ m}^3/\text{s}$

64. A jet of water with a velocity of 20 m/s strikes a flat plate perpendicular to its direction. If the flow rate is $0.5 \text{ m}^3/\text{s}$, calculate the force exerted by the jet on the plate

- (A) 5260 N

- (B) 10,000 N
- (C) 11,000 N
- (D) 10,525 N

65. Determine the critical depth for a rectangular channel with a width of 5 m and a flow rate of $10 \text{ m}^3/\text{s}$.

- (A) 0.738 m
- (B) 0.520 m
- (C) 0.005 m
- (D) 0.632 m

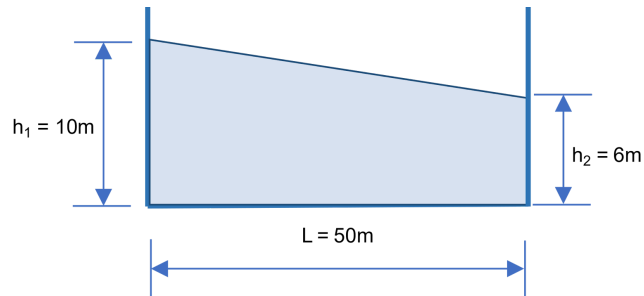
66. Calculate the head loss in a pipe with a length of 200 m, diameter of 0.3m, flow rate of $0.5 \text{ m}^3/\text{s}$, and a friction factor of 0.02 using the Darcy-Weisbach equation.

- (A) 12.657 m
- (B) 33.86 m
- (C) 83.56 m
- (D) 94.67 m

67. Determine the direct runoff for a watershed with a curve number (CN) of 90 and a rainfall of 7 inches.

- (A) 8.63 inches
- (B) 5.82 inches
- (C) 7.20 inches
- (D) 1.85 inches

68. A soil layer has a hydraulic conductivity of $2 \times 10^{-4} \text{ m/s}$ and an effective porosity of 0.30. The cross-sectional area available for flow is 5 m^2 , and the hydraulic head decreases from 10 m to 6 m over a flow length of 50 m. Determine the average seepage velocity in the soil.



- (A) $4.8 \times 10^{-5} \text{ m/s}$
- (B) $1.88 \times 10^{-5} \text{ m/s}$
- (C) $6.67 \times 10^{-5} \text{ m/s}$
- (D) $5.33 \times 10^{-5} \text{ m/s}$

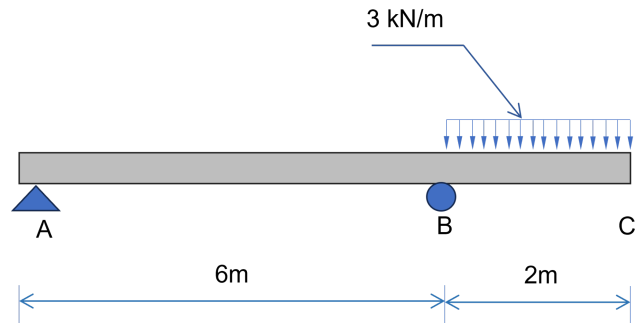
69. Calculate the direct runoff for a watershed with a curve number (CN) of 75 and a rainfall of 5 inches.

- (A) 2.45 inches
- (B) 5.2 inches
- (C) 7.98 inches
- (D) 5.8 inches

70. A well in a confined aquifer pumps at a rate of $Q = 0.015 \text{ m}^3/\text{s}$. The drawdown at a distance of $r = 50 \text{ m}$ is $s = 1.5 \text{ m}$. Calculate the storativity using the Theis equation assuming $T = 2 \times 10^{-3} \text{ m}^2/\text{s}$.

- (A) 0.030
- (B) 0.057
- (C) 0.032
- (D) 0.061

71. A simply supported beam of total length = 6 m has an overhang of 2 m on one side, with a uniform distributed load $w = 3 \text{ kN/m}$ on the overhang. Calculate the bending moment at the end (Point B) of overhang.



- (A) $10 \text{ kN} \cdot \text{m}$
- (B) $9 \text{ kN} \cdot \text{m}$
- (C) $6 \text{ kN} \cdot \text{m}$
- (D) $17 \text{ kN} \cdot \text{m}$

72. A warehouse roof is supported by a simply supported beam with a span of 15 meters, subjected to a central point load of 20 kN due to heavy equipment. Determine the deflection at the center of the beam.

- (A) $\frac{1406}{EI}$
- (B) $\frac{4218.75}{3EI}$
- (C) $\frac{EI}{1532}$
- (D) $\frac{5238.65}{EI}$

73. A rectangular frame with height 4 m and width 5 m carries a horizontal load $P = 15 \text{ kN}$ at the top left corner. Calculate the bending moments at the base.

- (A) $66 \text{ kN} \cdot \text{m}$.
- (B) $60 \text{ kN} \cdot \text{m}$.
- (C) $77 \text{ kN} \cdot \text{m}$.
- (D) $89 \text{ kN} \cdot \text{m}$.

74. A column of length $L = 4$ m carries an axial load $P = 80$ kN applied with an eccentricity $e = 0.1$ m. The column has a rectangular cross-section with width $b = 0.2$ m and depth $d = 0.3$ m. Calculate the maximum stress in the column.

- (A) 7 MPa.
- (B) 4 MPa.
- (C) 9 MPa.
- (D) 3 MPa.

75. Calculate the critical load for a column with a length of 6 m, a moment of inertia of $I = 350 \times 10^{-6} \text{ m}^4$, and a modulus of elasticity $E = 210$ GPa. The column is pinned at one end and fixed at the other.

- (A) 46.3 MN
- (B) 1.2 MN
- (C) 40.3 MN
- (D) 5.0 MN

76. A pedestrian bridge is designed as a simply supported beam with a span of 20 meters and carries a uniform load of 10 kN/m. Calculate the maximum deflection of the bridge.

- (A) $\frac{200.4 \times 10^3}{3EI}$
- (B) $\frac{200}{EI}$
- (C) $\frac{20.8 \times 10^3}{EI}$
- (D) $\frac{50.9 \times 10^3}{3EI}$

77. A rigid frame with a height of 4 m and width 6 m has a uniform load $w = 2$ kN/m on the top beam. Calculate the bending moments at the corners.

- (A) 6 kN · m.

(B) $7.97 \text{ kN} \cdot \text{m}$.

(C) $9 \text{ kN} \cdot \text{m}$.

(D) $8.15 \text{ kN} \cdot \text{m}$.

78. Calculate the net area of a bolted tension member with a gross area of 1200 mm^2 , bolt hole diameters of 20 mm and a thickness of the section of 10 mm . There are 4 bolt holes in a single line.

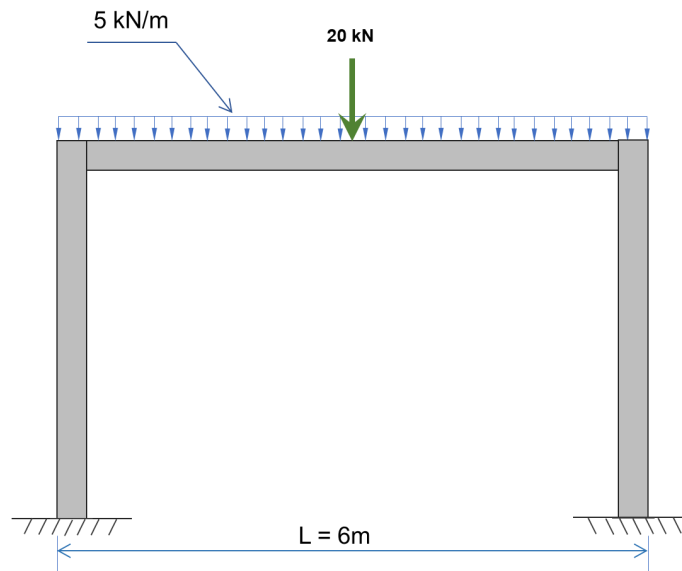
(A) 250 mm^2

(B) 366 mm^2

(C) 400 mm^2

(D) 480 mm^2

79. A portal frame (height 5 m , width 6 m) has a point load $P = 20 \text{ kN}$ at mid-span and a uniformly distributed load (UDL) of 5 kN/m over the entire beam, both supports are fixed, determine the fixed end moments.



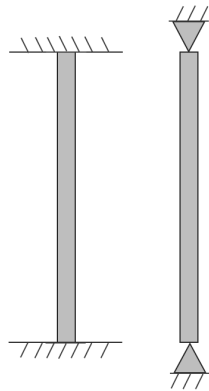
(A) 30 kN-m

(B) 40 kN-m

(C) 50 kN-m

(D) 60 kN-m

80. A column with a length of 6 m is fixed at both ends. If the Euler's critical load for this column is 500 kN, what will be the critical load if the column is changed to pinned-pinned boundary conditions? Assume all other parameters remain the same.



(A) 125 kN

(B) 250 kN

(C) 1000 kN

(D) 2000 kN

81. A civil engineer is evaluating the bearing capacity of a proposed foundation site for a high-rise building. The site investigation report provides the following information:

- The soil profile consists of a 4-meter thick layer of silty sand underlain by a layer of dense gravel.
- The groundwater table is located at a depth of 3 meters below the ground surface.
- The unit weight of the silty sand above the water table is 19 kN/m^3 and below the water table is 21 kN/m^3
- The unit weight of the dense gravel is 22 kN/m^3

- The internal friction angle (ϕ) of the silty sand is 28° .
- The internal friction angle (ϕ) of the dense gravel is 35° .
- The cohesion (c) of the silty sand is 5 kPa.
- The cohesion (c) of the dense gravel is 0 kPa.

The foundation will be a rectangular footing with dimensions 3 m by 6m, placed at a depth of 2.5 meters below the ground surface.

Which of the following is the most appropriate ultimate bearing capacity (q_u) for the proposed foundation site considering the layered soil profile and groundwater conditions?

- (A) 1040.6 kPa
- (B) 953.7 kPa
- (C) 1186 kPa
- (D) 2397.53 kPa

82. Determine the saturated unit weight of a soil sample with a dry unit weight of 18.0 kN/m^3 and a specific gravity of 2.65.

- (A) 20 kN/m^3
- (B) 33 kN/m^3
- (C) 21 kN/m^3
- (D) 11 kN/m^3

83. A soil sample has a D_{10} of 0.15 mm and a D_{60} of 0.85 mm. Calculate the Hazen Uniformity Coefficient (C_u) of the soil.

- (A) 5.67
- (B) 4.00
- (C) 3.75
- (D) 2.50

84. A civil engineer is designing a multi-story building foundation on a normally consolidated clay layer. The clay layer is 8 meters thick and is underlain by a dense sand layer, which acts as a drainage layer. The building footprint is a rectangular area of 20 meters by 30 meters, and the total load applied to the foundation is 3000 kN. The groundwater table is at the ground surface. The properties of the clay layer are as follows:

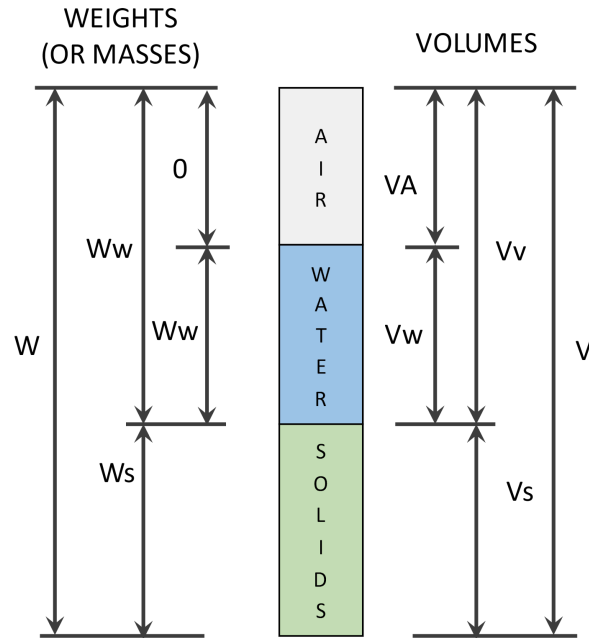
- Compression index, $C_c = 0.4$
- Initial void ratio, $e_0 = 1.0$
- Coefficient of consolidation, $C_v = 1 \times 10^{-3} \text{ m}^2/\text{day}$
- Effective stress increase due to the applied load, $\Delta\sigma' = 50 \text{ kPa}$

The engineer needs to determine the following:

1. The primary consolidation settlement.
2. The time required for 90% consolidation.

- (A) $S_c=281.6 \text{ mm}$; $t_{90}=37.17 \text{ years}$
(B) $S_c=200 \text{ mm}$; $t_{90}=30 \text{ years}$
(C) $S_c=300 \text{ mm}$; $t_{90}=43.58 \text{ years}$
(D) $S_c=156 \text{ mm}$; $t_{90}=35.35 \text{ years}$

85. A soil sample has a total volume of 7.28 m^3 and contains 25 kN of water. The specific gravity of soil solids is 2.70, and the sample has a degree of saturation of 80%. Determine the porosity (%) of the soil.



- A. 40.3%
- B. 41.0%
- C. 43.8%
- D. 46.7%

86. In a project requiring the stabilization of a 500 m^2 area using 8% cement by dry weight, the depth of stabilization is 0.3m, and the dry unit weight of the soil is 1800 kg/m^3 . Calculate the total amount of cement required.

- (A) 21.6 tonnes
- (B) 24.0 tonnes
- (C) 28.8 tonnes
- (D) 36.0 tonnes

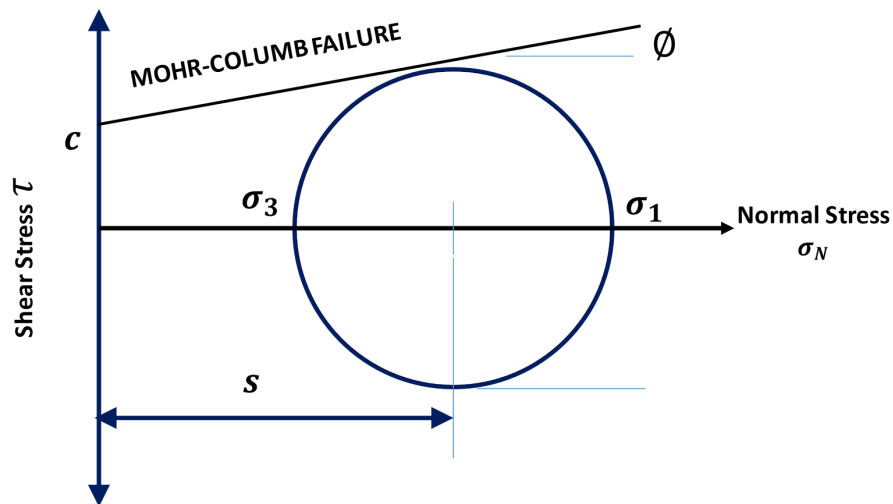
87. The specific gravity of the soil solids is 2.65. If the dry density of the soil is 1.65 g/cm^3 , what is the void ratio?

- (A) 0.50
- (B) 0.61
- (C) 0.80
- (D) 0.90

88. A soil sample has a bulk unit weight of 18 kN/m^3 and a water content of 10%. What is the dry unit weight of the soil?

- (A) 16.4 kN/m^3
- (B) 15.5 kN/m^3
- (C) 19.8 kN/m^3
- (D) 17.7 kN/m^3

89. A cohesive soil sample is tested in a triaxial compression test under drained conditions. The normal stress at failure is 85 kN/m^2 , Cohesion is 20 kN/m^2 and Angle of internal friction is 30° . Determine the shear stress at failure (τ_F).



- A. $\tau_F = 55.5 \text{ kN/m}^2$
- B. $\tau_F = 62.3 \text{ kN/m}^2$
- C. $\tau_F = 69.1 \text{ kN/m}^2$
- D. $\tau_F = 74.8 \text{ kN/m}^2$

90. Classify a soil sample according to the Unified Soil Classification System (USCS). The soil has 10% passing the No. 200 sieve, a liquid limit of 25%, and a plasticity index of 5%. The soil contains 15% gravel and 75% sand.

- (A) SW
- (B) SM
- (C) SP
- (D) SC

91. Determine the middle ordinate length (M) for a horizontal curve with a radius of 300 m and a central angle of 40 degrees.

- (A) 2.60 m
- (B) 18.09 m
- (C) 13.40 m
- (D) 11.70 m

92. Calculate the rate of change in grade (r) for a vertical curve with a length of 300 m that connects a +3% grade to a -1% grade.

- (A) 0.00008
- (B) 0.000133
- (C) 0.013
- (D) 0.015

93. Determine the decision sight distance (DSD) for a vehicle traveling at 70 km/h in an urban area with moderate traffic. Assume the maneuver requires

a speed/path/direction change and use AASHTO guidelines to estimate the DSD.

- (A) 130.5 m
- (B) 292.5 m
- (C) 353.2 m
- (D) 160 m

94. Calculate the superelevation (e) required for a spiral curve with a radius of 400m and a design speed of 80 km/h. Assume the side friction factor (f) is 0.15.

- (A) -0.024
- (B) 0.07
- (C) -1.052
- (D) 0.09

95. A horizontal curve has a radius of 250 m and a central angle of 30 degrees. Calculate the length of the curve.

- (A) 100.10 m
- (B) 125.0 m
- (C) 139.25 m
- (D) 130.89 m

96. For a passing sight distance (PSD) calculation, a car takes 10 seconds to pass another vehicle traveling at 60 km/h on a two-lane road. Determine the minimum PSD if the car travels at 80 km/h during the passing maneuver.

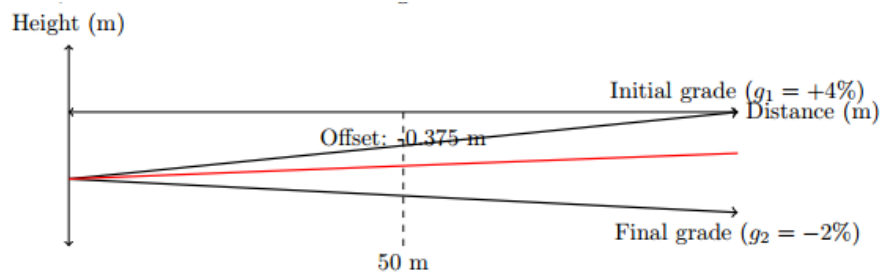
- (A) 400.00 m
- (B) 526.94 m
- (C) 626.94 m
- (D) 711.77 m

97. Calculate the stopping sight distance (SSD) for a car traveling at 90 km/h on a level road. Assume the perception-reaction time is 2.5 seconds and the deceleration rate is 3.4 m/s^2 .

- (A) 120 m
- (B) 130.67 m
- (C) 140 m
- (D) 154.41 m

98. A vertical curve connects two grades: +4% and -2%. The length of the curve is 200 m. Calculate the tangent offset at a point 50 m from the beginning of the curve.

- (A) 0.375 m
- (B) 2.00 m
- (C) 2.25 m
- (D) 0.512 m



99. What should be the minimum lane width for a highway with a design speed of 100 km/h?

- (A) 3.0 m
- (B) 3.5 m
- (C) 3.6 m
- (D) 3.8 m

100. A 3-phase airport terminal project has a total budget of \$1,500,000. The project is divided as follows:

Phase	Total Budget (\$)	Planned Completion (%)	Actual Completion (%)	Actual Cost (\$)
Phase 1	500,000	100%	100%	550,000
Phase 2	600,000	50%	45%	280,000
Phase 3	400,000	30%	25%	100,000

Calculate:

1. Cost Performance Index (CPI)
 2. Schedule Performance Index (SPI)
- A. CPI = 0.895, SPI = 0.915
- B. CPI = 0.915, SPI = 0.895
- C. CPI = 0.935, SPI = 0.945
- D. CPI = 0.985, SPI = 1.00

101. A project's initial schedule was 24 months. After 6 months, the project is 25% complete. What is the revised estimated duration if the rate of work completion remains constant?

- (A) 24 months
- (B) 30 months
- (C) 36 months
- (D) 48 months

102. A project has a total budget (Budget at Completion, BAC) of \$200,000 and is scheduled to be completed in 10 months. After 6 months, the following data is available:

- Planned Value (PV): \$120,000
- Earned Value (EV): \$100,000
- Actual Cost (AC): \$110,000

Calculate the Cost Performance Index (CPI), Schedule Performance Index (SPI), and Estimate at Completion (EAC).

- (A) CPI=0.1, SPI=0.3, EAC= 11,978
- (B) CPI=0.91, SPI=0.88, EAC= 115,142
- (C) CPI=0.91, SPI=0.75, EAC= 223,740
- (D) CPI=0.91, SPI=0.83, EAC= 219,780

103. A construction site requires the excavation of 1,000 cubic yards of soil. If the excavator has a bucket capacity of 2 cubic yards and can complete 30 cycles per hour, how many hours will it take to complete the excavation?

- (A) 16.67 hours
- (B) 20 hours
- (C) 25.44 hours
- (D) 30 hours

104. A city is awarding a \$10 million road construction contract using the Lowest Responsive Bidder (LRB) method. Four contractors submit bids, and the city applies a 10% penalty for incomplete documentation. The bids are:

Contractor	Bid Price (\$ Million)	Documentation Status
A	9.5	Complete
B	9.2	Incomplete
C	9.8	Complete
D	9.0	Incomplete

If an incomplete bid incurs a 10% penalty on bid price, which contractor wins the contract?

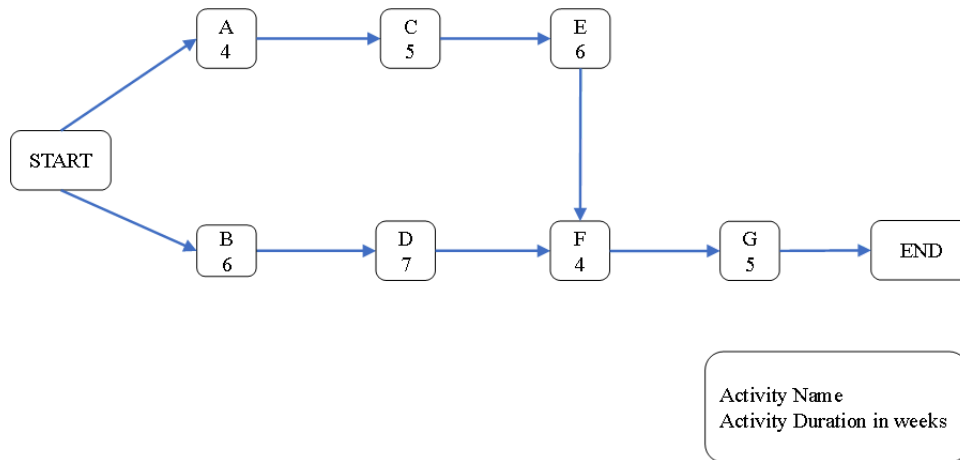
Options:

- A) Contractor A
- B) Contractor B

C) Contractor C

D) Contractor D

105. A construction project consists of seven activities (A to G) with the following relationships and durations (in weeks) as shown in the figure. What is the critical path?



- A. A → C → E → F → G → End
- B. B → D → F → G → End
- C. A → C → D → F → G → End
- D. B → D → E → F → G → End

106. A construction crew is installing pipe at a rate of 150 feet per day. If the project requires 4,500 feet of pipe to be installed, how many days will it take to complete the installation?

- (A) 30 days
- (B) 25 days
- (C) 17 days
- (D) 35 days

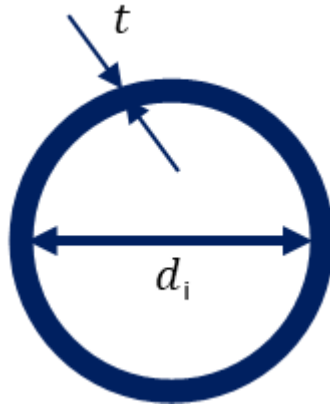
107. A project is scheduled to be completed in 12 months with a total budget of \$120,000. After 6 months, the project is 50% complete, and the Actual Cost (AC) is \$70,000. What is the Schedule Performance Index (SPI)?

- (A) 0.83
- (B) 0.90
- (C) 1.00
- (D) 1.10

108. Which of the following is an example of a lag in project scheduling?

- (A) Task B starts 2 days after Task A starts
- (B) Task B starts 2 days after Task A finishes
- (C) Task B starts immediately after Task A starts
- (D) Task B starts immediately after Task A finishes

109. A drainage pipe is shown in a sectional view with an internal diameter of 18 inches and a wall thickness of 2 inches. What is the outer diameter?



- A. 20 in.
- B. 22 in.
- C. 24 in.
- D. 26 in.

110. A structural plan indicates a beam span of 24 feet on the drawing, and the given scale of the drawing is $1/4" = 1'-0"$. However, during a site inspection, you find that the actual constructed beam length is 2 inches longer than the drawing indicates.

What is the actual constructed beam length in feet?

- A. 24.16 ft
- B. 24.17 ft
- C. 24.10 ft
- D. 24.20 ft

Solutions

[Click here for Problems](#)

1. Problem

Correct Answer: (B) $y = 2x$

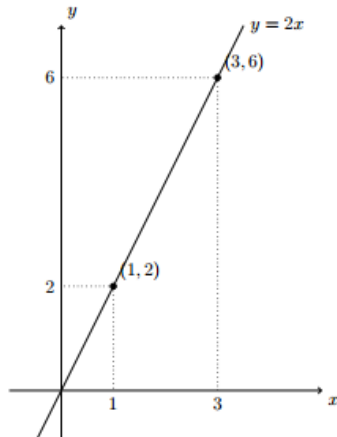
Explanation: The slope of the line passing through the points (1,2) and (3,6) is calculated as

$$\frac{6-2}{3-1} = \frac{4}{2} = 2$$

Using the point-slope form, $y - y_1 = m(x - x_1)$ and substituting $(x_1, y_1) = (1, 2)$ and $m = 2$, we get

$$y - 2 = 2(x - 1) \Rightarrow y = 2x.$$

where, m =slope; y =vertical coordinate; x =horizontal coordinate



2. Problem

Correct Answer: (B) 62.5

Explanation: The sample variance s^2 is calculated using the formula:

$$s^2 = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2$$

First, we calculate the sample mean $\bar{x}$:

$$\bar{x} = \frac{45 + 50 + 55 + 60 + 65}{5} = \frac{275}{5} = 55$$

Next, we calculate the squared deviations from the mean:

$$(45 - 55)^2 = (-10)^2 = 100$$

$$(50 - 55)^2 = (-5)^2 = 25$$

$$(55 - 55)^2 = 0^2 = 0$$

$$(60 - 55)^2 = 5^2 = 25$$

$$(65 - 55)^2 = 10^2 = 100$$

The sum of the squared deviations is:

$$100 + 25 + 0 + 25 + 100 = 250$$

Finally, the sample variance is:

$$s^2 = \frac{250}{5-1} = \frac{250}{4} = 62.5$$

3. Problem

Correct Answer: (A) $3x - 2y = 5$

Explanation: The slope of the given line $2x + 3y = 6$ is:

$$m = -\frac{2}{3}$$

A line perpendicular to this line will have a slope of the negative reciprocal, which is:

$$m' = \frac{3}{2}$$

Using the point-slope form with point (1,-1):

$$y - (-1) = \frac{3}{2}(x - 1) \quad y + 1 = \frac{3}{2}x - \frac{3}{2}$$

Multiplying everything by 2 to clear the fraction:

$$2y + 2 = 3x - 3$$

Rearranging to standard form:

$$3x - 2y = 5$$

4. Problem

Correct Answer: (A) $\frac{(x-2)^2}{16} - \frac{(y+1)^2}{9} = 1$

Explanation: For a hyperbola centered at (h,k) with a transverse axis length of $2a$ and a conjugate axis length of $2b$, the standard form of the equation is:

$$\frac{(x-h)^2}{a^2} - \frac{(y-k)^2}{b^2} = 1$$

Here, the center of the hyperbola is $(h,k) = (2,-1)$.

Given: - The length of the transverse axis is 8, so the length of the semitransverse axis is $a = \frac{8}{2} = 4$. - The length of the conjugate axis is

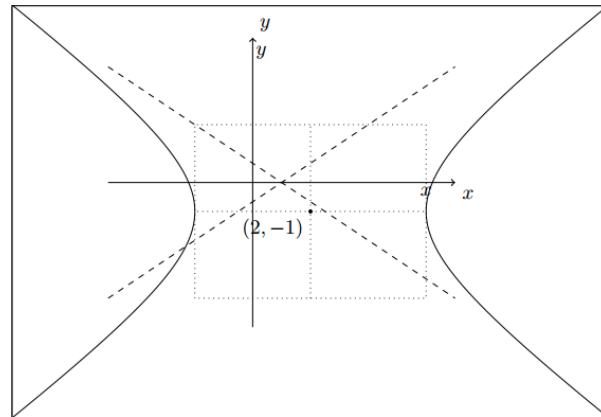
6, so the length of the semi-conjugate axis is $b = \frac{6}{2} = 3$.

Thus, substituting $h = 2$, $k = -1$, $a = 4$, and $b = 3$ into the standard form of the hyperbola, we get:

$$\frac{(x-2)^2}{4^2} - \frac{(y+1)^2}{3^2} = 1 \quad \frac{(x-2)^2}{16} - \frac{(y+1)^2}{9} = 1$$

Therefore, the correct equation is:

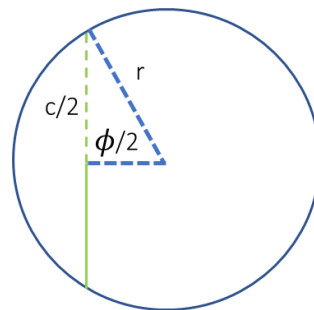
$$\frac{(x-2)^2}{16} - \frac{(y+1)^2}{9} = 1$$



5. Problem

Correct Answer: (B) 44.43 m^2

Explanation:



Segment Area formula:

$$A = \frac{r^2}{2}(\phi - \sin\phi)$$

To find the angle ϕ :

$$\sin \frac{\phi}{2} = \left(\frac{c/2}{r} \right)$$

$$\phi = 2 \sin^{-1}\left(\frac{c}{2r}\right)$$

$$\phi = 2 \sin^{-1}\left(\frac{16}{2 \times 10}\right)$$

$$\phi = 106.26^\circ$$

$$\phi = 106.26^\circ \times \frac{\pi}{180} = 1.85 \text{ radians}$$

Putting the values in segment area formula:

$$A = \frac{10^2}{2}(1.85 - \sin(1.85))$$

Correct answer: B) $A = 44.43 \text{ m}^2$

6. Problem

Correct Answer: (A) $x = 1 + \frac{\sqrt{3}}{3}$ and $x = 1 - \frac{\sqrt{3}}{3}$

Explanation: Find the First Derivative

$$f(x) = x^3 - 3x^2 + 2x$$

Differentiate $f(x)$ with respect to x :

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

$$f'(x) = 3x^2 - 6x + 2$$

$$3x^2 - 6x + 2 = 0$$

Use the quadratic formula: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ where, $a = 3$, $b = -6$, and $c = 2$.

$$x = \frac{-(-6) \pm \sqrt{(-6)^2 - 4 \cdot 3 \cdot 2}}{2 \cdot 3} \quad x = \frac{6 \pm \sqrt{36 - 24}}{6} \quad x = \frac{6 \pm \sqrt{12}}{6} \quad x = \frac{6 \pm 2\sqrt{3}}{6} \quad x = 1 \pm \frac{\sqrt{3}}{3}$$

So, the critical points are:

$$x = 1 + \frac{\sqrt{3}}{3} \text{ and } x = 1 - \frac{\sqrt{3}}{3}$$

7. Problem

Correct Answer: (B) $3x + 4y = 5$

Explanation: The radius at (3,4) is (3,4). The tangent line to the circle at (3,4) will be perpendicular to the radius. The slope of the radius is:

$$m = \frac{4-0}{3-0} = \frac{4}{3}$$

Therefore, the slope of the tangent line is:

$$m' = -\frac{3}{4}$$

Using the point-slope form, we get:

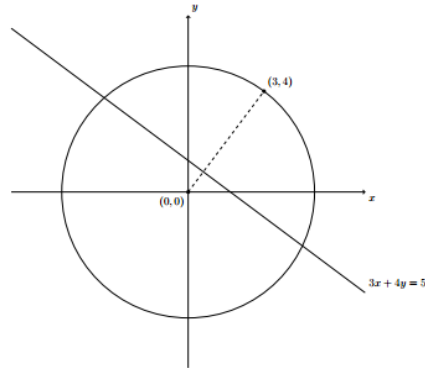
$$y - 4 = -\frac{3}{4}(x - 3)$$

Multiplying everything by 4 to clear the fraction:

$$4y - 16 = -3x + 9$$

Rearranging to standard form:

$$3x + 4y = 25$$



8. Problem

Correct Answer: A) $e = 5/4$, distance = 10

Explanation: Eccentricity is $e = c/a$, where $c = \sqrt{a^2 + b^2}$.

- Distance between the foci is $2c$.

Here:

- $a^2 = 16$, so $a = 4$
- $b^2 = 9$, so $b = 3$
- $c = \sqrt{16 + 9} = 5$

Eccentricity: $e = c/a = 5/4$

Distance between foci: $2c = 2(5) = 10$

Correct Answer: A) $e = 5/4$, distance = 10

9. Problem

Answer: C) Professional liability

Explanation: Professional liability arises from errors, omissions, or negligence in the performance of professional services, such as design errors that lead to structural failures.

10. Problem

Correct Answer: (B)

Explanation: The American Society of Civil Engineers (ASCE) focuses on civil engineering and sets standards for professional practice.

For example: ASCE 7 - Minimum Design Loads for Buildings and Other Structures

11. Problem

Answer: B) When they have not been in responsible charge of the work

Explanation: Engineers should only sign and seal documents for work over which they have had responsible charge to ensure accuracy and accountability.

According to the NSPE Code of Ethics - canon 2:

Section II.2.a: Engineers shall undertake assignments only when qualified by education or experience in the specific technical fields involved.

Section II.2.b: Engineers shall not affix their signatures to any plans or documents dealing with subject matter in which they lack competence, nor to any plan or document not prepared under their direction and control.

12. Problem

Answer: B) Report the hazard to their supervisor and take steps to mitigate it

Explanation: Engineers have a duty to report hazards and take appropriate actions to mitigate them, ensuring the safety and welfare of the public.

NSPE Code of Ethics - Canon 1- Section II.1.a states that If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate.

13. Problem

Correct Answer: (B)

Explanation: Both the ASCE and NSPE codes of ethics stress the importance of public welfare and safety in engineering practice.

14. Problem

Correct Answer: (B) Negligence

Explanation: Negligence describes a professional's failure to meet the standard of care, resulting in harm or damage.

NSPE Code of Ethics-canon 1 & canon 2

Negligence is considered a violation of these fundamental canons and rules of practice. If an engineer fails to uphold the safety, health, and welfare of the public, or if they perform services outside their areas of competence, they may be deemed negligent, especially if such actions result in harm or damage.

15. Problem

Correct Answer: (A) 15.2%

Explanation: The IRR is found by solving the equation for r :

$$0 = -C + \sum_{t=1}^n \frac{A_t}{(1+r)^t}$$

where C is the initial cost, A_t is the annual savings, n is the number of years.

Step 1: Identify the values: $C = 50,000$, $A_t = 15,000$, $n = 5$.

Step 2: Set up the equation and solve for r (using trial and error or a financial calculator):

$$0 = -50,000 + 15,000 \left(\frac{1-(1+r)^{-5}}{r} \right)$$

Using a financial calculator or trial and error, we find:

$$IRR = 15.2\%$$

16. Problem

Correct Answer: (C) \$20,567

Explanation: The present value P is calculated using the formula:

$$P = \frac{F}{(1+i)^n}$$

where F is the future amount, i is the annual interest rate, and n is the number of years.

Step 1: Identify the values: $F = 25,000$, $i = 0.05$, $n = 4$.

Step 2: Plug the values into the formula:

$$P = \frac{25,000}{(1+0.05)^4} \quad P = \frac{25,000}{1.215506} \quad P = 20,567.56$$

17. Problem

Correct Answer: (B) Project B

Explanation: $EMV_A = (0.60 \times 200,000) + (0.40 \times -100,000)$

$$= 120,000 - 40,000$$

$$= 80,000$$

$$EMV_B = (0.70 \times 150,000) + (0.30 \times -50,000)$$

$$= 105,000 - 15,000$$

$$= 90,000$$

Therefore, $EMV_B(90,000) > EMV_A(80,000)$

18. Problem

Correct Answer: (B) \$24,393

Explanation: The future value of an annuity F is calculated using the formula:

$$F = A \left(\frac{(1+i)^n - 1}{i} \right)$$

We need to solve for the annuity payment A .

Step 1: Rearrange the formula to solve for A :

$$A = \frac{F \cdot i}{(1+i)^n - 1}$$

$$A = \frac{1,000,000 \cdot 0.07}{(1+0.07)^{20} - 1}$$

$$A = \frac{70,000}{2.8697}$$

$$A = \$24,393$$

19. Problem

Correct Answer: (B) 7.43%

Explanation: The future value F is related to the present value P by the formula:

$$F = P(1 + i)^n$$

We need to solve for the interest rate i .

Step 1: Rearrange the formula to solve for i :

$$20,000 = 12,000(1 + i)^7 \quad \frac{20,000}{12,000} = (1 + i)^7 \quad 1.6667 = (1 + i)^7$$

Step 2: Take the 7th root of both sides:

$$1 + i = (1.6667)^{1/7}$$

$$1 + i = 1.0743 \quad i = 0.0743$$

Convert to percentage: $i = 7.43 \%$

20. Problem

Correct Answer: (C) 0 N

Explanation: Since the forces F_1 and F_2 are equal in magnitude but opposite in direction:

$$F_R = F_1 + F_2 = 20\text{N} + (-20\text{N}) = 0\text{ N}$$

21. Problem

Correct Answer: (D) 13.49 Nm

Explanation: To solve this problem, use the equation for the torque required for a square thread screw:

$$T = \frac{Fd_m}{2} \left(\frac{l + \pi \mu d_m}{\pi d_m - \mu l} \right)$$

$$F = 5000\text{ N}; d_m = 25\text{ mm} = 0.025\text{ m}; l = 5\text{ mm} = 0.005\text{ m}; \mu = 0.15$$

Substitute the values into the equation:

$$T = \frac{5000 \times 0.025}{2} \left(\frac{0.005 + \pi \times 0.15 \times 0.025}{\pi \times 0.025 - 0.15 \times 0.005} \right)$$

$$T = \frac{125}{2} \left(\frac{0.005 + 0.01178}{0.07854 - 0.00075} \right)$$

$$T = 62.5 \left(\frac{0.01678}{0.07779} \right)$$

$$T \approx 62.5 \times 0.2158$$

$$T \approx 13.49\text{ Nm}$$

22. Problem

Correct Answer: (D) 0 N

Explanation: Since all forces are equal in magnitude and symmetrically placed at right angles:

$$F_{Rx} = F_{1x} + F_{3x} = 25\text{N} - 25\text{N} = 0\text{ N}$$

$$F_{Ry} = F_{2y} + F_{4y} = 25\text{N} - 25\text{N} = 0\text{ N}$$

23. Problem

Correct Answer: A) 160 N·m

Moment about the origin:

$$M_0 = x F_y - y F_x$$

Force components:

$$F_x = 80 \cos 30^\circ = 69.28,$$

$$F_y = 80 \sin 30^\circ = 40$$

Substituting the values:

$$M_0 = (3 \times 40) - (4 \times 69.28)$$

$$M_0 = 120 - 277.12 = -157.12\text{ N-m} \approx 160\text{ N-m}$$

24. Problem

Correct Answer: (A) 10 N

Explanation: The resultant force R can be found using the law of cosines:

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

Given $F_1 = F_2 = 10\text{N}$ and $\theta = 120^\circ$,

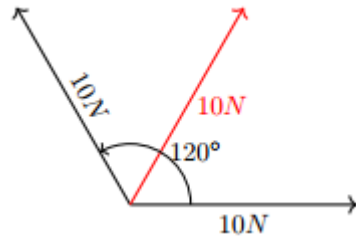
Calculating $\cos 120^\circ$:

$$\cos 120^\circ = -\frac{1}{2}$$

Therefore,

$$R = \sqrt{100 + 100 + 2 \times 10 \times 10 \times -\frac{1}{2}} = \sqrt{200 - 100} = \sqrt{100}$$

$R = 10 \text{ N}$



25. Problem

Correct Answer: (B) 18.03N at 56.31°

Explanation: The resultant force F_R can be found using vector addition:

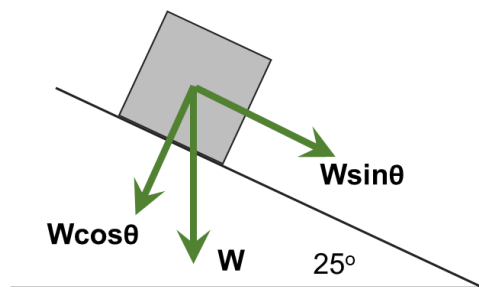
$$F_R = \sqrt{F_{1x}^2 + F_{2y}^2} = \sqrt{10^2 + 15^2} = \sqrt{100 + 225} = \sqrt{325} \approx 18.03 \text{ N}$$

The angle θ is given by:

$$\theta = \tan^{-1}\left(\frac{F_{2y}}{F_{1x}}\right) = \tan^{-1}\left(\frac{15}{10}\right) = \tan^{-1}(1.5) \approx 56.31^\circ$$

26. Problem

Correct Answer: A) 59 N



The force required to prevent the box from sliding down the incline is equal to the sum of the force due to gravity along the incline and the force of static friction opposing the motion.

1. Weight component along the incline:

$$F_{\text{gravity}} = mg \sin \theta$$

$$F_{\text{gravity}} = 100 \text{ kg} \times 9.81 \text{ m/s}^2 \times \sin 25^\circ = 414.6 \text{ N}$$

2. Normal force:

$$N = mg \cos \theta$$

$$N = 100 \text{ kg} \times 9.81 \text{ m/s}^2 \times \cos 25^\circ = 889.1 \text{ N}$$

3. Maximum static friction force:

$$F_s = \mu_s \cdot N$$

$$F_s = 0.4 \times 889.1 = 355.6 \text{ N}$$

4. Required force to prevent sliding:

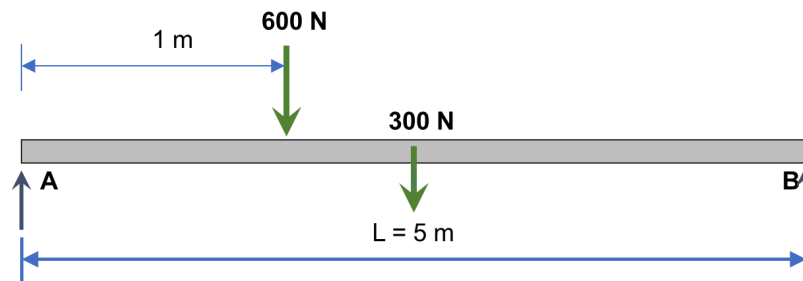
$$F_{\text{required}} = F_{\text{gravity}} - F_s$$

$$F_{\text{required}} = 414.6 \text{ N} - 355.6 \text{ N} = 59 \text{ N}$$

Thus, the minimum force required to prevent the box from sliding is 59 N

27. Problem

Correct Answer: D) 630 N



Sum of vertical forces (+ $\uparrow$):

$$R_A + R_B = 300 + 600 = 900$$

Taking moments about A (+ Clockwise):

$$(R_B \times 5) = (600 \times 1) + (300 \times 2.5)$$

$$5R_B = 600 + 750$$

$$R_B = 1350 / 5 = 270 \text{ N}$$

Substituting Values:

$$R_A + 270 = 900$$

$$R_A = 630 \text{ N}$$

28. Problem

Correct Answer: (C) 90 m

Explanation:

$$R = \frac{v_0^2 \sin 2\theta}{g} = \frac{30^2 \sin 90^\circ}{9.81} = 90 \text{ m}$$

29. Problem

Correct Answer: (A) $12\mathbf{i} + 24\mathbf{j}$

Explanation: Velocity components:

$$Dx/dt = 6t \text{ and } dy/dt = 6t^2$$

At $t = 2$:

$$v_x = 6 \times 2 = 12 \text{ m/s}$$

$$\text{and, } v_y = 6 \times 2^2 = 24 \text{ m/s}$$

Velocity vector:

$$\mathbf{v} = 12\mathbf{i} + 24\mathbf{j}$$

30. Problem

Correct Answer: (C) 5 m/s^2

Explanation: The force down the plane is:

$$F_1 = mg \sin \theta = 10 \times 9.81 \times \sin 45^\circ = 10 \times 9.81 \times \frac{\sqrt{2}}{2} \approx 69.3 \text{ N}$$

The net force is:

$$F_{\text{net}} = F_{\parallel} - f = 69.3 - 20 = 49.3 \text{ N}$$

The acceleration is:

$$a = \frac{F_{\text{net}}}{m} = \frac{49.3}{10} \approx 4.93 \text{ m/s}^2$$

31. Problem

Correct Answer: C) 10.2 m/s^2

Tangential velocity is given by:

$$v_t = u + a_t t \quad (u = 0 \text{ m/s}, a_t = 2 \text{ m/s}^2, t = 5 \text{ s})$$

$$v_t = 0 + 2(5) = 10 \text{ m/s}$$

Centripetal acceleration is:

$$a_c = v_t^2 / r = 10^2 / 10 = 10 \text{ m/s}^2$$

Total acceleration is:

$$a_{\text{total}} = \sqrt{a_t^2 + a_c^2} = \sqrt{2^2 + 10^2} = 10.19 \text{ m/s}^2 \approx 10.2 \text{ m/s}^2$$

32. Problem

Correct Answer: C) $7.5 \text{ kg} \cdot \text{m}^2/\text{s}$

The initial angular momentum of the particle is given by:

$$L_{\text{initial}} = I_{\text{initial}} \omega$$

$$\text{where } I_{\text{initial}} = MR^2 = 4 \times (0.5)^2 = 4 \times 0.25 = 1.0 \text{ kg} \cdot \text{m}^2.$$

Thus, the initial angular momentum is:

$$L_{\text{initial}} = 1.0 \times 5 = 5.0 \text{ kg} \cdot \text{m}^2$$

The moment of inertia is increased by 50%, so the new moment of inertia becomes:

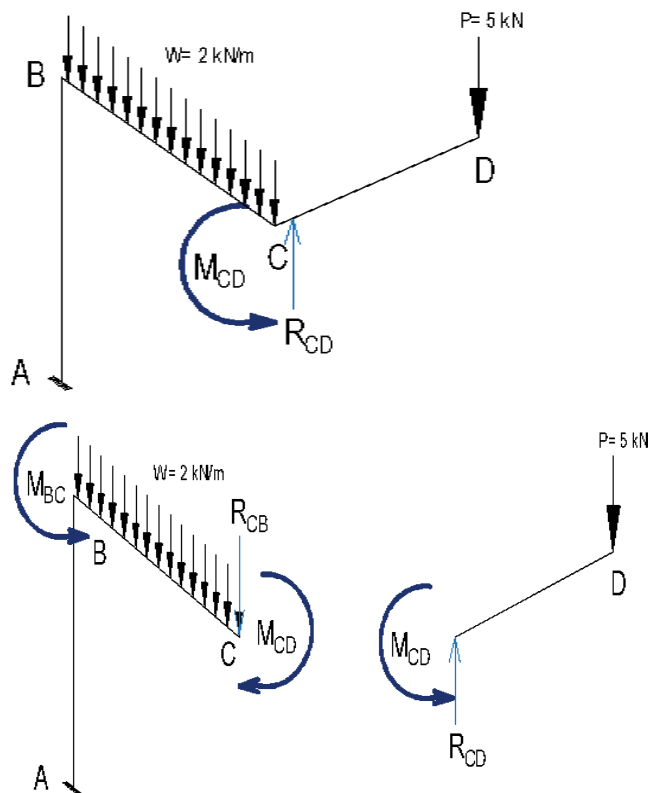
$$I_{\text{new}} = 1.5 \times I_{\text{initial}} = 1.5 \times 1.0 = 1.5 \text{ kg}\cdot\text{m}^2$$

Now, the new angular momentum is:

$$L_{\text{new}} = I_{\text{new}} \omega = 1.5 \times 5 = 7.5 \text{ kg}\cdot\text{m}^2/\text{s}$$

33. Problem

Correct Answer: C) Maximum at Point B



The bending moment will be maximum at point B due to applied loads of both Point and uniformly distributed load.

34. Problem

Correct Answer: (C) 28°

Explanation: The angle of rotation θ_p to the principle plane is given by:

$$\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y} = \frac{2 \times 30}{80 - 40} = \frac{60}{40} = 1.5 \rightarrow 2\theta_p = \tan^{-1}(1.5) \approx 56.3^\circ \Rightarrow \theta_p \approx 28.1^\circ$$

35. Problem

Correct Answer: (A) Does not yield

Explanation: Calculate the section modulus:

$$S = \frac{bh^2}{6} = \frac{100 \times 200^2}{6} = 666666.67 \text{ mm}^2$$

Calculate the maximum bending stress:

$$\sigma = \frac{M}{S} = \frac{50 \times 10^6}{666666.67} = 75 \text{ MPa}$$

Compare with yield stress:

Since $\sigma = 75 \text{ MPa} < \sigma_y = 250 \text{ MPa}$, the beam does not yield.

36. Problem

Correct Answer: (A) 6.66 kN

Explanation: Distance from left support to load (a): $a = L/3 = 8/3 = 2.67 \text{ m}$

Distance from right support to load (b): $b = L - a = 8 - 2.67 = 5.33 \text{ m}$

Determine reactions at supports:

$$R_A = \frac{Pb}{L} = \frac{10 \times 5.33}{8} = 6.66 \text{ kN} \quad R_B = \frac{Pa}{L} = \frac{10 \times 2.67}{8} = 3.34 \text{ kN}$$

Calculate shear force at $x = 2 \text{ m}$:

Since the concentrated load is located at $x = 2.67$ m, which is beyond the point of interest $x = 2$ m, the shear force at $x = 2$ m will only involve the left support reaction R_A . The shear force to the left of the load (at $x = 2$ m) is equal to the reaction R_A , as no other load has been applied before this point $\Rightarrow V(x = 2\text{ m}) = R_A = 6.66$ kN. Thus, the shear force at $x = 2$ m is 6.66 kN.

37. Problem

Correct Answer: (A) Deflection 19.03 mm, Yielding

Explanation: Calculate the moment of inertia:

$$I = bh^3/12$$

$$= \frac{0.1 \text{ m} \times (0.2 \text{ m})^3}{12}$$

$$= 6.67 \times 10^{-5} \text{ m}^4$$

2. Calculate the deflection at the free end:

$$\delta = \frac{PL^3}{3EI} = \frac{100,000 \text{ N} \times (2\text{ m})^3}{3 \times 210 \times 10^9 \text{ Pa} \times 6.67 \times 10^{-5} \text{ m}^4} = 19.03 \text{ mm}$$

3. Calculate the maximum bending moment:

$$M_{\max} = P L = 100,000 \text{ N} \times 2 \text{ m} = 200,000 \text{ Nm}$$

$$3. \text{ Calculate the maximum bending stress: } \sigma_{\max} = \frac{M_{\max} c}{I}$$

$$\text{The distance from the neutral axis is: } c = \frac{h}{2} = \frac{0.2 \text{ m}}{2} = 0.1 \text{ m}$$

$$\sigma_{\max} = \frac{M_{\max} c}{I} = \frac{200,000 \text{ Nm} \times 0.1 \text{ m}}{6.67 \times 10^{-5} \text{ m}^4} = 300 \text{ MPa}$$

Since $\sigma_{\max} = 300 \text{ MPa} > \sigma_y = 250 \text{ MPa}$, the beam will yield

38. Problem

Correct Answer: (A) It will not yield

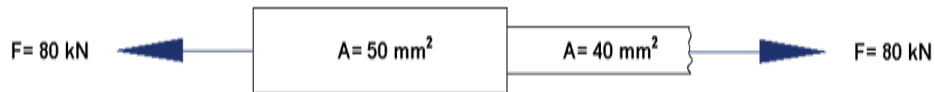
Explanation: using the von Mises yield criterion

$$\sigma_{vM} = \sqrt{\sigma_x^2 - \sigma_x \sigma_y + \sigma_y^2 + 3\tau_{xy}^2} \rightarrow \sigma_{v,M} = \sqrt{200^2 - 200 \times 100 + 100^2 + 3 \times 50^2}$$
$$= \sqrt{40,000 - 20,000 + 10,000 + 7500} = 193.6 \text{ MPa}$$

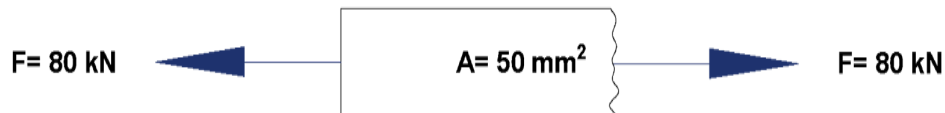
$\sigma_{vM} < 300 \text{ MPa}$, hence the material will not yield

39. Problem

Correct Answer: A) 2 GPa



$$\text{Stress at Central segment} = \frac{F}{A} = \frac{80}{40} = 2 \text{ GPa}$$

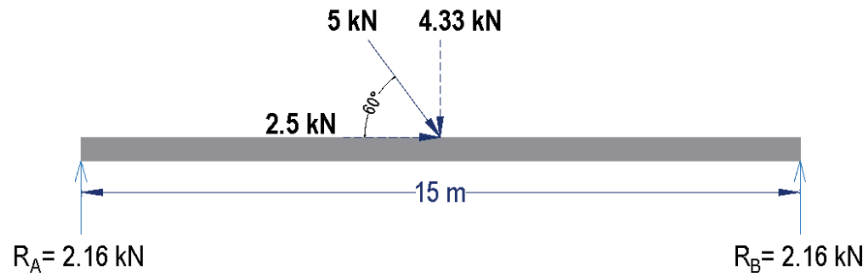


$$\text{Stress at Outer segment} = \frac{F}{A} = \frac{80}{50} = 1.6 \text{ GPa}$$

So, the stress is higher at center as compared to outer segment, so the critical axial stress is 2GPa

40. Problem

Correct Answer: B) 304.46/EI



$$v_{max} = \frac{(-PL^3)}{48EI}$$

$$= \frac{-5 \sin(60) \times (15)^3}{48EI} = 304.46/EI$$

41. Problem

Correct Answer: (D) 644.3 kg, 1288.6 kg, 144.9 kg

Explanation: Total parts = 1 + 2 + 4 + 0.45 = 7.45

-Since the density of concrete is 2400 kg/m^3 , the total mass of 1 cubic meter of concrete is: Total weight of concrete = 2400 kg

-Calculate the mass of fine aggregate based on the mix proportions:

$$\text{Fine aggregate} = \frac{2}{7.45} \times 2400 \text{ kg} = 644.3 \text{ kg}$$

$$\text{Coarse aggregate} = \frac{4}{7.45} \times 2400 \text{ kg} = 1288.6 \text{ kg}$$

$$\text{Water} = \frac{0.45}{7.45} \times 2400 \text{ kg} = 144.9 \text{ kg}$$

42. Problem

Correct Answer: (C) 0.0392

Explanation:

True stress: $\sigma_t = \frac{F'}{A_f}$

True strain = $\ln\left(\frac{\text{Final length}}{\text{Original length}}\right) = \ln\left(\frac{260}{250}\right) = 0.0392$

43. Problem

Correct Answer: C) 7.2mm

Fracture toughness is given by:

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

For central crack $Y = 1$

Rearrange for a_c :

$$a_c = \frac{(K_{1C}/\sigma)^2}{\pi} = \frac{(1.2/8)^2}{3.1416} = 0.00716m = 7.16mm \approx 7.2mm$$

44. Problem

Correct Answer: A) Elongation: 15%, Reduction in Area: 20%

Percent Elongation:

$$\text{Formula: Percent Elongation} = [(\text{Final Length} - \text{Initial Length}) / \text{Initial Length}] * 100\%$$

$$\text{Percent Elongation} = [(230 \text{ mm} - 200 \text{ mm}) / 200 \text{ mm}] * 100\%$$

$$\text{Percent Elongation} = (30 \text{ mm} / 200 \text{ mm}) * 100\%$$

$$\text{Percent Elongation} = 0.15 * 100\%$$

$$\text{Percent Elongation} = 15\%$$

Percent Reduction in Area:

$$\text{Percent Reduction in Area} = [(\text{Initial Area} - \text{Final Area}) / \text{Initial Area}] * 100\%$$

$$\text{Percent Reduction in Area} = [(50 \text{ mm}^2 - 40 \text{ mm}^2) / 50 \text{ mm}^2] * 100\%$$

$$\text{Percent Reduction in Area} = (10 \text{ mm}^2 / 50 \text{ mm}^2) * 100\%$$

$$\text{Percent Reduction in Area} = 0.2 * 100\%$$

Percent Reduction in Area = 20%

Results:

Percent Elongation: 15%

Percent Reduction in Area: 20%

45. Problem

Correct Answer: (D) 19.68 MPa, 0.001968

Explanation: Calculate the moment of inertia: $I = \frac{bh^3}{12} = \frac{0.1 \times 0.2^3}{12} = 6.67 \times 10^{-5} m^4$

Use the beam deflection formula to find the beam length:

$$\delta_{max} = \frac{PL^3}{48EI} \rightarrow L^3 = \frac{48EI\delta_{max}}{P} = \frac{48 \times 10 \times 10^9 \times 6.67 \times 10^{-5} \times 0.02}{15,000} = 3.5 m$$

Calculate the maximum bending moment:

$$M_{max} = \frac{PL}{4} = \frac{15,000 \times 3.5}{4} = 13,125 \text{ Nm}$$

Calculate the maximum bending stress:

$$\sigma_{max} = \frac{M_{max}c}{I} \text{ where } c \text{ is: } h/2 = 0.2/2 = 0.1 \text{ m}$$

$$\sigma_{max} = \frac{13,125 \times 0.1}{6.67 \times 10^{-5}} = 19.68 \text{ MPa}$$

Calculate the maximum strain:

$$\epsilon_{max} = \frac{\sigma_{max}}{E} = \frac{19.68 \times 10^6}{10 \times 10^9} = 0.001968$$

46. Problem

Correct Answer: (C) 0.0953, 0.1

Explanation:

$$\text{True strain} = \ln\left(\frac{\text{Final length}}{\text{Original length}}\right) = \ln\left(\frac{165}{150}\right) = 0.0953$$

$$\epsilon_{eng} = \frac{165\text{mm}-150\text{mm}}{150\text{mm}} = \frac{15}{150} = 0.1$$

47. Problem

Correct Answer: (B) 12.91 m/s

Explanation: The velocity of the air (v) can be determined using the following equation derived from Bernoulli's principle:

$$v = \sqrt{\frac{2\Delta P}{\rho}}$$

$$\Delta P = 100 \text{ Pa}$$

$$\rho = 1.2 \text{ kg/m}^3$$

$$v = \sqrt{\frac{2 \times 100}{1.2}}$$

$$= 12.91 \text{ m/s}$$

48. Problem

Correct Answer: (C) $1.11 \times 10^{-4} \text{ m}^2/\text{s}$

Explanation: Kinematic Viscosity = Dynamic Viscosity / Density

$$= 0.1 \text{ Pa}\cdot\text{s} / 900 \text{ kg/m}^3 = 1.11 \times 10^{-4} \text{ m}^2/\text{s}$$

49. Problem

Correct Answer: (C) 18.5 m/s

Explanation: The velocity of the liquid (v) can be calculated using the following corrected formula:

$$v = \frac{\Delta t \cdot c}{2L}$$

Substituting the values:

Given:

Length of the path of the ultrasonic signal (L) = 1.2 m

Time difference (Δt) = 0.03 s

Velocity of sound in the liquid (c) = 1480 m/s

$$v = \frac{1480 \cdot 0.03}{2 \cdot 1.2}$$

$$v = \frac{44.4}{2.4} = 18.5 \text{ m/s}$$

50. Problem

Correct Answer: (D) $0.203 \text{ m}^3/\text{s}$

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.

$$A_1 = \pi \left(\frac{250}{2}\right)^2 = 0.0491 \text{ m}^2 \rightarrow A_2 = \pi \left(\frac{150}{2}\right)^2 = 0.0177 \text{ m}^2 \rightarrow \Delta P = 60 \text{ kPa} = 60000 \text{ Pa}$$

$$\rho = 1000 \text{ kg/m}^3$$

$$\left(\frac{A_2}{A_1}\right) = \left(\frac{0.0177}{0.0491}\right)^2 \approx (0.36)^2 = 0.1296$$

$$Q = 0.98 \cdot 0.0177 \cdot \sqrt{\frac{2 \cdot 60,000}{1000 \cdot (1 - 0.1296)}}$$

$$= 0.203 \text{ m}^3/\text{s}$$

51. Problem

Correct Answer: C) 146.42 kPa

Pressure due to oil:

$$P_{\text{oil}} = \rho_{\text{oil}} g h_{\text{oil}}$$

$$P_{\text{oil}} = 800 \times 9.81 \times 2 = 15,696 = 15.696 \text{ kPa.}$$

Pressure due to water:

$$P_{\text{water}} = \rho_{\text{water}} g h_{\text{water}}$$

$$P_{\text{water}} = 1000 \times 9.81 \times 3 = 29,430 = 29.430 \text{ kPa.}$$

$$\text{Total pressure} = P_{\text{atm}} + P_{\text{oil}} + P_{\text{water}}$$

$$P_{\text{total}} = 101.3 + 15.696 + 29.430 = 146.42 \text{ kPa}$$

52. Problem

Correct Answer: (A) 0.081 m³/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:

$$\text{Flow rate } (Q) = A_1 A_2 \sqrt{\frac{2\Delta P}{\rho(A_1^2 - A_2^2)}}$$

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.

$$A_1 = \pi \left(\frac{200}{2} \right)^2 = 0.0314 \text{ m}^2 \rightarrow A_2 = \pi \left(\frac{100}{2} \right)^2 = 0.00785 \text{ m}^2 \rightarrow \Delta P = 50 \text{ kPa} = 50000 \text{ Pa}$$

$$\rho = 1000 \text{ kg/m}^3$$

$$Q = 0.0314 \times 0.00785 \sqrt{\frac{2 \times 50000}{1000(0.0314^2 - 0.00785^2)}}$$

$$= 0.081 \text{ m}^3/\text{s}$$

53. Problem

Correct Answer: (B) 1 Pa

Explanation: Shear stress = $\mu(dv/dy)$; Where, μ is the dynamic viscosity (Pa·s), dv/dy is the velocity gradient

$$= 0.01 \text{ Pa}\cdot\text{s} \times 0.1 \text{ m/s} / 0.001 \text{ m}$$

$$= 1 \text{ Pa}$$

54. Problem

Correct Answer: (D) 11466

Explanation:

$$\text{Reynolds number} = \frac{\rho v D}{\mu}$$

$$Q = 0.05 \text{ m}^3/\text{s}$$

$$D = 0.1 \text{ m}$$

$$v = Q/A$$

$$= 0.05 / (\pi(100/2)^2) = 6.37 \text{ m/s}$$

$$\rho = 900 \text{ kg/m}^3$$

$$\mu = 0.05 \text{ Pa}\cdot\text{s}$$

$$\text{Reynolds number} = (900 \times 6.37 \times 0.1) / 0.05$$

$$= 11466$$

55. Problem

Correct Answer: (C) $\lambda = -92.99^\circ$

Explanation:

$$\lambda_0 = -99^\circ ; k_0 = 0.9996 ; X = 500000 \text{ m} ; Y = 4649776.224 \text{ m}$$

$$\phi = Y / (k_0 \cdot a) ; a = 6378137$$

$$\phi = 4649776.224 / (0.9996 \cdot 6378137)$$

$$\phi = 0.728 \text{ radians}$$

$$\phi = 41.72^\circ$$

$$\Delta\lambda = X / (k_0 \cdot N \cdot \cos \phi)$$

$$N = \frac{a}{\sqrt{1 - e^2 \sin^2 \phi}}$$

$$e = 0.081819191$$

$$N = \frac{6378137}{\sqrt{1 - 0.081819191^2 \sin^2 41.72^\circ}} = 6383563.96$$

$$\Delta\lambda = 500000 / (0.9996 \cdot 6383563.96 \cdot \cos 41.72^\circ)$$

$$\Delta\lambda = 500000 / (6383350.94 \cdot 0.745)$$

$$\Delta\lambda = 500000 / 4754677.95$$

$$\Delta\lambda = 0.105 \text{ radians}$$

$$\Delta\lambda = 6.01^\circ$$

$$\lambda = \lambda_0 + \Delta\lambda$$

$$\lambda = -99^\circ + 6.01^\circ ; \lambda = -92.99^\circ$$

56. Problem

Correct Answer: (A) 12829183.0 m

Explanation:

$$\lambda_0 = -123^\circ$$

$$k_0 = 0.9996$$

$$\lambda = -120^\circ ; \phi = 35^\circ ; \Delta\lambda = \lambda - \lambda_0$$

$$\Delta\lambda = -120^\circ - (-123^\circ)$$

$$\Delta\lambda = 3^\circ$$

$$X = k_0 \cdot N \cdot \Delta\lambda \cdot \cos \phi$$

$$N = \frac{a}{\sqrt{1 - e^2 \sin^2 \phi}}$$

$$a = 6378137 ; e = 0.081819191$$

Substituting the values

$$N = 6385280.704$$

$$X = 0.9996 \cdot 6385280.704 \cdot 3 \cdot \cos 35^\circ$$

$$X = 0.9996 \cdot 6385280.704 \cdot 3 \cdot 0.819152$$

$$X = 15667675.5 \cdot 0.819152$$

$$X = 12829183.0 \text{ m}$$

57. Problem

Correct Answer: (D) 64.5 m^2

Explanation:

$$A = \frac{h}{2} \left(y_0 + 2 \sum_{i=1}^{n-1} y_i + y_n \right) \rightarrow h = 3m \rightarrow A = \frac{3}{2} (1 + 2(4 + 9) + 16) = 64.5 \text{ m}^2$$

58. Problem

Correct Answer: (C) 101.110 m

Explanation:

- Step 1: Calculate the Height of Instrument (HI) for Position 1:

$HI_1 = \text{Elevation of A} + \text{Back Sight on A} = 100.000 + 2.435 = 102.435 \text{ m}$

- Step 2: Calculate the Elevation of B using Position 1 readings:

$\text{Elevation of B} = HI_1 - \text{Fore Sight on B} = 102.435 - 1.865 = 100.570 \text{ m}$

- Step 3: Calculate the Height of Instrument (HI) for Position 2:

$HI_2 = \text{Elevation of B} + \text{Back Sight on B} = 100.570 + 2.210 = 102.780 \text{ m}$

- Step 4: Calculate the Elevation of C using Position 2 readings:

$\text{Elevation of C} = HI_2 - \text{Fore Sight on C} = 102.780 - 1.670 = 101.110 \text{ m}$

The elevation of point C is 101.110 m

59. Problem

Correct Answer: (A) 5 units²

Explanation:

$$A = \frac{1}{2} |x_1y_2 + x_2y_3 + x_3y_4 + x_4y_5 + x_5y_1 - (y_1x_2 + y_2x_3 + y_3x_4 + y_4x_5 + y_5x_1)|$$

$$A = \frac{1}{2} |0 \cdot 4 + 2 \cdot 3 + 4 \cdot 1 + 3 \cdot 2 + 1 \cdot 0 - (0 \cdot 2 + 4 \cdot 4 + 3 \cdot 3 + 1 \cdot 1 + 2 \cdot 0)|$$

$$A = \frac{1}{2} |16 - 26| \rightarrow A = \frac{1}{2} |-10| \rightarrow A = 5 \text{ units}^2$$

60. Problem

Correct Answer: (D) 179.32 km

Explanation:

$$\Delta\lambda = \lambda_2 - \lambda_1$$

$$\Delta\lambda = -123^\circ - (-121^\circ)$$

$$\Delta\lambda = -2^\circ$$

$$\Delta\lambda = -0.0349 \text{ radians}$$

$$\Delta\phi = \phi_2 - \phi_1$$

$$\Delta\phi = 0$$

$$a = \sin^2(\Delta\phi/2) + \cos(\phi_1) \cos(\phi_2) \sin^2(\Delta\lambda/2)$$

$$a = \cos(36^\circ) \cos(36^\circ) \sin^2(-0.0349/2)$$

$$a = 0.8090 \times 0.8090 \times \sin^2(-0.01745)$$

$$a = 0.8090 \times 0.8090 \times 0.000304$$

$$a = 0.000198$$

$$c = 2 \times \text{atan2}(\sqrt{a}, \sqrt{1-a})$$

$$c = 2 \times \text{atan2}(0.01407, 0.9999)$$

$$c = 0.02814$$

$$d = R \times c$$

$$R = 6371 \text{ km}$$

$$d = 6371 \times 0.02814$$

$$d = 179.32 \text{ km}$$

61. Problem

Correct Answer: (C) 0.903

Explanation:

$$Fr = \frac{V}{\sqrt{gy}} = \frac{4}{\sqrt{9.81 \times 2}} = \frac{4}{\sqrt{19.62}} = \frac{4}{4.43} = 0.903$$

62. Problem

Correct Answer: (B) 2.459 m

Explanation:

$$E = y + \frac{V^2}{2g} = 2 + \frac{(3)^2}{2 \times 9.81}$$

$$E = 2 + \frac{9}{19.62} = 2 + 0.459 = 2.459m$$

63. Problem

Correct Answer: (A) $0.2512 \text{ m}^3/s$

Explanation: Using the Darcy-Weisbach equation for pressure drop

$$\Delta P = f \frac{L}{D} \frac{\rho V^2}{2} \rightarrow f = \frac{\Delta P D}{L \frac{\rho V^2}{2}} \rightarrow \Delta P = 10000 Pa, L = 100m, D = 0.4m, \rho = 1000 kg/m^3$$

$$V = \sqrt{\frac{2 \Delta P \cdot D}{f \cdot L \cdot \rho}} = \sqrt{\frac{2 \times 10000 \times 0.4}{0.02 \times 100 \times 1000}} = \sqrt{\frac{8000}{2000}} = \sqrt{4} = 2 \text{ m/s}$$

$$Q = AV \rightarrow A = \frac{\pi D^2}{4} = \frac{\pi (0.4)^2}{4} = 0.1256 \text{ m}^2$$

$$Q = 0.1256 \text{ m}^2 \times 2 \text{ m/s} = 0.2512 \text{ m}^3/s$$

64. Problem

Correct Answer: (B) 10,000 N

Explanation:

$$F = \rho Q V, \rho = 1000 kg/m^3$$

$$F = 1000 \times 0.5 \times 20 = 10000 N$$

65. Problem

Correct Answer: (A) 0.738 m

Explanation: Using critical flow equation

$$y_c = \left(\frac{Q^2}{g0^2} \right)^{1/3} = \left(\frac{10^2}{9.81 \times 5^2} \right)^{1/3} = (0.408)^{1/3} = 0.738m$$

66. Problem

Correct Answer: (B) 33.86 m

Explanation:

$$h_f = f \frac{L}{D} \frac{V^2}{2g} \rightarrow A = \frac{\pi D^2}{4} = \frac{\pi(0.3)^2}{4} = 0.0707m^2$$

$$V = \frac{Q}{A} = \frac{0.5}{0.0707} = 7.07m/s$$

$$h_f = 0.02 \frac{200}{0.3} \frac{(7.07)^2}{2 \times 9.81} = 0.02 \times 666.67 \times 2.54 = 13.33 \times 2.54 = 33.86m$$

67. Problem

Correct Answer: (B) 5.82 inches

Explanation:

$$S = \frac{1000}{CN} - 10 = \frac{1000}{90} - 10 = 1.11 \text{ inches}$$

$$P = 7 \text{ inches}$$

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

$$Q = \frac{(7 - 0.222)^2}{7 + 0.888} = \frac{45.94}{7.888} = 5.82 \text{ inches}$$

68. Problem

Correct Answer: D) $5.33 \times 10^{-5} m/s$

Using Darcy's Law:

$$v = \frac{-K}{n} \left(\frac{dh}{dx} \right)$$

Where:

$$K = 2 \times 10^{-4} \text{ m/s}, n = 0.30, dh = 6 - 10 = -4 \text{ m}, dx = 50 \text{ m}$$

$$v = \frac{-(2 \times 10^{-4})}{0.30} \left(\frac{-4}{50} \right)$$

$$v = 5.33 \times 10^{-5} \text{ m/s}$$

69. Problem

Correct Answer: (A) 2.45 inches

Explanation:

$$S = \frac{1000}{CN} - 10 \rightarrow \frac{1000}{75} - 10 = 3.33 \text{ inches}$$

$$P = 5 \text{ inches}$$

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \rightarrow \frac{(5 - 0.2 \times 3.33)^2}{5 + 0.8 \times 3.33} = 2.45 \text{ inches}$$

70. Problem

Correct Answer: (A) 0.030

Explanation:

$$s = \frac{Q}{4\pi T} W(u)$$

$$W(u) \approx \ln\left(\frac{Tt}{r^2 S}\right)$$

Assume $t = 1$ day,

$$s = \frac{Q}{4\pi T} \cdot \ln\left(\frac{Tt}{r^2 S}\right)$$

$$1.5 = \frac{0.015}{4\pi \cdot 2 \times 10^{-3}} \cdot \ln\left(\frac{2 \times 10^{-3} \cdot 86400}{50^2 \cdot S}\right)$$

$$e^{0.8} \times S = 0.069 \rightarrow S = \frac{0.069}{e^{0.8}} \rightarrow S = 0.030$$

71. Problem

Correct Answer: (C) $6 \text{ kN} \cdot \text{m}$

Explanation:

Moment at point B is given by: $M_B = wL\left(\frac{L}{2}\right)$

$$M_B = 3 \text{ kN} * 2 \text{ m} * \left(\frac{2 \text{ m}}{2}\right) = 6 \text{ kN} \cdot \text{m}$$

72. Problem

Correct Answer: (A) $\frac{1406}{EI}$

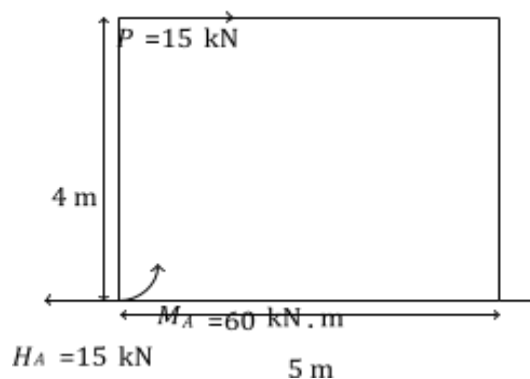
Explanation: For a simply supported beam with a central point load P, the maximum deflection δ_{max} occurs at the center of the beam and is given by the formula:

$$\delta_{max} = \frac{PL^3}{48EI} \rightarrow \frac{20 \times 15^3}{48EI} \rightarrow \frac{1406}{EI}$$

73. Problem

Correct Answer: (B) $60 \text{ kN} \cdot \text{m}$.

Explanation:



Horizontal reaction at base A : $H_A = P = 15 \text{ kN}$,

Moment at base A : $M_A = P \times h = 15 \times 4 = 60 \text{ kN} \cdot \text{m}$.

74. Problem

Correct Answer: (B) 4 MPa.

Explanation:

Direct Stress:

$$\begin{aligned}\sigma_d &= P / A = 80 \text{ kN} / (0.2 \times 0.3 \text{ m}^2) \\ &= 1333.33 \text{ kN/m}^2 = 1.33 \text{ MPa}.\end{aligned}$$

Bending Stress:

$$M = P \times e = 80 \text{ kN} \times 0.1 \text{ m} = 8 \text{ kN} \cdot \text{m},$$

$$\begin{aligned}S &= (b \times d^2) / 6 \\ &= (0.2 \times 0.3^2) / 6 = 0.003 \text{ m}^3,\end{aligned}$$

$$\begin{aligned}\sigma_b &= M / S \\ &= 8 \text{ kN} \cdot \text{m} / 0.003 \text{ m}^3 \\ &= 2666.67 \text{ kN/m}^2 = 2.67 \text{ MPa}.\end{aligned}$$

Maximum Stress:

$$\sigma_{\max} = \sigma_d + \sigma_b = 1.33 + 2.67 = 4 \text{ MPa}.$$

75. Problem

Correct Answer: (C) 40.3 MN

Explanation:

$$L_{eff} = \frac{L}{\sqrt{2}} = \frac{6}{\sqrt{2}} = 4.24 \text{ m}$$

Critical load: $P_{cr} = \frac{\pi^2 EI}{L_{eff}^2}$

$$P_{cr} = \frac{\pi^2 \times 210 \times 10^9 \times 350 \times 10^{-6}}{4.24^2} = 40.3 \text{ MN}$$

76. Problem

Correct Answer: (C) $\frac{20.8 \times 10^3}{EI}$

Explanation: For a simply supported beam subjected to a uniform load w , the maximum deflection δ_{max} occurs at the center of the beam and is given by the formula:

$$\delta_{max} = \frac{5wL^4}{384EI} \rightarrow \frac{5 \times 10 \times 20^4}{384EI} \rightarrow \frac{8,000,000 \text{ kN} \cdot \text{m}^4}{384EI}$$

$$\delta_{max} = \frac{8,000,000}{384} \times \frac{1}{EI}$$

$$\delta_{max} = \frac{20.8 \times 10^3}{EI}$$

77. Problem

Correct Answer: (C) 9 kN · m.

Explanation:

Total load $w \times 6 = 12 \text{ kN}$,

Reactions are equal due to symmetry: $R_A = R_B = 12/2$

= 6 kN.

Internal Bending Moments:

Moment at supports: $M_A = M_B = 0$ (assuming pinned supports),

Moment at top corners: $M_{AB} = (w \times L^2)/8$

$$= (2 \times 6^2)/8$$

$$= 9 \text{ kN} \cdot \text{m}.$$

78. Problem

Correct Answer: (C) 400 mm^2

Explanation:

Net area: $A_n = A_g - \text{number of holes} \times \text{hole diameter} \times \text{thickness}$

Assume thickness $t = 10 \text{ mm}$

$$A_n = 1200 - 4 \times 20 \times 10 = 1200 - 800 = 400 \text{ mm}^2$$

79. Problem

Correct Answer: A) 30 kN-m

For a fixed beam under UDL and a point load at mid-span, the fixed-end moments are:

$$M_A = M_B = \frac{wl^2}{12} + \frac{PL}{8}$$

$$M_A = M_B = \frac{5(6)^2}{12} + \frac{20(6)}{8} = 30 \text{ kN} - \text{m}$$

80. Problem

Correct Answer: A) 125 kN

The Euler's critical load is inversely proportional to the square of the effective length factor (K):

$$P_{cr} \propto \frac{1}{(KL)^2}$$

- Fixed-Fixed: $K = 0.5$
- Pinned-Pinned: $K = 1.0$

The ratio of critical loads is:

$$\frac{P_{cr, \text{pinned-pinned}}}{P_{cr, \text{fixed-fixed}}} = \left(\frac{K_{\text{fixed-fixed}}}{K_{\text{pinned-pinned}}} \right)^2 = \left(\frac{0.5}{1.0} \right)^2 = 0.25$$

Thus:

$$P_{cr, \text{pinned-pinned}} = 0.25 \times 500 = 125 \text{ kN}$$

81. Problem

Correct Answer: (A) 1040.6 kPa

Explanation: Understand the bearing capacity equation for layered soils

For a layered soil profile, Terzaghi's bearing capacity equation is modified to account for the contributions of each soil layer. For the silty sand layer (above and below the water table):

$$q_u = cN_c + \gamma' D_f N_q + 0.5 \gamma' B N_\gamma$$

Since the foundation depth (2.5 m) is above the dense gravel layer, we will primarily consider the properties of the silty sand.

Adjust for the presence of the water table

The effective unit weight (γ') of the submerged soil is calculated as:

$$\gamma' = \gamma - \gamma_w$$

Where:

- $\gamma = 21 \text{ kN/m}^3$ (unit weight of silty sand below the water table)
- $\gamma_w = 9.81 \text{ kN/m}^3$ (unit weight of water)

$$\gamma' = 21 \text{ kN/m}^3 - 9.81 \text{ kN/m}^3 = 11.19 \text{ kN/m}^3$$

Calculate the bearing capacity factors

Given:

- $N_q = 22.4$
- $N_\gamma = 20.3$
- $N_c = 14.8$

Calculate the contribution of each term:

Cohesion term(cN_c):

$$cN_c = 5kPa \times 14.8 = 74kPa$$

Depth term ($0.5\gamma'BN_\gamma$):

$$\gamma' D_f N_q = 11.19kN/m^3 \times 2.5m \times 22.4 = 626.36kPa$$

Width term ($0.5\gamma'BN_\gamma$):

$$0.5\gamma'BN_\gamma = 0.5 \times 11.19kN/m^3 \times 3m \times 20.3 = 340.25kPa$$

Sum the contributions to find the ultimate bearing capacity

$$q_u = cN_c + \gamma' D_f N_q + 0.5\gamma'BN_\gamma = 74kPa + 626.36kPa + 340.25kPa = 1040.61kPa$$

82. Problem

Correct Answer: (C) $21kN/m^3$

Explanation: The saturated unit weight (γ_{sat}) is given by:

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

First, find the void ratio (e):

$$\gamma_d = \frac{\gamma_w G_x}{1+e} \rightarrow e = \frac{\gamma_w G_x}{\gamma_d} - 1$$

Substituting the given values ($\gamma_w = 9.81 \text{ kN/m}^3$):

$$e = \frac{9.81 \times 2.65}{18.0} - 1 = \frac{25.9665}{18.0} - 1 = 1.445 - 1 = 0.445$$

Now, calculate γ_{sat} :

$$\gamma_{sat} = \frac{(2.65 + 0.445)(9.81)}{1 + 0.445} = \frac{30.4}{1.445} = 21 \text{ kN/m}^3$$

83. Problem

Correct Answer: (A) 5.67

Explanation: The Hazen Uniformity Coefficient (Cu) is given by:

$$Cu = \frac{D_{60}}{D_{10}} = \frac{0.85}{0.15} = 5.67$$

84. Problem

Correct Answer: (A) $S_c = 281.6 \text{ mm}$; $t_{90} = 37.17 \text{ years}$

Explanation: Step 1: Calculate the Primary Consolidation Settlement (S_c)

$$S_c = \frac{C_c \cdot H}{1 + e_0} \log \left(\frac{\sigma'_f}{\sigma'_i} \right)$$

Where:

- H = Thickness of the clay layer = 8 m
- C_c = Compression index = 0.4
- e_0 = Initial void ratio = 1.0
- σ'_f = Final effective stress
- σ'_i = Initial effective stress

Assuming the initial effective stress (σ'_i) is the pre-consolidation pressure, we need the final effective stress:

$$\sigma'_f = \sigma'_i + \Delta\sigma'$$

Given:

$$\Delta\sigma' = 50 \text{ kPa}$$

$$S_c = \frac{0.4 \times 8}{1 + 1.0} \log \left(\frac{\sigma'_i + 50}{\sigma'_i} \right)$$

Assuming $\sigma'_i = 100 \text{ kPa}$ (a reasonable assumption for normally consolidated clay):

$$S_c = \frac{3.2}{2} \log \left(\frac{100 + 50}{100} \right) = 1.6 \log \left(\frac{150}{100} \right) = 1.6 \log(1.5) = 0.2816m = 281.6mm$$

Step 2: Calculate the Time Required for 90% Consolidation (t_{90})

The time required for consolidation is given by:

$$T_v = \frac{C_v \cdot t}{H_d^2}$$

Where:

- T_v = Time factor for 90% consolidation (from Terzaghi's consolidation theory, $T_{90} \approx 0.848$)
- C_v = Coefficient of consolidation = $1 \times 10^{-3} \text{ m}^2/\text{day}$
- t = Time required
- H^d = Drainage path length = $H/2$ (for double drainage)

Given:

- $H = 8 \text{ m}$
- $H_d = 8/2 = 4 \text{ m}$

$$T_{90} = \frac{C_v \cdot t_{90}}{H_d^2}$$

$$t_{90} = \frac{T_{90} \cdot H_d^2}{C_v}$$

$$t_{90} = \frac{0.848 \times 4^2}{1 \times 10^{-3}}$$

$$t_{90} = \frac{0.848 \times 16}{1 \times 10^{-3}} = \frac{13.568}{1 \times 10^{-3}} = 13568 \text{ days}$$

To convert days to years:

$$t_{90} = \frac{13568}{365} \approx 37.17 \text{ years}$$

85. Problem

Correct Answer: C) 43.8%

We know that:

$$V_w = \frac{W_w}{\gamma_w}$$

Substituting values:

$$V_w = \frac{25}{9.81}$$

$$V_w = 2.55 \text{ m}^3$$

Using the degree of saturation equation:

$$S = \frac{V_w}{V_v} \times 100$$

$$V_v = \frac{V_w}{S} \times 100$$

Substituting values:

$$V_v = \frac{2.55}{80} \times 100$$

$$V_v = 3.19 \text{ m}^3$$

Porosity is given by:

$$n = \frac{V_v}{V} \times 100$$

Substituting values:

$$n = \frac{3.19}{7.28} \times 100$$

$$n = 43.8\%$$

86. Problem

Correct Answer: (A) 21.6 tonnes

Explanation: First, calculate the volume of soil to be stabilized:

$$\text{Volume} = \text{Area} \times \text{Depth} = 500 \text{ m}^2 \times 0.3 \text{ m} = 150 \text{ m}^3$$

Next, calculate the dry weight of the soil:

$$\text{Dry weight} = \text{Volume} \times \text{Dry unit weight} = 150 \text{ m}^3 \times 1800 \text{ kg/m}^3 = 270000 \text{ kg} = 270 \text{ tonnes}$$

Finally, calculate the amount of cement needed:

$$\text{Cement required} = 8\% \times 270 \text{ tonnes} = 0.08 \times 270 = 21.6 \text{ tonnes}$$

87. Problem

Correct Answer: (B) 0.61

Explanation: The void ratio (e) is given by:

$$e = \frac{G_s \times \rho_w}{\rho_d} - 1$$

where $G_s = 2.65$, $\rho_w = 1 \text{ g/cm}^3$, and $\rho_d = 1.65 \text{ g/cm}^3$

$$e = \frac{2.65 \times 1}{1.65} - 1 = 0.606 \approx 0.61$$

88. Problem

Correct Answer: (A) 16.4 kN/m³

Explanation: The dry unit weight γ_d is given by:

$$\gamma_d = \frac{\gamma}{1+w}$$

where γ is the bulk unit weight and w is the water content.

$$\gamma_d = \frac{18}{1+0.10} = \frac{18}{1.1} = 16.36 \approx 16.4 \text{ kN/m}^3$$

89. Problem

Correct Answer: C) $\tau_F = 69.1 \text{ kN/m}^2$

The shear stress at failure will be:

$$\tau_F = c + \sigma_N \tan \phi$$

$$\tau_F = 20 + (85.0 \times \tan 30^\circ)$$

$$\tau_F = 20 + (85.0 \times 0.577)$$

$$\tau_F = 20 + 49.1$$

$$\tau_F = 69.1 \text{ kN/m}^2$$

90. Problem

Correct Answer: (B) SM

Explanation: According to the USCS: - 10% passing the No. 200 sieve, liquid limit of 25%, and plasticity index of 5% classifies the soil as sand with little fines. - The soil is classified as SM (silty sand).

91. Problem

Correct Answer: (B) 18.09m

Explanation:

$$M = R \left(1 - \cos \left(\frac{\Delta}{2} \right) \right) = 300 \left(1 - \cos \left(\frac{40}{2} \right) \right) = 300 (1 - \cos(20))$$

$$M = 300 \times (1 - 0.9397) = 300 \times 0.0603 = 18.09 \text{ m}$$

92. Problem

Correct Answer: (B) 0.000133

Explanation:

$$r = \frac{|g_1 - g_2|}{L} = \frac{|0.03 - (-0.01)|}{300} = \frac{0.04}{300} = 0.000133$$

93. Problem

Correct Answer: (B) 292.5 m

Explanation: The Decision Sight Distance (DSD) is the distance required for a driver to detect an unexpected or difficult-to-perceive information source or condition in a roadway environment, recognize the hazard, select an appropriate speed and path, and initiate and complete the maneuver safely and efficiently.

The DSD values provided by the American Association of State Highway and Transportation Officials (AASHTO) are generally used in the absence of

a specific formula. According to the AASHTO guidelines, DSD varies depending on the speed and the type of maneuver (stop, speed/path/direction change)

Use AASHTO Guidelines for DSD:

According to the AASHTO guidelines for urban areas with moderate traffic, the typical DSD values are:

For stopping: $\approx 160\text{--}200$ meters

For speed/path/direction change: $\approx 275\text{--}310$ meters

Since the problem does not specify the type of maneuver, we can consider the average value within the range for urban conditions.

$$DSD = \frac{275+310}{2} = \frac{585}{2} = 292.5 \text{ meters}$$

94. Problem

Correct Answer: (A) -0.024

Explanation:

$$e + f = \frac{V^2}{127R} = \frac{(80)^2}{127 \times 400} = \frac{6400}{50800} = 0.126$$

Given $f = 0.15$,

$$\epsilon = 0.126 - 0.15 = -0.024$$

95. Problem

Correct Answer: (D) 130.89 m

Explanation: $L = \frac{\pi}{180} \times R \times \Delta = \frac{\pi}{180} \times 250 \times 30 = 130.899m$

96. Problem

Correct Answer: (B) 526.94 m

Explanation:

$$PSD = 2 \times \left(V_1 \times t + \frac{V_1^2 - V_2^2}{2a} \right) = 2 \times \left(\left(\frac{80}{3.6} \right) \times 10 + \frac{\left(\frac{80}{3.6} \right)^2 - \left(\frac{0}{3.6} \right)^2}{2 \times 1.5} \right) =$$

$$= 2 \times \left(22.22 \times 10 + \frac{22.22^2 - 16.67^2}{3} \right) = 2 \times 263.47 = 526.94m$$

97. Problem

Correct Answer: (D) 154.41 m

Explanation:

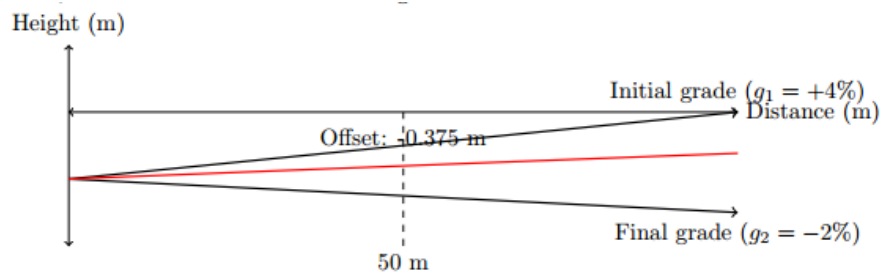
$$SSD = V \times t + \frac{V^2}{2a} = \left(\frac{90}{3.6} \right) \times 2.5 + \frac{\left(\frac{90}{3.6} \right)^2}{2 \times 3.4} = 25 \times 2.5 + \frac{25^2}{6.8} = 154.41m$$

98. Problem

Correct Answer: (A) 0.375

Explanation:

$$Y = \frac{g_1 - g_2}{2L} x^2 = \frac{0.04 - (-0.02)}{2 \times 200} \times (50)^2 = \frac{0.06}{400} \times 2500 = 0.375m$$



99. Problem

Correct Answer: (C) 3.6 m

Explanation: According to the AASHTO guidelines and general highway design standards, the recommended minimum lane width for highways is influenced by the design speed. For a highway with a design speed of 100 km/h, the following points are considered:

Design Speed Consideration:

- Higher design speeds typically require wider lanes to ensure safety and accommodate higher vehicle speeds.
- For design speeds of 100 km/h and above, wider lanes help to provide a margin of safety for drivers, reduce the risk of side-swipe collisions, and accommodate larger vehicles.

AASHTO guidelines typically recommend a minimum lane width of **3.6 meters (12 feet)** for highways with high design speeds, such as 100 km/h.

100. Problem

Correct Answer: C) CPI = 0.935, SPI = 0.945

Calculate BCWP (Earned Value) for each phase:

$$BCWP = (Actual\ Completion\%) \times (Total\ Budget)$$

- Phase 1: $100\% \times 500,000 = 500,000 \$$
- Phase 2: $45\% \times 600,000 = 270,000 \$$
- Phase 3: $25\% \times 400,000 = 100,000 \$$

$$BCWP_{Total} = 500,000 + 270,000 + 100,000 = 870,000 \$$$

Calculate BCWS (Planned Value) for each phase:

$$BCWS = (Planned\ Completion\%) \times (Total\ Budget)$$

- Phase 1: $100\% \times 500,000 = 500,000 \$$
- Phase 2: $50\% \times 600,000 = 300,000 \$$
- Phase 3: $30\% \times 400,000 = 120,000 \$$

$$BCWS_{Total} = 500,000 + 300,000 + 120,000 = 920,000 \$$$

And ACWP:

$$ACWP_{Total} = 550,000 + 280,000 + 100,000 = 930,000 \$$$

So, CPI and SPI:

$$CPI = \frac{BCWP}{ACWP} = \frac{870,000}{930,000} = 0.935$$

$$SPI = \frac{BCWP}{BCWS} = \frac{870,000}{920,000} = 0.945$$

101. Problem

Correct Answer: (A) 24 months

Explanation:

$$Work\ Completion\ Rate = \frac{25\%}{6\ months} = \frac{1}{24}\ per\ month$$

$$Revised\ Duration = \frac{100\%}{Work\ Completion\ Rate} = 24\ months$$

102. Problem

Correct Answer: (D) CPI=0.91, SPI=0.83, EAC= 219,780

Explanation:

$$CPI = \frac{EV}{AC} = \frac{100,000}{110,000} \approx 0.91 \rightarrow SPI = \frac{EV}{PV} = \frac{100,000}{120,000} \approx 0.83$$

$$EAC = \frac{BAC}{CPI} = \frac{200,000}{0.91} \approx 219,780$$

Evaluation:

- CPI indicates the project is over budget.
- SPI indicates the project is behind schedule.

- EAC predicts the total project cost will exceed the budget by \$19,780.

103. Problem

Correct Answer: (A) 16.67 hours

Explanation:

$$\text{Cycles per hour} = 30 \quad \text{Volume per cycle} = 2 \text{ cubic yards}$$

$$\text{Productivity rate} = 30 \times 2 = 60 \text{ cubic yards / hour}$$

$$\text{Hours required} = \frac{\text{Total volume}}{\text{Productivity rate}} = \frac{1,000 \text{ cubic yards}}{60 \text{ cubic yards / hour}} \approx 16.67 \text{ hours}$$

104. Problem

Correct Answer: A) Contractor A

Adjust Bids with 10% Penalty:

$$\text{Contractor B: } 9.2 + (0.1 \times 9.2) = 10.12\text{M}$$

$$\text{Contractor D: } 9.0 + (0.1 \times 9.0) = 9.9\text{M}$$

Compare Final Bids:

Contractor A: 9.5M

Contractor B (penalized): 10.12M

Contractor C: 9.8M

Contractor D (penalized): 9.9M

Lowest Responsive Bidder:

Contractor A has the lowest final bid at \$9.5M

105. Problem

Correct Answer: A) A → C → E → F → G → End

The critical path is the longest path through the network diagram, determining the project duration.

$$\text{Path A} \rightarrow \text{C} \rightarrow \text{E} \rightarrow \text{F} \rightarrow \text{G} \rightarrow \text{End} = 4 + 5 + 6 + 4 + 5 = 24 \text{ weeks}$$

$$\text{Path B} \rightarrow \text{D} \rightarrow \text{F} \rightarrow \text{G} \rightarrow \text{End} = 6 + 7 + 4 + 5 = 22 \text{ weeks}$$

Other paths do not exist

Path A $\rightarrow$ C $\rightarrow$ E $\rightarrow$ F $\rightarrow$ G $\rightarrow$ End is the longest path, so it is the most critical

106. Problem

Correct Answer: (A) 30 days

Explanation: Total length of pipe = 4,500 feet

Daily installation rate = 150 feet/day

$$\text{Days required} = \frac{\text{Total length of pipe}}{\text{Daily installation rate}} = \frac{4,500 \text{ feet}}{150 \text{ feet / day}} = 30 \text{ days}$$

107. Problem

Correct Answer: (C) 1.00

Explanation:

$$\text{Planned Value (PV)} = \frac{\text{Total Budget}}{\text{Total Duration}} \times \text{Time Elapsed} = \frac{120,000}{12} \times 6 = 60,000$$

$$\text{Earned Value (EV)} = \text{Percentage Complete} \times \text{Total Budget} = 0.50 \times 120,000 = 60,000$$

$$SPI = \frac{EV}{PV} = \frac{60,000}{60,000} = 1.00$$

108. Problem

Correct Answer: (B) Task B starts 2 days after Task A finishes

Explanation: A lag is the amount of time by which a successor activity is required to be delayed with respect to a predecessor activity. In this case, Task B starts 2 days after Task A finishes.

109. Problem

Correct Answer: B) 22 in.

$$\text{Outer Diameter} = \text{Inner Diameter} + 2 \times \text{Thickness} = 18 + 2 \times 2 = 22 \text{ in}$$

110. Problem

Correct Answer: B) 24.17 ft

Understanding Scale

The drawing uses $1/4" = 1'-0"$, meaning that every $1/4$ inch on paper represents 1 foot in reality.

Original Beam Length from Drawing

Given beam span on drawing = 24 feet (this is already in actual dimensions).

Extra Length in Inches Converted to Feet

$$\text{Extra length in reality} = 2 \text{ inches}$$

$$\text{Convert to feet: } 2 \text{ inches} \times 1/12 = 0.1667 \text{ feet}$$

Actual Constructed Length

$$24 + 0.1667 = 24.1667 \approx 24.17 \text{ ft}$$