



FE CIVIL EXAM 02

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Problems

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

- (A) 3
- (B) 8
- (C) 10
- (D) 9

2. What is the eccentricity of an ellipse, defined by the equation $x^2/a^2 + y^2/b^2 = 1$ where $a > b$ (a = semi-major axis; b = semi-minor axis, and x, y = coordinates of any point on the ellipse in a Cartesian coordinate system)?

- (A) $e = \sqrt{a^2 - b^2}$
- (B) $e = \sqrt{a^2 + b^2}$
- (C) $e = \sqrt{1 - \frac{b^2}{a^2}}$
- (D) $e = \sqrt{1 + \frac{b^2}{a^2}}$

3. What is the equation of a line parallel to $y = -3x + 4$ passing through the point $(1, 2)$?

- (A) $y = -3x + 5$
- (B) $y = -3x - 1$
- (C) $y = -3x + 1$
- (D) $y = -3x + 7$

4. Which equation represents the circle's center point $(x+2)^2 + (y-3)^2 = 16$?

(A) $(-2, 3)$

(B) $(0, -3)$

(C) $(3, 3)$

(D) $(-1, 1)$

5. Select the correct equation of a circle with diameter endpoints at $(1, 2)$ and $(5, 6)$.

(A) $(x - 1)^2 + (y - 2)^2 = \sqrt{3}$

(B) $(x + 3)^2 + (y + 4)^2 = 8$

(C) $(x - 3)^2 + (y - 4)^2 = 8$

(D) $(x - y)^2 + (x + y)^2 = 1$

6. Which equation represents the line passing through the points $(-1, -2)$ and $(4, 3)$?

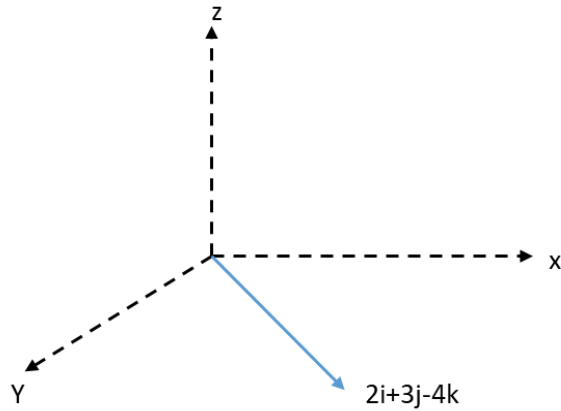
(A) $y = x + 1$

(B) $y = x - 1$

(C) $y = x + 2$

(D) $y = x - 2$

7. Which of the following vectors is parallel to the vector $A = 2i + 3j - 4k$?



- (A) $4i + 6j - 8k$
- (B) $i + j - k$
- (C) $3i + 2j - 4k$
- (D) $i - j + k$

8. Determine the coordinates of the focus of the parabola defined by the equation $y^2=4ax$ (where, x =horizontal coordinate, y =vertical coordinate, a =distance from vertex to focus)

- (A) $(a, 0)$
- (B) $(0, a)$
- (C) (a, a)
- (D) $(0, 0)$

9. Using the Fundamental Theorem of Calculus, calculate the definite integral

$$\int_1^3 (4x^3 - 2x)dx.$$

- (A) 14
- (B) 72
- (C) 18

(D) 20

10. According to the NCEES Rules of Professional Conduct, what should an engineer do if their professional judgment is overruled and the public's health, safety, or welfare is endangered?

- (A) Ignore the issue
- (B) Report the issue to the appropriate authority
- (C) Follow the overruling instructions without question
- (D) Seek advice from colleagues

11. In the context of professional liability, what does the term "standard of care" refer to?

- (A) The highest level of care possible
- (B) The ordinary level of skill and care commonly used by competent practitioners in the field
- (C) The minimal acceptable level of service
- (D) The care level stipulated by the client

12. In case of a conflict of interest, what is the best course of action for an engineer?

- (A) Continue working without disclosure
- (B) Disclose the conflict to all relevant parties
- (C) Withdraw from the project immediately
- (D) Ignore the conflict if it seems minor

13. What is professional liability insurance primarily used for in engineering practice?

- (A) To cover personal health expenses

- (B) To protect against claims of negligence or errors in professional services
- (C) To ensure engineering projects against natural disasters
- (D) To cover the costs of engineering software

14. If an engineer's professional judgment is overruled in a way that compromises public safety, they should:

- (A) Resign from their position
- (B) Report the issue to a higher authority
- (C) Comply with the decision and move on
- (D) Start a public campaign against their employer

15. A \$10,000 investment is compounded annually at 5%. What will be its worth after 10 years?

- (A) \$15,109.35
- (B) \$16,288.95
- (C) \$12,579
- (D) \$11,963.75

16. What is the equivalent annual worth of an investment that needs \$5,000 of initial investment and \$1,500 of returns annually for 5 years at an interest rate of 6 %?

- (A) \$1187
- (B) \$1,045
- (C) \$1,125
- (D) \$1,223

17. A company produces two products, X and Y, with the following data:

Product	Selling price	Variable cost	Sales mix
X	\$200/ unit	\$120/ unit	60%
Y	\$300/ unit	\$180/ unit	40%

The company incurs fixed costs of \$250,000. How many total units must the company sell to break even?

- A) 2,504 units
- B) 2,604 units
- C) 2,704 units
- D) 3,804 units

18. How much should be invested today to accumulate \$20,000 in 8 years if the interest rate is 5% compounded quarterly?

- (A) \$13,440
- (B) \$12,190
- (C) \$13,840
- (D) \$14,080

19. With an annual interest rate of 6% compounded monthly, how much should you save each month to accumulate \$10,000 in 5 years?

- (A) \$149.25
- (B) \$150.75
- (C) \$153.87
- (D) \$143.33

20. A company is considering two investment options, A and B, with the following cash flows (in \$1,000):

Year	Cash Flow (A)	Cash Flow (B)
0	-50	-50
1	20	30
2	25	20
3	30	15

The discount rate is uncertain, varying uniformly between 8% and 12%.

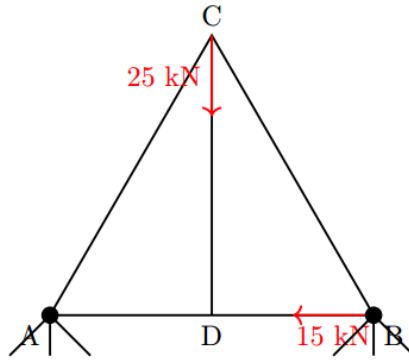
Using the expected value of the discount rate, which investment option has a higher Net Present Value (NPV)?

- A) A has a higher NPV by \$6.31 (in \$1000)
- B) B has a higher NPV by \$6.31 (in \$1000)
- C) A and B have the same NPV
- D) B has a higher NPV by \$1.50k (in \$1000)

21. A truss bridge is designed with multiple triangular elements to distribute loads efficiently. During an inspection, it is observed that one of the joints, specifically joint D, is subjected to the following forces:

- A vertical of 25kN load acting downward.
- A horizontal of 15kN load acting to the right.

The truss is supported by a pin at point A and a roller at point B. Which of the following statements is true regarding the forces in the truss members connected to joint D?



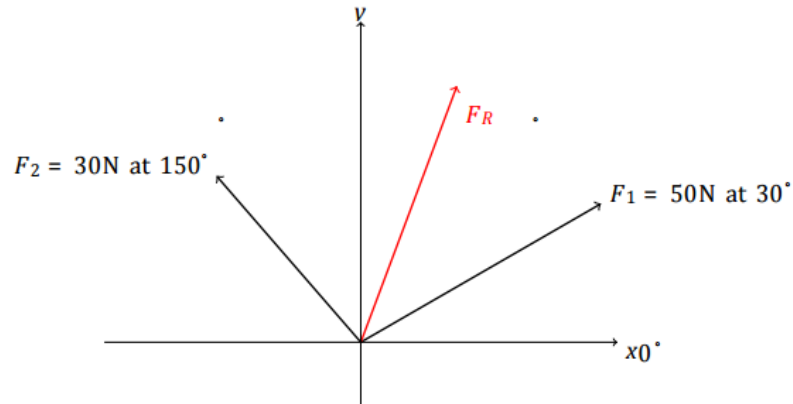
- (A) The force in member CD must be in tension to balance the vertical load.
- (B) The force in member CD must be in compression to balance the vertical load.
- (C) The horizontal reaction at support A must be greater than 15 kN.
- (D) The vertical reaction at support A must be less than 25 kN.

22. Determine the resultant force and its direction for the following force system:

Forces:

$$F_1 = 50\text{N at } 30^\circ,$$

$$F_2 = 30\text{N at } 150^\circ$$



- (A) 60N at 60°
- (B) 40N at 120°
- (C) 57.74N at 89.13°
- (D) 43.59N at 66.59°

23. A beam is supported at two points, A and B, with a point load P acting at point C between A and B. The beam is in equilibrium. Which of the following equations represents the sum of moments about point A (let x be the distance from point A to C, R_A and R_B the reactions at the supports A and B, respectively)?

- (A) $R_B \times L - P \times x = 0$
- (B) $R_B \times L + P \times x = 0$
- (C) $R_A \times L - P \times x = 0$
- (D) $R_A \times L + P \times x = 0$

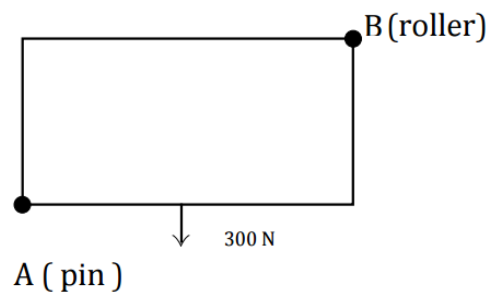
24. Two parallel forces, $F_1 = 30\text{N}$ and $F_2 = 50\text{N}$ in opposite directions, are separated by a distance of 3m. The moment of this system about a point midway between the forces is:

- (A) 90 Nm
- (B) 45 Nm

(C) 75 Nm

(D) 30 Nm

25. A rectangular frame is supported by a pin at one corner and a roller at the opposite corner. A horizontal force of 300N acts at the mid-point of one of the longer sides. Determine the horizontal reaction at the pin support.



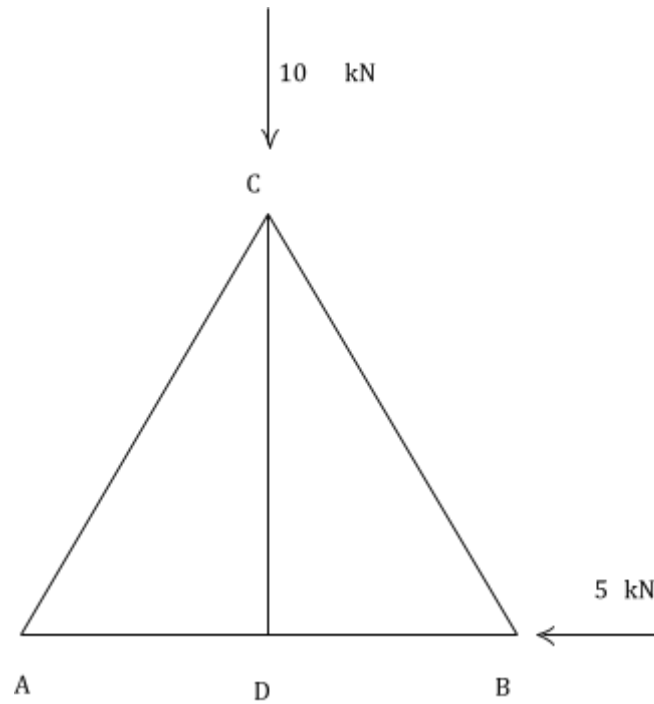
(A) -125N

(B) 225N

(C) -550N

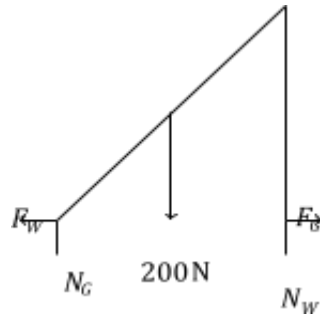
(D) 0 N

26. A truss is loaded as shown below. Using the method of joints, determine the force in member AC. Assume all members are pin-connected and the truss is in equilibrium



- (A) 7.67kN
- (B) 5.77kN
- (C) 3.07kN
- (D) 12.78kN

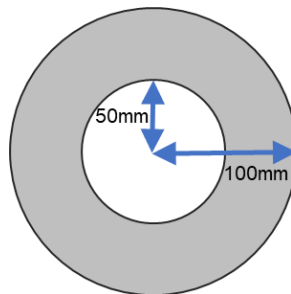
27. A ladder leaning against a smooth wall makes an angle of 60° with the ground. The weight of the ladder is 200N and it is in equilibrium. Calculate the normal reaction at the ground and determine the direction of reactions on the figure.



- (A) 100N upward
- (B) 100N downward
- (C) 200N upward
- (D) 200N downward

28. Find the moment of inertia of a hollow circular section with inner radius $R_i = 50 \text{ mm}$ and outer radius $R_o = 100 \text{ mm}$ about its centroidal axis.

- A. $5.3 \times 10^7 \text{ mm}^4$
- B. $6.3 \times 10^7 \text{ mm}^4$
- C. $7.3 \times 10^7 \text{ mm}^4$
- D. $8.3 \times 10^7 \text{ mm}^4$



29. $\mathbf{r}(t) = (3t^2, 2t, t^3)$ shows the curved path that a particle moves along. What is the vector of speed at time $t = 2$?

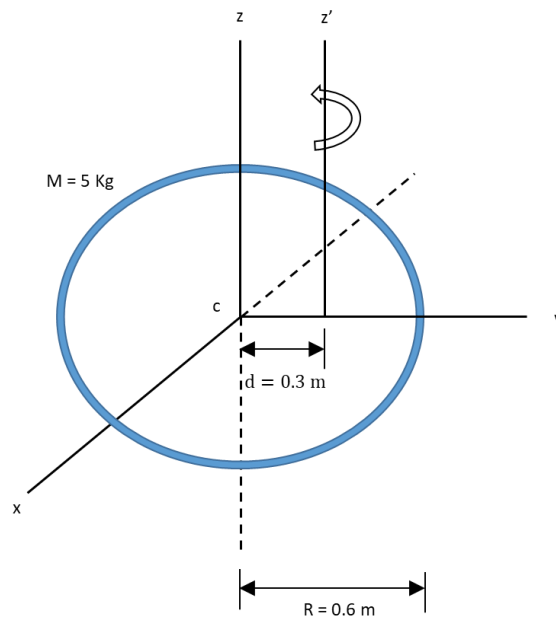
- (A) $(12, 2, 12)$

(B) (12, 2, 6)

(C) (6, 2, 12)

(D) (6, 4, 12)

30. A ring of mass $M = 5 \text{ kg}$ and radius $R = 0.6 \text{ m}$ is rotating about a parallel axis located 0.3 m away from the center. Using the parallel axis theorem, what is the moment of inertia of the ring about this new axis?



(A) $1.35 \text{ kg}\cdot\text{m}^2$

(B) $2.25 \text{ kg}\cdot\text{m}^2$

(C) $3.45 \text{ kg}\cdot\text{m}^2$

(D) $4.25 \text{ kg}\cdot\text{m}^2$

31. A particle is launched with an initial speed of 20 m/s at an angle of 30° from the horizontal. What is the highest point it reaches?

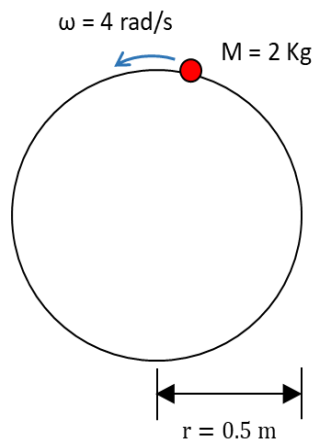
(A) 5 m

(B) 10 m

(C) 15m

(D) 20m

32. A particle of mass 2 kg is moving with an angular velocity of 4 rad/s in a circular path of radius 0.5 m. What is the magnitude of the angular momentum of the particle?



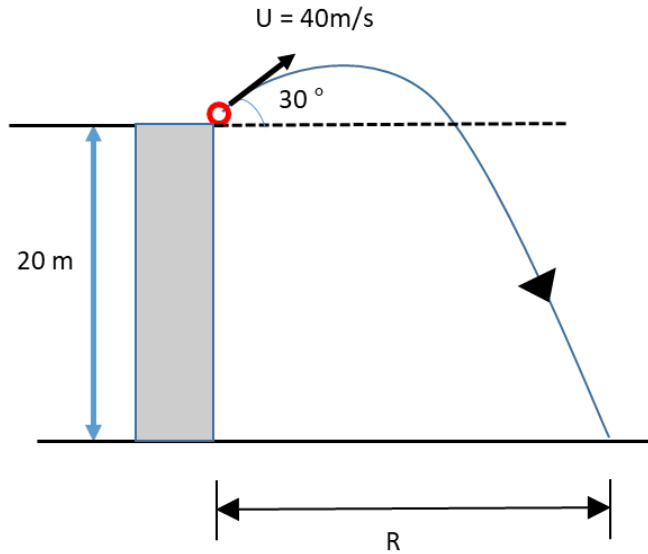
(A) $1.0 \text{ kg}\cdot\text{m}^2/\text{s}$

(B) $2.0 \text{ kg}\cdot\text{m}^2/\text{s}$

(C) $4.0 \text{ kg}\cdot\text{m}^2/\text{s}$

(D) $8.0 \text{ kg}\cdot\text{m}^2/\text{s}$

33. A projectile is fired at a speed of 40 m/s from the top of a building 20 m high at an angle of 30° above the horizontal. How far from the base of the building will the projectile hit the ground? (Take $g=9.81 \text{ m/s}^2$)

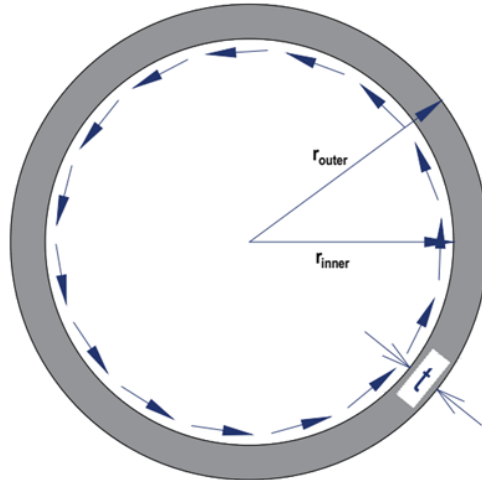


- (A) 140 m
- (B) 150 m
- (C) 160 m
- (D) 170 m

34. Determine if a material having a 250 MPa yield strength will yield under the following stress states: $\sigma_x = 100 \text{ MPa}$, $\sigma_y = 50 \text{ MPa}$, and $\tau_{xy} = 60 \text{ MPa}$, using the von Mises yield criterion.

- (A) 135.3 MPa
- (B) 275 MPa
- (C) 621.35 MPa
- (D) 150.25 MPa

35. A thin wall cylinder having thickness of 5 mm and diameter of 600 mm. A pressure of 2000 MPa applied on the wall. Find the tangential stress on the wall of a cylinder.



- (A) 100 GPa
- (B) 120 GPa
- (C) 150 GPa
- (D) 200 GPa

36. For the specified stress condition ($\sigma_x = 60$ MPa, $\sigma_y = 20$ MPa, and $\tau_{xy} = 40$ MPa), construct the Mohr's circle. Which of the following describes the radius correctly?

- (A) $2\sqrt{2}$ MPa
- (B) $\sqrt{3}$ MPa
- (C) 53.2 MPa
- (D) $20\sqrt{5}$ MPa

37. Normal stresses ($\sigma_x = 50$ MPa, $\sigma_y = 30$ MPa, and shear stress ($\tau_{xy} = 20$ MPa) are applied to a location in a stressed body. Determine the primary stresses.

- (A) 62.36 MPa, 17.64 MPa
- (B) 0 MPa, 89.75 MPa
- (C) 11 MPa, 125.25 MPa

(D) $2\sqrt{2}$ MPa, 365 MPa

38. A torque of 500 Nm is applied to a solid circular shaft with a diameter of 20 mm. Identify the torsional shear stress

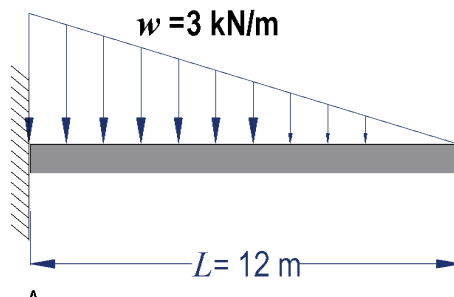
(A) 318.31 MPa

(B) 163.25 MPa

(C) 200 MPa

(D) 286 MPa

39. A uniformly varying load of 3kN/m is applied on a cantilever beam having length of 12 meters. The load is zero at tip while maximum at support. What will be the slope of the bending moment diagram at tip?



(A) Horizontal Slope

(B) Vertical Slope

(C) Both A & B

(D) None of the above

40. Determine the strain energy contained in a rod with a diameter of 10 mm, a length of 1 m, and a tensile tension of 10 kN. Let's say the substance is made of steel and has an elasticity modulus of 200 GPa.

(A) 2.25 J

(B) 0.125 J

(C) 3.18 J

(D) 1.675 J

41. For a concrete mix design, determine the volume of coarse aggregates needed per cubic meter of concrete. Assume the following:

- Total aggregate content: 1600 kg/m^3
 - Fine aggregate content: 700 kg/m^3
 - Bulk density of coarse aggregate: 1500 kg/m^3

(A) 0.6 m^3

(B) 0.8 m^3

(C) 0.11 m^3

(D) 1.35 m^3

42. For an asphalt mix design, calculate the amount of bitumen percentage required if the mix contains 1000 kg of aggregate and the bitumen content is 5% by weight of the total mix.

(A) 125 kg

(B) 50.50 kg

(C) 52.63 kg

(D) 63.75 kg

43. A concrete mix requires the addition of a super plasticizer with a dosage of 0.8% by weight of cement. Calculate the amount of super plasticizer needed for 500 kg of cement.

(A) 10 kg

(B) 11 kg

(C) 8 kg

(D) 4 kg

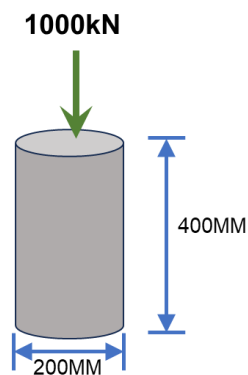
44. A concrete mix requires a compressive strength of 40 MPa after 28 days. Given a water-cement ratio of 0.45 and a cement efficiency factor of 0.85, and assuming a water content of 180 kg/m^3 , determine the cement content needed per cubic meter.

- (A) 470.58 kg/m^3
- (B) 105.94 kg/m^3
- (C) 93.75 kg/m^3
- (D) 524.55 kg/m^3

45. A concrete mix design specifies a water-cement ratio of 0.4, a cement content of 350 kg/m^3 , and a fine-to-coarse aggregate ratio of 1:2. If the density of the concrete is 2400 kg/m^3 , calculate the amount of fine and coarse aggregates needed per cubic meter of concrete.

- (A) 100.52 kg, 400.61 kg
- (B) 636.67 kg, 1273.33 kg
- (C) 300 kg, 1200 kg
- (D) 520 kg, 900 kg

46. A concrete cylinder with a diameter of 200 mm and a length of 400 mm is subjected to a compressive force of 1,000 kN. Calculate the maximum compressive stress just before yielding. The compressive strength of the concrete is known to be 40 MPa. What is the safety factor for the concrete?

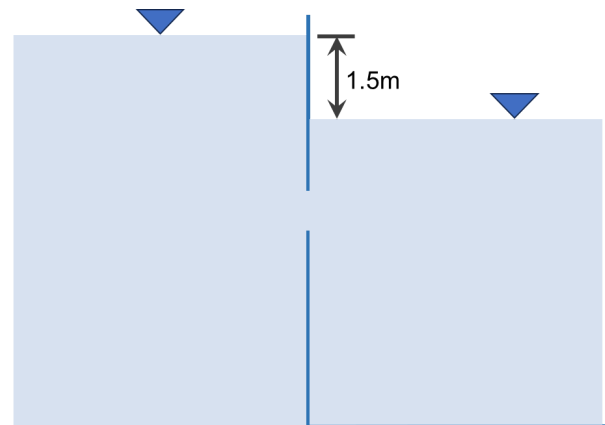


- (A) 1.00
- (B) 1.25
- (C) 1.50
- (D) 2.00

47. An orifice meter is used to measure the flow rate of oil (density = 900 kg/m^3) in a pipe with a diameter of 150 mm. The diameter of the orifice is 75 mm, and the pressure drop across the orifice is 20 kPa. Calculate the flow rate of oil.

- (A) $0.007 \text{ m}^3/\text{s}$
- (B) $0.055 \text{ m}^3/\text{s}$
- (C) $0.0304 \text{ m}^3/\text{s}$
- (D) $0.075 \text{ m}^3/\text{s}$

48. A submerged orifice has a coefficient of discharge $C_d = 0.62$. The difference in water head between the upstream and downstream is 1.5 m. The orifice has a cross-sectional area of 0.02 m^2 . Calculate the flow rate.



- A) $0.054 \text{ m}^3/\text{s}$
- B) $0.067 \text{ m}^3/\text{s}$

C) $0.072 \text{ m}^3/\text{s}$

D) $0.083 \text{ m}^3/\text{s}$

49. A rotameter is used to measure the flow rate of a gas in a pipe. The flow rate is found to be $0.02 \text{ m}^3/\text{s}$ at a pressure of 150 kPa and a temperature of 20°C . Calculate the flow rate at standard conditions (101.3 kPa and 0°C).

(A) $0.0276 \text{ m}^3/\text{s}$

(B) $1.055 \text{ m}^3/\text{s}$

(C) $1.044 \text{ m}^3/\text{s}$

(D) $0.075 \text{ m}^3/\text{s}$

50. A turbine flow meter is installed in a pipeline to measure the flow rate of oil with a density of 850 kg/m^3 . The flow rate is found to be $0.1 \text{ m}^3/\text{s}$. Calculate the Reynolds number if the diameter of the pipe is 100 mm and the viscosity of the oil is $0.1 \text{ Pa}\cdot\text{s}$

(A) 1155

(B) 10815.5

(C) 17361.5

(D) 985.36

51. A differential pressure flow meter is used to measure the flow rate of a gas in a pipeline. The pressure drop across the meter is 30 kPa, and the diameter of the pipe is 150 mm. The density of the gas is 1.2 kg/m^3 . Calculate the flow rate of the gas.

$0.055 \text{ m}^3/\text{s}$

$3.95 \text{ m}^3/\text{s}$

$0.078 \text{ m}^3/\text{s}$

$2.64 \text{ m}^3/\text{s}$

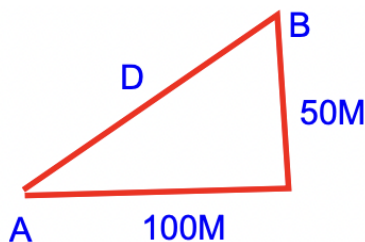
52. A pump adds 100 kW of power to the water flowing through a pipe. The flow rate is $0.1 \text{ m}^3/\text{s}$. If the inlet pressure to the pump is 200 kPa and the inlet diameter is 150 mm, what is the pressure at the outlet of the pump, assuming the outlet diameter is the same as the inlet diameter and the change in elevation across the pump is negligible? (Assume the density of water is 1000 kg/m^3 .)

- A. 1200 kPa
- B. 1400 kPa
- C. 1300 kPa
- D. 1100 kPa

53. Water flows through a pipe with a velocity of 2 m/s at a point where the diameter is 0.3 m. The pipe then narrows to a diameter of 0.15 m. Calculate the velocity of water at the narrower section.

- (A) 7.67 m/s
- (B) 8 m/s
- (C) 1.32 m/s
- (D) 3 m/s

54. Calculate the distance between two points A and B if the horizontal distance is 100 meters and the vertical distance is 50 meters.



- (A) 101.7 m

- (B) 511.5 m
- (C) 111.8 m
- (D) 213.2 m

55. Using the trapezoidal rule, compute the area under the curve for $y = [3, 5, 7, 9]$ with intervals of 2 m.

- (A) 66 m^2
- (B) 28 m^2
- (C) 36 m^2
- (D) 76 m^2

56. A point has the following State Plane Coordinates:

- Easting (E) = 600,000 meters
- Northing (N) = 2,500,000 meters

The SPCS zone uses a scale factor of 0.9998 and a false easting of 300,000 meters. What is the approximate longitude of the point if the central meridian is at 80°W ? (Use Earth's Radius = 6,371,000 m)

- A. 77.3°W
- B. 82.7°W
- C. 79.8°W
- D. 80.2°W

57. Compute the area under the curve using the trapezoidal rule with intervals of 1 m: $y = [2, 4, 6, 8, 10]$.

- (A) 17 m^2
- (B) 24 m^2
- (C) 33 m^2
- (D) 77 m^2

58. Calculate the area under the curve using the trapezoidal rule for $y = [1, 3, 6, 10, 15]$ with intervals of 2.5 m.

- (A) 77.2 m^2
- (B) 63.65 m^2
- (C) 67.50 m^2
- (D) 11.22 m^2

59. Using Simpson's rule, compute the area under the curve for $y = [1, 4, 6, 8, 10]$ with intervals of 1 m.

- (A) 25.37 m^2
- (B) 23.67 m^2
- (C) 36.98 m^2
- (D) 45.32 m^2

60. Convert the geographic coordinates (latitude 45° N , longitude 90° W) to UTM coordinates assuming the central meridian is 87° W and scale factor is 0.9996.

- (A) -5264873.2 m
- (B) -9632854.1 m
- (C) -9121410.5 m
- (D) -9577487.3 m

61. The water is moving through the pipe at a speed of 3 meters per second and has a pressure of 200 kilopascals. Given a decrease in pipe diameter and an increase in velocity to 5 m/s, determine the corresponding new pressure.

- (A) 192 kPa
- (B) 112 kPa
- (C) 139 kPa
- (D) 109 kPa

62. Calculate the head loss in a pipe with a diameter of 0.5 m, length of 150 m, flow rate of $0.4 \text{ m}^3/\text{s}$, and a Hazen-Williams coefficient of 130.

- (A) 3.5m
- (B) 96.75m
- (C) 1.05m
- (D) 12.86m

63. Calculate the flow rate in a rectangular channel with a width of 3 m, depth of 2 m, slope of 0.001, and Manning's roughness coefficient of 0.015.

- (A) $15.26 \text{ m}^3/\text{s}$
- (B) $18.89 \text{ m}^3/\text{s}$
- (C) $23.67 \text{ m}^3/\text{s}$
- (D) $11.40 \text{ m}^3/\text{s}$

64. A sluice gate controls the flow of water in an open channel. The upstream depth is 3 m and the downstream depth is 1 m. Calculate the velocity of flow under the gate.

- (A) 6 meter/second
- (B) 4.03meter/second
- (C) 2.27meter/second
- (D) 6.27meter/second

65. Calculate the pressure drop in a pipe with a length of 500 m, diameter of 0.3 m, flow rate of $0.5 \text{ m}^3/\text{s}$, and a friction factor of 0.02.

- (A) 224.5 kPa
- (B) 833.1 kPa
- (C) 139.5 kPa
- (D) 233.38 kPa

66. Calculate the head loss in a circular pipe with a diameter of 0.4 m, length of 200 m, flow rate of $0.3 \text{ m}^3/\text{s}$, and Darcy-Weisbach friction factor of 0.02.

- (A) 1.91meter
- (B) 2.91meter
- (C) 3.91meter
- (D) 5.91meter

67. A centrifugal pump delivers water at a flow rate of $0.02 \text{ m}^3/\text{s}$ with a head of 30 m. Calculate the required pump power if the pump efficiency is 70.

- (A) 8.41kW
- (B) 11.21kW
- (C) 3.37kW
- (D) 7.05kW

68. A pump delivers a flow rate of $0.05 \text{ m}^3/\text{s}$ at a head of 15 m. If the power supplied to the pump is 5 kW, determine the pump efficiency.

- (A) 72.13%
- (B) 69.67%
- (C) 68.45%
- (D) 147.15%

69. Calculate the flow rate in a pipe with a diameter of 0.5 m, length of 100 m, and Hazen-Williams coefficient of 120. The head loss is 5 m.

- (A) $0.905 \text{ m}^3/\text{s}$
- (B) $0.105 \text{ m}^3/\text{s}$
- (C) $1.06 \text{ m}^3/\text{s}$
- (D) $0.632 \text{ m}^3/\text{s}$

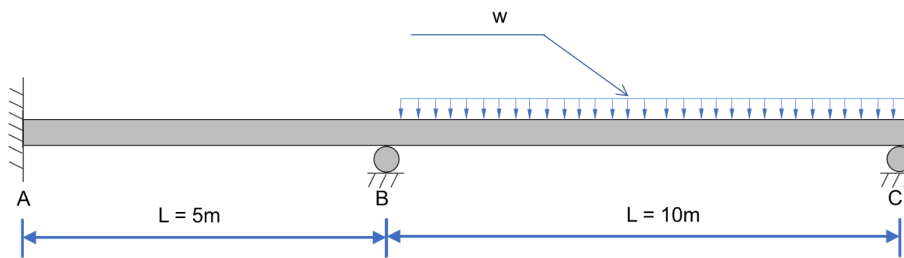
70. Calculate the hydraulic radius for a trapezoidal channel with a bottom width of 4 m, side slopes of 2:1, and a depth of 2 m.

- (A) 1.24 m
- (B) 1.05 m
- (C) 1.09 m
- (D) 2.67 m

71. Calculate the block shear strength of a steel member with a shear area of 400 mm^2 and a tensile area of 600 mm^2 . The shear yield strength is 250 MPa and the tensile yield strength is 400 MPa. The resistance factor is 0.75.

- (A) 218 kN
- (B) 276 kN
- (C) 720 kN
- (D) 225 kN

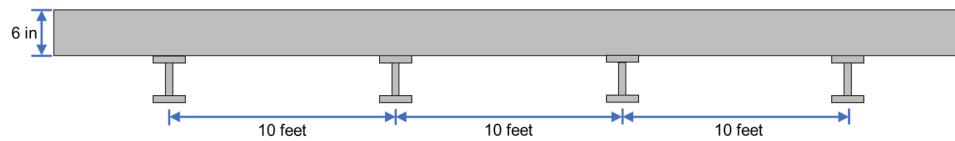
72. For the beam shown below, which of the following statements is TRUE about the moment distribution method?



The distribution factor member BC at B (EI is constant):

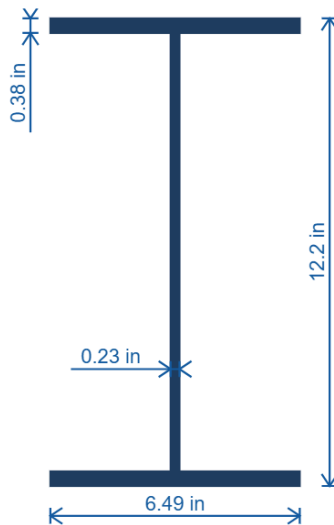
- A) 0
- B) 0.27
- C) 0.50
- D) 0.73

73. A reinforced concrete slab with a thickness of 6 inches is supported by steel beams spaced at 10 feet on center. The density of concrete is 150 lb/ft^3 . What is the dead load per linear foot of the beam?



- (A) 750 lb/ft
- (B) 900 lb/ft
- (C) 1,200 lb/ft
- (D) 1,500 lb/ft

74. A W12x26 steel beam ($F_y = 50 \text{ ksi}$) has a web thickness (t_w) of 0.23 in and a depth (h) of 12.2 in. What is the design shear strength ($\phi_v V_n$) of the beam? (use: $\phi_v = 1.0$, $C_v = 1.0$)



- A. 84.18 kips
- B. 140.32 kips
- C. 120.43 kips

D. 64.18 kips

75. Find the nominal shear strength for a beam with a span of 8 m subjected to a uniform load of 30 kN/m. The concrete strength is 35 MPa and the yield strength of stirrups is 250 MPa. Use a depth of 600 mm and a width of 350mm.

(A) 121.6 kN

(B) 221.6 kN

(C) 335.7 kN

(D) 285.9 kN

76. Which of the following equations is a fundamental part of the Slope Deflection Method?

(A) $\Delta = \frac{PL^3}{3EI}$

(B) $M_{AB} = \frac{EI}{L}(2\theta_A + \theta_B) + M_f$

(C) $V = \frac{wL}{2}$

(D) $F = k \cdot x$

77. Determine the strength reduction factor for flexure in a beam with a net tensile strain of 0.005. The reduction factor for flexure is 0.65 for strain of 0.002 and increases linearly to 0.9 for strain of 0.005 and greater.

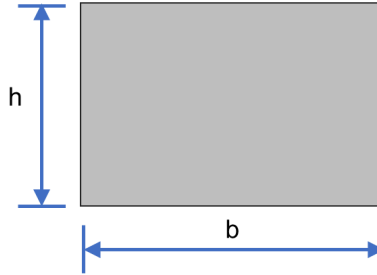
(A) $\Phi = 0.90$

(B) $\Phi = 0.75$

(C) $\Phi = 0.86$

(D) $\Phi = 0.20$

78. A column buckles about its X-axis when loaded axially. What does this indicate about the moment of inertia (I) of the cross-section?



- (A) $I_x = I_y$
- (B) $I_x < I_y$
- (C) $I_x > I_y$
- (D) $I_x = 0$

79. Calculate the design tensile strength of a steel member with an effective area of 900 mm^2 and a yield strength of 300 MPa. The resistance factor is 0.9.

- (A) 240 kN
- (B) 243 kN
- (C) 283 kN
- (D) 233 kN

80. A cantilever balcony extends 5 meters from the building and carries a uniform load of 2 kN/m. Calculate the maximum deflection at the free end using the conjugate beam method.

- (A) $\frac{8125}{EI}$
- (B) $\frac{625}{2EI}$
- (C) $\frac{2125}{2EI}$
- (D) $\frac{5}{EI}$

81. Calculate the design strength of a bolted connection with 4 bolts, each having a shear strength of 50 kN and a resistance factor of 0.75.

- (A) 150 kN
- (B) 100 kN
- (C) 230 kN
- (D) 110 kN

82. In a Cone Penetration Test (CPT), the tip resistance is measured to be 12 MPa and the sleeve friction is 0.5 MPa. Determine the friction ratio (R_f).

- (A) $R_f = 4.17\%$
- (B) $R_f = 4.86\%$
- (C) $R_f = 5.32\%$
- (D) $R_f = 3.76\%$

83. Using the AASHTO Soil Classification System, classify a soil with the following characteristics: 45% passing the No. 200 sieve, liquid limit = 30%, and plasticity index = 10%.

- (A) A-2-4
- (B) A-4
- (C) A-6
- (D) A-7-6

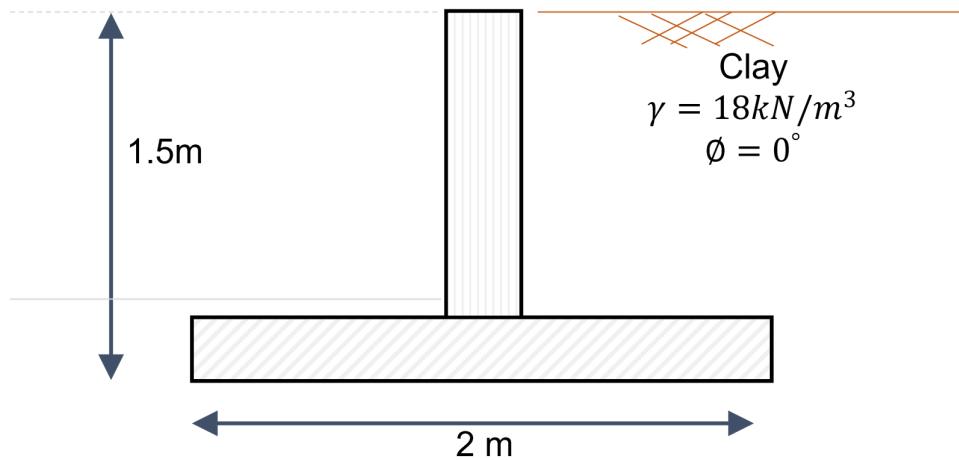
84. In an oedometer test, the void ratio of a soil sample decreases from 0.85 to 0.75 when the pressure is increased from 50 kPa to 150 kPa. Determine the compression index (C_c).

- (A) 0.215
- (B) 0.132
- (C) 0.053
- (D) 0.209

85. What is the degree of saturation of a soil sample if the volume of water is 0.15 m^3 , the volume of voids is 0.25 m^3 , and the volume of solids is 0.75 m^3 ?

- (A) 0.6
- (B) 0.75
- (C) 0.4
- (D) 0.5

86. A 2 m wide Strip footing is placed on a cohesive soil layer (Stiff clay) having Cohesion (c) = 25 kN/m^2 , Unit weight of soil (γ) = 18 kN/m^3 . The footing is placed at a depth of 1.5 m below ground surface and the water table is at 100 ft. The Bearing capacity factors $N_q = 1$, $N_c = 5.7$, $N_\gamma = 0$ and Factor of safety (FS) = 3. Determine the allowable bearing capacity (q_a) of the soil using Terzaghi's Bearing Capacity Equation.



- A. $q_a = 27 \text{ kN/m}^2$
- B. $q_a = 56.5 \text{ kN/m}^2$
- C. $q_a = 169.5 \text{ kN/m}^2$
- D. $q_a = 508.5 \text{ kN/m}^2$

87. A soil sample has a maximum dry density of 1.85 g/cm^3 and an optimum moisture content of 12% from the Standard Proctor Test. If the soil is compacted in the field with a dry density of 1.78 g/cm^3 , what is the relative compaction?

- (A) 97.55%
- (B) 78.33%
- (C) 96.22%
- (D) 50.00%

88. During a Direct Shear Test, the normal stress applied is 100 kPa and the shear stress at failure is 75 kPa. Determine the angle of internal friction (ϕ).

- (A) $\phi = 35.32^\circ$
- (B) $\phi = 36.87^\circ$
- (C) $\phi = 42.85^\circ$
- (D) $\phi = 34.45^\circ$

89. A soil sample tested in a triaxial compression test shows the following results: - Confining pressure: 100 kPa - Deviator stress at failure: 150 kPa. Determine the shear strength parameters (cohesion and internal friction angle) using the Mohr-Coulomb equation.

- (A) $c=0\text{kPa}$, $\phi=23.2^\circ$
- (B) $c=2\text{kPa}$, $\phi=25^\circ$
- (C) $c=0\text{kPa}$, $\phi=19.7^\circ$
- (D) $c=5\text{kPa}$, $\phi=23.2^\circ$

90. Calculate the Factor of Safety (FS) against slope instability for a slope with a planar slip surface using the following data:

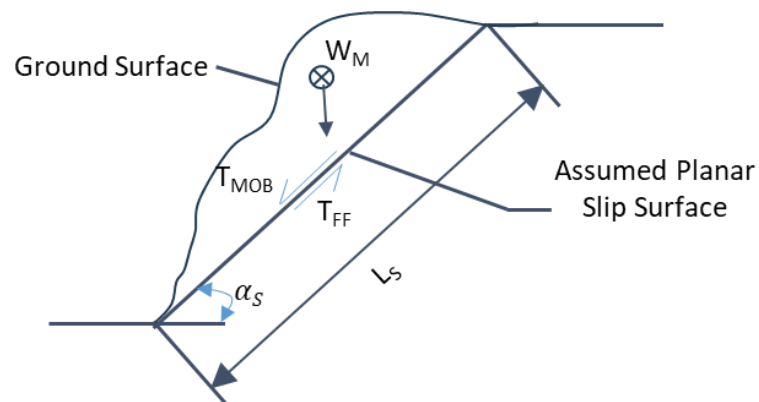
Cohesion of the soil (c): 500 lb/ft^2

Length of the slip surface (L_s): 20ft

Weight of the soil above the slip surface (W_M): 3000 lb

Angle of internal friction (ϕ): 30°

Angle of the slip surface with the horizontal (α_s): 20°



- A. 10.5
- B. 12.6
- C. 11.3
- D. 12.5

91. In a vane shear test, the torque required to shear the soil is 12 Nm and the vane dimensions are 50 mm in diameter and 100 mm in height. Determine the undrained shear strength (τ_u) of the soil.

- (A) 23.85 kPa
- (B) 26.19 kPa
- (C) 25.55 kPa
- (D) 12.25 kPa

92. A soil sample has a mass of solids of 300 kg and a total mass of 400 kg. What is the water content of the soil?

- (A) 25.66%
- (B) 20%
- (C) 33.33%
- (D) 30%

93. Determine the appropriate shoulder width for a rural highway with an annual average daily traffic (AADT) of 5000 vehicles.

- (A) 2.0 m
- (B) 2.5 m
- (C) 3.0 m
- (D) 3.5 m

94. Calculate the curve radius (R) for a horizontal curve with a curve length (L) of 200 m and a central angle (Δ) of 20 degrees.

- (A) 573.57 m
- (B) 303.33 m
- (C) 389.52 m
- (D) 500.10 m

95. Calculate the tangent distance (T) for a horizontal curve with a radius (R) of 500 m and a central angle (Δ) of 30 degrees.

- (A) 155.54 m
- (B) 201.11 m
- (C) 257.93 m
- (D) 133.95 m

96. Determine the stopping sight distance (SSD) for a vehicle traveling at 100km/h on a road with a downgrade of 4%. Assume the perception-reaction time is 2.5 seconds and the deceleration rate is 3.0 m/s^2 .

- (A) 150.50 m
- (B) 175.76 m
- (C) 183.13 m
- (D) 225.55 m

97. Calculate the tangent elevation for a vertical curve connecting a +5% grade to a -3% grade over a length of 500 m. The initial elevation is 150 m.

- (A) 155 m
- (B) 160.75 m
- (C) 157.5 m
- (D) 170 m

98. A horizontal curve on a highway has a radius of 350 m and a central angle of 45 degrees. Calculate the length of the subchord for a 5-degree deflection.

- (A) 35.25 m
- (B) 30.52 m
- (C) 40.52 m
- (D) 46.15 m

99. A vertical curve is designed to connect a +3% grade to a -2% grade over a length of 400 m. Calculate the elevation at the midpoint of the curve if the elevation at the beginning of the curve is 100 m.

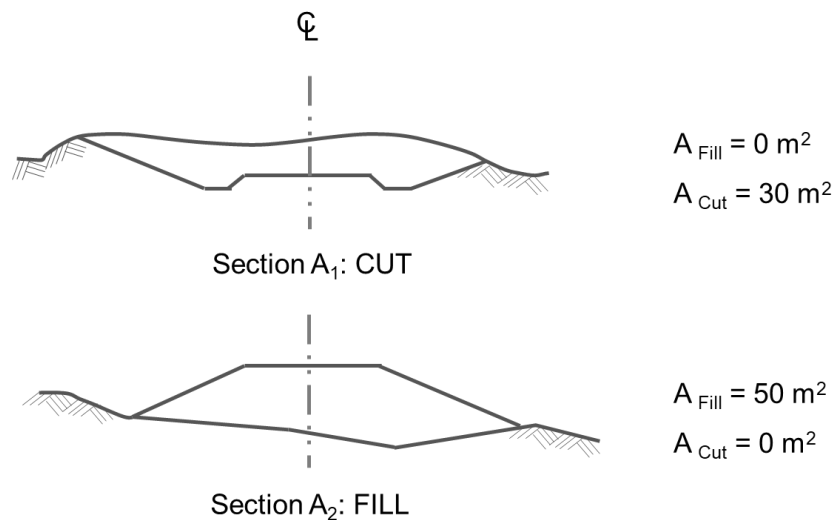
- (A) 100 m
- (B) 103.5 m
- (C) 95.6 m
- (D) 103 m

100. A construction project requires the calculation of earthwork volume for a section of a road. The section has the following properties:

Length of The section $L = 300$ meters

Cross sectional area at the beginning of the section $A_1 = 30 \text{ m}^2$ (cut)

Cross sectional area at the end of the section $A_2 = 50 \text{ m}^2$ (fill)



- A. 12000 m^3
- B. 15000 m^3
- C. 18000 m^3
- D. 9000 m^3

101. Determine the external distance (E) for a horizontal curve with a radius (R) of 600 m and a central angle (Δ) of 45 degrees.

- (A) 49.2 m
- (B) 75.67 m
- (C) 101.10 m
- (D) 125.50 m

102. A project involves the construction of a reinforced concrete slab with a length of 50 feet, width of 30 feet, and thickness of 6 inches. The cost of concrete is \$110 per cubic yard, and the cost of rebar is \$1,500 per ton. Rebar is required at 120 pounds per cubic yard of concrete. Calculate the total cost of materials for the slab.

- (A) \$5,560
- (B) \$8,160
- (C) \$9,560
- (D) \$10,660

103. A project manager uses the Program Evaluation and Review Technique (PERT) to estimate the duration of a critical task. The optimistic time (O) is 4 days, the pessimistic time (P) is 10 days, and the most likely time (M) is 6 days. Calculate the expected duration (TE) and the standard deviation for the task.

- (A) 6.33 days, 1 day
- (B) 4.25 days, 0 day
- (C) 6.33 days, 11 days
- (D) 7.53 days, 3 days

104. An estimator is evaluating the cost of installing a new water pipeline. The pipeline is 2 miles long and requires 200 pipe sections, each 52.8 feet in length. The cost of each pipe section is \$500. Additionally, installation labor costs \$10 per foot. Calculate the total cost of the pipeline installation.

- (A) \$150,000
- (B) \$205,600
- (C) \$500,000
- (D) \$700,000

105. A contractor is estimating the cost of earthwork for a construction project. The total volume of excavation required is 5,000 cubic yards. The contractor plans to use a bulldozer with an average production rate of 300 cubic yards per hour. The cost of operating the bulldozer, including labor,

fuel, and maintenance, is \$150 per hour. Determine the total cost of excavation.

- (A) \$2,500
- (B) \$3,500
- (C) \$7,500
- (D) \$8,500

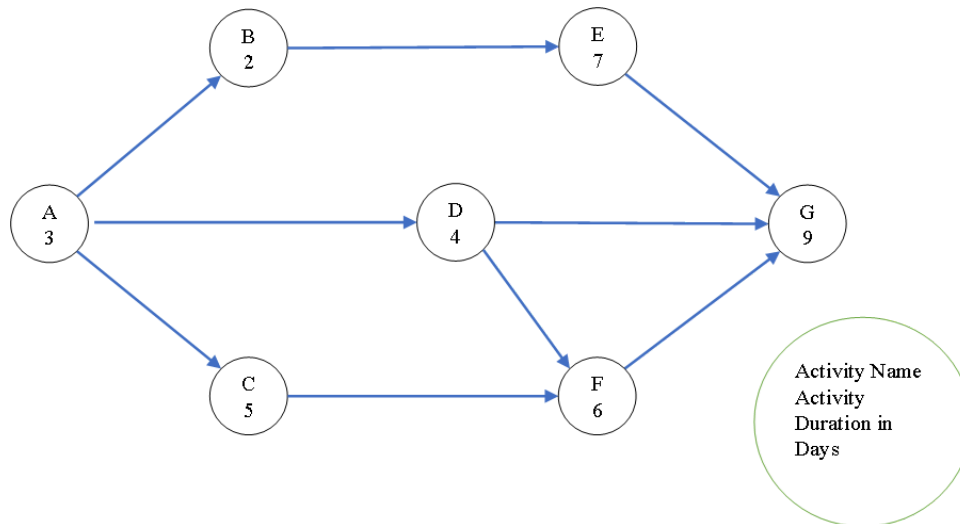
106. A construction project includes paving a 500-foot long road with asphalt. The width of the road is 24 feet and the depth of the asphalt layer is 4 inches. If the unit cost of asphalt paving is \$15 per square yard, calculate the total cost of paving the road.

- (A) \$10,000
- (B) \$12,000
- (C) \$15,000
- (D) \$20,000

107. A contractor is preparing a bid for a construction project that involves 10,000 square feet of roofing. The cost of roofing materials is \$5 per square foot, and labor costs are \$3 per square foot. If the contractor wants to include a 15% profit margin on the total cost, what should be the bid price?

- (A) \$72,000
- (B) \$80,500
- (C) \$92,000
- (D) \$95,500

108. The given figure displays a node diagram representing project activities, with each duration presented in days. All relationships between activities are "finish to start." What is the early start date for activity F?



- A. 6 Days
- B. 7 Days
- C. 8 Days
- D. 9 Days

109. A dam construction project consists of four major work packages, each with different planned and actual completion rates. At a progress review, the following data is collected:

Work Package	Total Budget (\$)	Planned Completion (%)	Actual Completion (%)	Actual Cost (\$)
Excavation	300,000	100%	100%	320,000
Concrete Work	500,000	50%	40%	210,000
Mechanical	400,000	30%	25%	110,000
Electrical	200,000	20%	15%	50,000

Calculate:

1. Cost Variance (CV)

2. Schedule Variance (SV)

- A. $CV = -60,000, SV = -80,000$
- B. $CV = +80,000, SV = +60,000$
- C. $CV = -80,000, SV = +60,000$
- D. $CV = +80,000, SV = -60,000$

110. A project manager is considering two methods for a concrete pour: Method A and Method B. Method A has a fixed cost of \$8,000 and a variable cost of \$100 per cubic yard. Method B has a fixed cost of \$12,000 and a variable cost of \$80 per cubic yard. For a pour of 200 cubic yards, determine the cost-effective method and its total cost.

(A) Method A; \$28,000

(B) Method A; \$30,000

(C) Both Method A and Method B

(D) Method B; \$30,000

Solutions

[Click here for Problems](#)

1. Problem

Correct Answer: (D) 9

Explanation: Find the critical point by setting the first derivative to zero:

$$f'(x) = -2x + 4 = 0$$

$$x = 2$$

Evaluate $f(x)$ at $x = 2$:

$$f(2) = -(2)^2 + 4(2) + 5 = -4 + 8 + 5 = 9$$

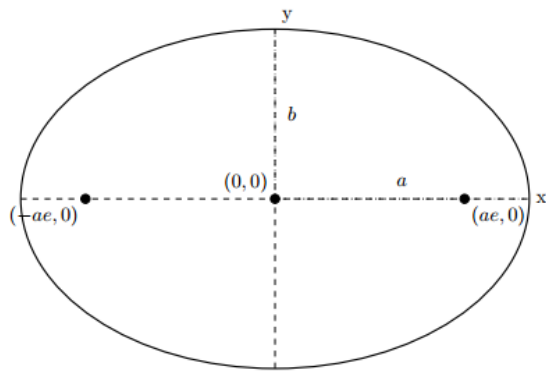
2. Problem

Correct Answer: (C) $e = \sqrt{1 - \frac{b^2}{a^2}}$

Explanation: The eccentricity e of an ellipse is given by $e = \sqrt{1 - \frac{b^2}{a^2}}$

when $a > b$.

Where, a = semi-major axis; b = semi-minor axis, and x, y are the coordinates of any point on the ellipse in a Cartesian coordinate system.



3. Problem

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

Explanation: Step 1: Identify the slope of the given line

The equation of the given line is $y = -3x + 4$. This is in the slope-intercept form $y = mx + b$, where m is the slope and b is the y-intercept.

For the given line:

Slope (m) = -3

Step 2: Understand the property of parallel lines

Parallel lines have the same slope. Therefore, the slope of the line we are trying to find will also be -3 .

Step 3: Use the point-slope form of the equation of a line

The point-slope form of the equation of a line is given by:

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

where:

- m is the slope

- (x_1, y_1) is a point on the line

Given:

- Slope $(m) = -3$
- Point $(x_1, y_1) = (1, 2)$

Step 4: Substitute the given point and slope into the point-slope form
 Substitute $m = -3$, $x_1 = 1$, and $y_1 = 2$ into the point-slope form equation:

$$y - 2 = -3(x - 1)$$

Step 5: Simplify the equation

Expand and simplify the equation to get it into slope-intercept form

$(y = mx + b)$:

$$y - 2 = -3(x - 1)$$

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

Add 2 to both sides of the equation:

$$y = -3x + 3 + 2; y = -3x + 5$$

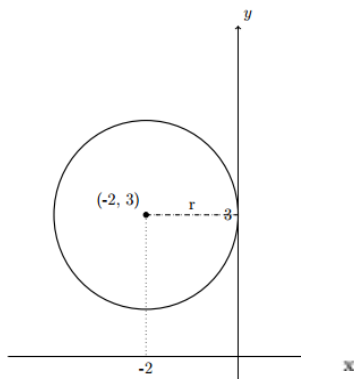
4. Problem

Correct Answer: (A) $(-2, 3)$

Explanation: The general form of the circle equation is $(x-h)^2 + (y-k)^2 = r^2$
 where (h, k) is the center and r is the radius.

$$\text{Here, } \sqrt{(x + 2)^2 + (y - 3)^2} = 4$$

Implies the center is $(-2, 3)$ and the radius is $\sqrt{16} = 4$.



5. Problem

Correct Answer: (C) $(x - 3)^2 + (y - 4)^2 = 8$

Explanation: The center of the circle is the midpoint of the endpoints of the diameter $(1, 2)$ and $(5, 6)$. The midpoint is:

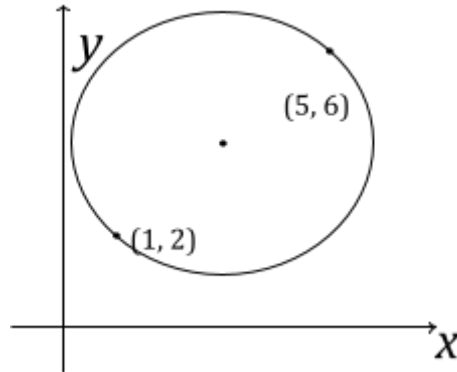
$$\frac{(x+2)^2}{9} + \frac{(y-3)^2}{25} = 1$$

The radius is half the distance between the endpoints:

$$\frac{\sqrt{(5-1)^2 + (6-2)^2}}{2} = \frac{\sqrt{16+16}}{2} = \frac{\sqrt{32}}{2} = \sqrt{8} = 2\sqrt{2}$$

Thus, the equation is:

$$(x - 3)^2 + (y - 4)^2 = 8$$



6. Problem

Correct Answer: (B) $y = x - 1$

Explanation: Step 1: Identify the coordinates of the points

The coordinates of the two points are:

$$(x_1, y_1) = (-1, -2)$$

$$(x_2, y_2) = (4, 3)$$

Step 2: Calculate the slope of the line

The slope (m) of the line passing through two points (x_1, y_1) and

(x_2, y_2) is

given by:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

Substitute the coordinates of the points into the formula:

$$m = \frac{3 - (-2)}{4 - (-1)} = \frac{3 + 2}{4 + 1} = \frac{5}{5} = 1$$

Step 3: Use the point-slope form of the equation of a line. The point-slope form of the equation of a line is:

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

Using the slope $m = 1$ and one of the points, say $(-1, -2)$, the equation becomes: $y - (-2) = 1(x - (-1))$

Simplify: $y + 2 = 1(x + 1)$

Step 4: Simplify to get the equation in slope-intercept form

Distribute and simplify the equation: $y + 2 = x + 1$

Subtract 2 from both sides to solve for y: $y = x + 1 - 2$

$$y = x - 1$$

7. Problem

Correct Answer: A) $4i + 6j - 8k$

Explanation: Two vectors are parallel if one is a scalar multiple of the other.

For $A = 2i + 3j - 4k$, multiplying each component by 2 gives:

$$2 \times (2i + 3j - 4k) = 4i + 6j - 8k$$

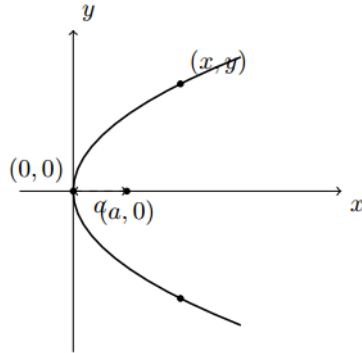
Thus, A and $4i + 6j - 8k$ are parallel.

8. Problem

Correct Answer: (A) $(a, 0)$

Explanation: For the parabola $y^2 = 4ax$, the focus is located at $(a, 0)$

Where, x: horizontal coordinate; y: vertical coordinate;
a: distance from vertex to focus



9. Problem

Correct Answer: (B) 72

Explanation:

The given function is $4x^3 - 2x$.

the antiderivative of $4x^3 - 2x$ is:

$$\int (4x^3 - 2x) dx = x^4 - x^2 + C$$

Apply the Fundamental Theorem of Calculus

$$\int_a^b f(x) dx = F(b) - F(a)$$

Here, $F(x) = x^4 - x^2 + C$. (Where C is the constant of integration)

Evaluate the antiderivative at the bounds

$$F(3) = 3^4 - 3^2 = 81 - 9 = 72 \quad F(1) = 1^4 - 1^2 = 1 - 1 = 0$$

Calculate the definite integral

$$\int_1^3 (4x^3 - 2x)dx = F(3) - F(1) = 72 - 0 = 72$$

10. Problem

Answer: B) Report the issue to the appropriate authority

Explanation: The primary responsibility of engineers, as indicated by various professional codes of ethics, is to ensure the safety, health, and welfare of the public. This responsibility is paramount and takes precedence over all other considerations in the practice of engineering.

11. Problem

Answer: B) The ordinary level of skill and care commonly used by competent practitioners in the field

Explanation: The "standard of care" refers to the level of care and competence that a reasonably prudent engineer would provide under similar circumstances.

12. Problem

Answer: B) Disclose the conflict to all relevant parties

Explanation: Engineers must disclose any conflicts of interest to maintain transparency and uphold ethical standards.

13. Problem

Answer: B) To protect against claims of negligence or errors in professional services

Explanation: Professional liability insurance, also known as errors and omissions insurance, provides coverage for claims of negligence, errors, or omissions in the performance of professional services.

14. Problem

Answer: B) Report the issue to a higher authority

Explanation: Engineers are required to take appropriate actions to ensure public safety, including reporting the issue to a higher authority.

15. Problem

Correct Answer: (B) \$16,288.95

Explanation: Using $FV = PV \times (1 + i)^n$

$$\begin{aligned} FV &= 10,000 \times (1 + 0.05)^{10} \\ &= \$16,288.95 \end{aligned}$$

16. Problem

Correct Answer: (A) \$1187

Explanation: The equivalent annual worth A is calculated using the formula:

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

where P is the present value, i is the annual interest rate, and n is the number of years.

Step 1: Identify the values: $P = 5,000$, $i = 0.06$, $n = 5$.

Step 2: Plug the values into the formula:

$$A = 5,000 \left(\frac{0.06(1+0.06)^5}{(1+0.06)^5 - 1} \right)$$

$$A = 5000 \left(\frac{0.06 \times 1.3382}{1.3382 - 1} \right)$$

$$A = 5000 \times 0.2374$$

$$A = 1,187$$

17. Problem

Correct Answer: B) 2,604 units

Contribution margin per unit for each product:

$$CM_x = 200 - 120 = 80,$$

$$CM_y = 300 - 180 = 120$$

Weighted average contribution margin:

$$\begin{aligned}\text{Weighted CM} &= (80 \times 0.6) + (120 \times 0.4) \\ &= 48 + 48 = 96\end{aligned}$$

Break-even point:

$$\text{Break-even Units} = \text{Fixed Costs} / \text{Weighted CM}$$

$$\text{Break-even Units} = 250,000 / 96 \approx 2,604$$

18. Problem

Correct Answer: (A) \$13,440

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

$$P = \frac{F}{1 + \frac{i}{m})^{mn}}$$

where F is the future amount, i is the annual interest rate, m is the number of compounding periods per year, and n is the number of years.

Step 1: Identify the values: $F = 20,000$, $i = 0.05$, $m = 4$, $n = 8$.

Step 2: Plug the values into the formula:

$$P = \frac{20,000}{(1 + \frac{0.05}{4})^{4 \times 8}}$$

$$P = \frac{20,000}{(1.0125)^{32}}$$

$$P = \frac{20,000}{1.488}$$

$$P = 13,440$$

19. Problem

Correct Answer: (D) \$143.33

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

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

We need to solve for the annuity payment A .

Step 1: Identify the values: $F = 10,000$, $i = 0.06$, $m = 12$, $n = 5$.

Step 2: Rearrange to solve for A :

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

$$A = \frac{10,000 \cdot 0.005}{(1.005)^{60} - 1}$$

$$A = \frac{50}{0.34885}$$

$$A = 143.33$$

20. Problem

Correct Answer: A) A has a higher NPV by \$6.31 (in \$1000)

Calculate the expected discount rate.

Since the discount rate varies uniformly between 8% and 12%:

Expected discount rate $(i) = (8\% + 12\%) / 2 = 10\% = 0.10$

Compute NPVs for both options at $i = 0.10$.

For Option A:

$$NPV_A = -50 + \frac{20}{(1+0.10)^1} + \frac{25}{(1+0.10)^2} + \frac{30}{(1+0.10)^3} = 11.38 \text{ (in \$1000)}$$

For Option B:

$$NPV_B = -50 + \frac{30}{(1+0.10)^1} + \frac{20}{(1+0.10)^2} + \frac{15}{(1+0.10)^3} = 5.07 \text{ (in \$1000)}$$

Compare the NPVs.

Option A has a higher NPV by: $11.38 - 5.07 = 6.31$ (in \$1,000)

21. Problem

Correct Answer: (B.) The force in member CD must be in compression to balance the vertical load

Explanation: To determine the correct answer, we need to analyze the forces acting on joint D and the reactions at the supports.

Vertical Load at Joint D:

- The vertical load of 25 kN acting downward must be balanced by the vertical component of the forces in the members connected to joint D.

Horizontal Load at Joint D:

- The horizontal load of 15 kN acting to the right must be balanced by the horizontal component of the forces in the members connected to joint D.

Force in Member CD:

- Since the vertical load at D is 25 kN downward, the member CD must be in compression to balance this load, pushing upwards at joint D.

Reactions at Supports:

- The horizontal reaction at support A (A_x) must equal 15 kN to balance the horizontal load.

- The vertical reaction at support A (A_y) must equal 25 kN to balance the vertical load.

Therefore, the correct statement is:

(B.) The force in member CD must be in compression to balance the vertical load

22. Problem

Correct Answer: (D) 43.59N at 66.59°

Explanation: Break each force into its components:

$$F_{1x} = 50\cos 30^\circ = 43.3\text{N}, F_{1y} = 50\sin 30^\circ = 25\text{ N}$$

$$F_{2x} = 30\cos 150^\circ = -25.98\text{N}, F_{2y} = 30\sin 150^\circ = 15\text{ N}$$

Summing the components:

$$F_x = F_{1x} + F_{2x} = 43.3 - 25.98 = 17.32\text{ N}$$

$$F_y = F_{1y} + F_{2y} = 25 + 15 = 40\text{ N}$$

The magnitude of the resultant force F is given by: $F = \sqrt{F_x^2 + F_y^2}$

$$F = \sqrt{17.32^2 + 40^2} = 43.59\text{ N}$$

Calculate the direction of the resultant force:

$$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right) = \tan^{-1}\left(\frac{40}{17.32}\right) \approx 66.59^\circ$$

23. Problem

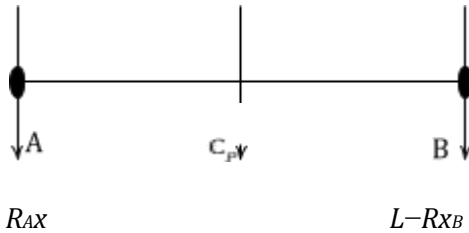
Correct Answer: (A) $R_B \times L - P \times x = 0$

Explanation: Step 1: Identify the Supports and Forces

- Support A: Typically, a pin or hinge support which can resist both vertical and horizontal forces.

- Support B: Typically, a roller support which can resist only vertical forces.
- Point C: The location of the point load P .

Step 2: Set Up the Free Body Diagram (FBD)



Step 3: Assume Distances

- Let the distance from A to C be x .
- Let the distance from C to B be $L - x$, where L is the total length of the beam from A to B.

Step 4: Sum of Moments about Point A

To ensure equilibrium, the sum of moments about point A must be zero.

Step 5: Write the Moment Equations

- Moment due to R_B at point B: $R_B \times L$.
- Moment due to point load P at point C: $P \times x$.

Since R_B produces a counterclockwise moment and P produces a clockwise moment about point A, the equation can be written as:

$$R_B \times L - P \times x = 0$$

Step 6: Rearrange the Equation

Solving for R_B :

$$R_B \times L = P \times x$$

$$R_B = \frac{P \times x}{L}$$

Conclusion

The correct equation representing the sum of moments about point A is:

$$R_B \times L - P \times x = 0$$

24. Problem

Correct Answer: (D) 30 Nm

Explanation: Calculate moments due to each force:

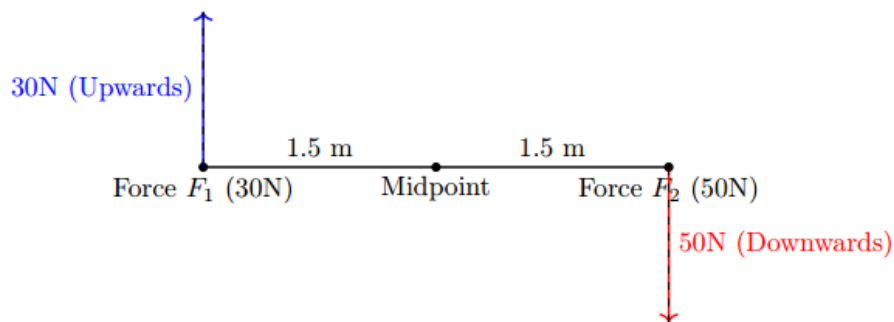
-Upward force on the left side creates a counterclockwise moment.

$$M_1 = -F_1 \times d = -30\text{ N} \times 1.5\text{ m} = -45\text{ Nm}$$

-Downward force on the right side creates a clockwise moment.

$$M_2 = F_2 \times d = 50\text{ N} \times 1.5\text{ m} = 75\text{ Nm}$$

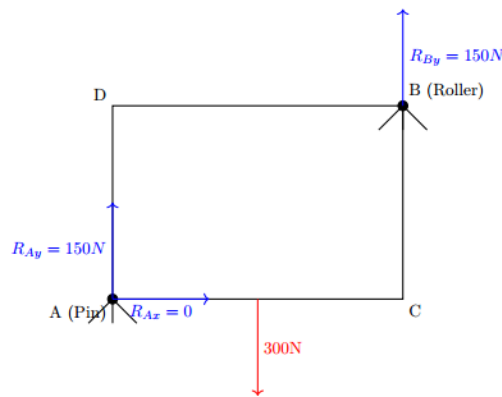
$$M_{\text{net}} = 75 - 45 = 30\text{ Nm}$$



25. Problem

Correct Answer: (D) 0 N

Explanation: For a rectangular frame with a horizontal force at the midpoint, the horizontal reaction at the pin support must be zero to balance the forces.



26. Problem

Correct Answer: (B) 5.77 kN

Explanation: The truss is equilateral and symmetrical. For an equilateral triangle: each internal angle is 60° and each side is of equal length. Since this is an equilateral triangle, $\theta = 60^\circ$.

Since the force 10 kN acts vertically downward, it must be balanced by the vertical components of the forces in members AC and BC.

The vertical equilibrium equation at C is: $F_{AC} \sin(60^\circ) + F_{BC} \sin(60^\circ) = 10 \text{ kN}$

Since the truss is symmetrical, $F_{AC} = F_{BC} \rightarrow 2F_{AC} \sin(60^\circ) = 10$

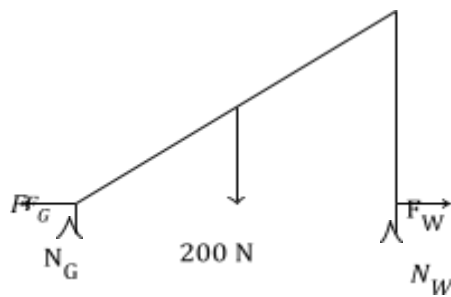
$$2F_{AC} \times \frac{\sqrt{3}}{2} = 10 \Rightarrow F_{AC} = \frac{10}{\sqrt{3}} \rightarrow 5.77 \text{ kN}$$

27. Problem

Correct Answer: (C) 200 N Upward

Explanation: The normal reaction at the ground for a ladder in equilibrium is equal to the weight of the ladder:

$$N_G = 200 \text{ N}$$



28. Problem

Correct Answer: C) $7.3 \times 10^7 \text{ mm}^4$

The moment of inertia for a hollow circle about its centroidal axis is:

$$I = \frac{\pi}{4} (R_o^4 - R_i^4)$$

Substitute $R_o = 100 \text{ mm}$ and $R_i = 50 \text{ mm}$:

$$I = \frac{\pi}{4} (100^4 - 50^4)$$

$$I = \frac{\pi}{4} (10^8 - (6.25 \times 10^6))$$

$$I = 7.3 \times 10^7 \text{ mm}^4$$

29. Problem

Correct Answer: (A) (12, 2, 12)

Explanation:

$$v(t) = \frac{dr(t)}{dt} = (6t, 2, 3t^2) \rightarrow v(2) = (6 \times 2, 2, 3 \times 2^2) \rightarrow v(2) = (12, 2, 12)$$

30. Problem

Correct Answer: B) $2.25 \text{ kg} \cdot \text{m}^2$

Using the parallel axis theorem:

$$I_{\text{new}} = I_{\text{center}} + Md^2$$

where $d = 0.3 \text{ m}$, $M = 5 \text{ kg}$, and $I_{\text{center}} = MR^2$.

Calculate I_{center} :

$$I_{\text{center}} = 5 \times (0.6)^2 = 5 \times 0.36 = 1.8 \text{ kg} \cdot \text{m}^2$$

Apply the parallel axis theorem:

$$I_{\text{new}} = 1.8 + 5 \times (0.3)^2 = 1.8 + 5 \times 0.09 = 1.8 + 0.45 = 2.25 \text{ kg} \cdot \text{m}^2$$

31. Problem

Correct Answer: (A) 5 m

Explanation: Using the formula for maximum height $h = u^2 \sin^2 \theta / 2g$, where:

- $u = 20 \text{ m/s}$ (initial speed)
- $\theta = 30^\circ$ (angle of launch)
- $g = 9.8 \text{ m/s}^2$ (acceleration due to gravity)

$$h = 20^2 \sin^2 30^\circ / 2 \times 9.8$$

$$= 400 \times 0.25 / 19.6$$

$$=100/19.6 \approx 5.1 \text{ m}$$

32. Problem

Correct Answer: B) $2.0 \text{ kg}\cdot\text{m}^2/\text{s}$

The angular momentum L of a particle moving in a circular path is given by:

$$L = I \omega$$

where $I = mr^2$ is the moment of inertia of the particle, and ω is the angular velocity.

Substitute $m = 2 \text{ kg}$, $r = 0.5 \text{ m}$, and $\omega = 4 \text{ rad/s}$:

$$I = 2 \times (0.5)^2 = 2 \times 0.25 = 0.5 \text{ kg}\cdot\text{m}^2$$

Now, calculate the angular momentum:

$$L = 0.5 \times 4 = 2.0 \text{ kg}\cdot\text{m}^2/\text{s}$$

33. Problem

Correct Answer: D) 170 m

Break the initial velocity into components:

$$u_x = u \cos\theta = 40 \cos 30^\circ = 40 \times 0.866 = 34.64 \text{ m/s}$$

$$u_y = u \sin\theta = 40 \sin 30^\circ = 40 \times 0.5 = 20 \text{ m/s}$$

Use the vertical motion equation to find the total time of flight. The vertical position is given by:

$$y = u_y t - \frac{1}{2} (gt^2)$$

The projectile hits the ground when $y = -20 \text{ m}$:

$$-20 = 20t - \frac{1}{2}(9.81)t^2$$

$$0 = 4.905t^2 - 20t - 20$$

Solve this quadratic equation:

$$t = \frac{-(-20) \pm \sqrt{(-20)^2 - 4(4.905)(-20)}}{2(4.905)}$$

$$t = \frac{20 \pm 28.14}{9.81} = + 4.9, - 0.82$$

Since time cannot be negative, we take $t \approx 4.9\text{s}$ as the time of flight

Now calculate the horizontal range:

$$R = u_x \cdot t = 34.64 \times 4.9 \approx 169.7 \approx 170 \text{ m}$$

34. Problem

Correct Answer: (A) 135.3 MPa

Explanation: $\sigma_{vM} = \sqrt{\sigma_x^2 - \sigma_x \sigma_y + \sigma_y^2 + 3\tau_{xy}^2}$

$$\begin{aligned}\sigma_{vM} &= \sqrt{100^2 - 100 \times 50 + 50^2 + 3 \times 60^2} \\ &= \sqrt{10000 - 5000 + 2500 + 10800} = 135.3 \text{ MPa}\end{aligned}$$

$\sigma_{vM} < 250 \text{ MPa}$, hence the material will not yield

35. Problem

Correct Answer: B) 120 GPa

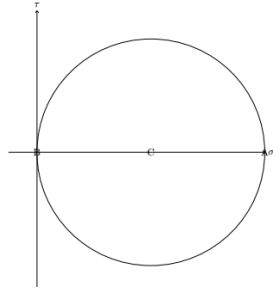
$$\begin{aligned}\sigma_t &= \frac{P \times d}{2t} \\ &= \frac{2000 \times 600}{2 \times 5} = 120 \text{ GPa}\end{aligned}$$

36. Problem

Correct Answer: (D) $20\sqrt{5}$ MPa

Explanation:

$$\text{Center} = \left(\frac{\sigma_x + \sigma_y}{2}, 0 \right) = (40, 0) \rightarrow \text{Radius} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2} \right)^2 + \tau_{xy}^2} = \sqrt{400 + 1600} = 20\sqrt{5}$$



37. Problem

Correct Answer: (A) 62.36 MPa, 17.64 MPa

Explanation:

$$\sigma_1, \sigma_2 = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_1, \sigma_2 = 40 \pm \sqrt{100 + 400} = 40 \pm 22.36 =$$

$$\sigma_1 = 62.36 \text{ MPa}, \sigma_2 = 17.64 \text{ MPa}$$

38. Problem

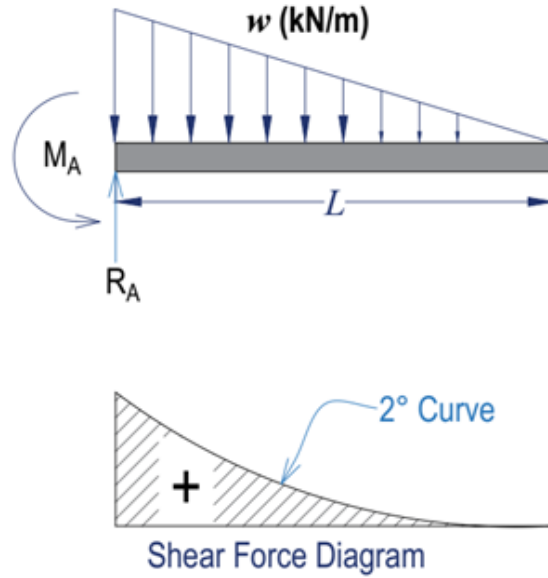
Correct Answer: (A) 318.31 MPa

Explanation:

$$\tau = \frac{Tr}{J} = \frac{500 \times 0.01}{\frac{\pi}{32} \times 0.02^4} = 318.31 \text{ MPa}$$

39. Problem

Correct Answer: A) Horizontal Slope



As the load is zero at the tip, so the resistive bending moment will also be zero leading to horizontal slope.

40. Problem

Correct Answer: (C) 3.18 J

Explanation: $A = \frac{\pi d^2}{4} = \frac{\pi (0.01)^2}{4} = 7.854 \times 10^{-5} m^2$

$$U = \frac{F^2 L}{2EA} = \frac{(10,000 N)^2 \times 1 m}{2 \times 200 \times 10^9 Pa \times 7.854 \times 10^{-5} m^2} = 3.18 J$$

41. Problem

Correct Answer: (A) 0.6 m³

Explanation: Coarse aggregate content =

Total aggregate content – Fine aggregate content = 1600 – 700

= 900 kg/m³

$$\begin{aligned}\text{Volume of coarse aggregates} &= \text{Coarse aggregate content/Bulk density} \\ &= 900/1500 = 0.6 \text{ m}^3\end{aligned}$$

42. Problem

Correct Answer: (C) 52.63 kg

Explanation: Total mix weight = 1000 kg + Bitumen weight

Let B be the bitumen weight:

$$B = 0.05 \times (1000 + B)$$

Solving for B:

$$B = 52.63 \text{ kg}$$

43. Problem

Correct Answer: (D) 4 kg

Explanation: Convert the percentage dosage to a decimal:

$$\text{Dosage (decimal form)} = \frac{0.8}{100} = 0.008$$

Amount of super plasticizer = Dosage (decimal form) × Weight of cement

$$\text{Amount of super plasticizer} = 0.008 \times 500 \text{ kg}$$

$$\text{Amount of super plasticizer} = 4 \text{ kg}$$

44. Problem

Correct Answer: (A) 470.58 kg/m³

Explanation:

$$\text{Cement content} = \frac{\text{Water content}}{\text{Efficiency factor} \times \text{Water-cement ratio}} \rightarrow \frac{180}{0.85 \times 0.45} = 470.58 \text{ kg/m}^3$$

45. Problem

Correct Answer: (B) 636.67 kg, 1273.33 kg

Explanation: Water mass = $0.4 \times 350 \text{ kg} = 140 \text{ kg}$

Total mass of aggregates = $2400 \text{ kg} - (350 \text{ kg} + 140 \text{ kg}) = 1910 \text{ kg}$

Total aggregates part = $1 + 2 = 3$

Fine aggregate = $\frac{1}{3} \times 1910 \text{ kg} = 636.67 \text{ kg}$

Coarse aggregate = $\frac{2}{3} \times 1910 \text{ kg} = 1273.33 \text{ kg}$

46. Problem

Correct Answer: B) 1.25

Calculate the cross-sectional area of the cylinder:

The cylinder's diameter is 200 mm, so the radius is 100 mm or 0.1 meters.

$$\text{Area (A)} = \pi * r^2 = \pi * (0.1 \text{ m})^2 \approx 0.0314 \text{ m}^2$$

Calculate the maximum compressive stress:

$$\text{Compressive stress } (\sigma) = \text{Force (F)} / \text{Area (A)}$$

$$\sigma = 1,000 \text{ kN} / 0.0314 \text{ m}^2 = 1,000,000 \text{ N} / 0.0314 \text{ m}^2 \approx 31.83 \text{ MPa}$$

Calculate the safety factor:

$$\text{Safety factor} = \text{Compressive strength} / \text{Maximum compressive stress}$$

$$\text{Safety factor} = 40 \text{ MPa} / 31.83 \text{ MPa} \approx 1.25$$

47. Problem

Correct Answer: (C) $0.0304 \text{ m}^3/\text{s}$

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

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

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.

$$A_1 = \pi \left(\frac{150}{2} \right)^2 = 0.0177 \text{ m}^2 \rightarrow A_2 = \pi \left(\frac{75}{2} \right)^2 = 0.00442 \text{ m}^2 \rightarrow \Delta P = 20 \text{ kPa} = 20,000 \text{ Pa}$$

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

$$Q = 0.0177 \times 0.00442 \sqrt{\frac{2 \times 20000}{900 (0.0177^2 - 0.00442^2)}} =$$

$$= 0.0304 \text{ m}^3/\text{s}$$

48. Problem

Correct Answer: B) $0.067 \text{ m}^3/\text{s}$

The flow through a submerged orifice is given by:

$$Q = C_d A \sqrt{2gh}$$

Substituting the given values:

$$Q = 0.62 \times 0.02 \sqrt{2 \times 9.81 \times 1.5}$$

$$Q = 0.067 \text{ m}^3/\text{s}$$

49. Problem

Correct Answer: (A) $0.0276 \text{ m}^3/\text{s}$

Explanation: The flow rate at standard conditions (Q_2) can be calculated using the ideal gas law, which states that:

$$\frac{P_1 V}{T_1} = \frac{P_2 V_2}{T_2}$$

Since Q represents the volumetric flow rate, we can rearrange this equation to solve for Q_2 :

$$Q_2 = Q_1 \cdot \frac{P_1}{P_2} \cdot \frac{T_2}{T_1}$$

Given:

- Initial flow rate (Q_1) = 0.02 m³/s
- Initial pressure (P_1) = 150 kPa
- Initial temperature (T_1) = 20°C = 293.15 K (20 + 273.15)
- Standard pressure (P_2) = 101.3 kPa
- Standard temperature (T_2) = 0°C = 273.15 K

$$Q = 0.02 \text{ m}^3/\text{s}$$

$$P = 150 \text{ kPa}$$

$$P_{\text{standard}} = 101.3 \text{ kPa}$$

$$T = 20 + 273 = 293 \text{ K}$$

$$T_{\text{standard}} = 0 + 273 = 273 \text{ K}$$

$$Q_{\text{standard}} = 0.02 \frac{150}{101.3} \frac{273}{293} = 0.0276 \text{ m}^3/\text{s}$$

50. Problem

Correct Answer: (B) 10815.5

Explanation:

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

$$Q = 0.1 \text{ m}^3/\text{s}$$

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

$$v = \frac{Q}{A} = \frac{0.1}{\pi \left(\frac{100}{2}\right)^2} = 12.73 \text{ m/s}$$

$$\rho = 850 \text{ kg/m}^3$$

$$\mu = 0.1 \text{ Pa}\cdot\text{s}$$

$$\text{Reynolds number} = (850 \times 12.73 \times 0.1)/0.1$$

$$= 10815.5$$

51. Problem

Correct Answer: (B) $3.95 \text{ m}^3/\text{s}$

Explanation: The formula is derived from the application of Bernoulli's equation and the continuity equation.

$$Q = A\sqrt{\frac{2\Delta P}{\rho}}$$

This formula is typically used in the context of flow measurement devices like orifice plates, Venturi meters, and nozzles.

The formula can be derived as:

Bernoulli's Equation:

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho gh_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho gh_2$$

For a horizontal flow (ignoring height differences, $h_1=h_2$):

$$P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho V_2^2$$

$$\Delta P = P_1 - P_2$$

$$\Delta P = \frac{1}{2}\rho(V_2^2 - V_1^2)$$

$$A_1 V_1 = A_2 V_2 = Q$$

$$\Delta P = \frac{1}{2}\rho V_2^2 \quad V_2 = \sqrt{\frac{2\Delta P}{\rho}}$$

$$Q = AV_2 = A\sqrt{\frac{2\Delta P}{\rho}}$$

$$A = \pi(150/2)^2 = 0.0177 \text{ m}^2$$

$$\Delta P = 30 \text{ kPa} = 30,000 \text{ Pa}$$

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

$$Q = 0.0177\sqrt{\frac{2 \times 30000}{1.2}} = 3.95 \text{ m}^3/\text{s}$$

52. Problem

Correct Answer: A) 1200 kPa

Power Equation:

$$\text{Power} = \rho g Q h_{\text{pump}}$$

where h is the head added by the pump.

$$100000 \text{ W} = (1000)(9.81)(0.1)h$$

$$h_{\text{pump}} = 101.94 \text{ m}$$

Bernoulli's Equation (with pump head):

$$P_1/\rho g + V_1^2/2g + z_1 + h_{\text{pump}} = P_2/\rho g + V_2^2/2g + z_2$$

Since the inlet and outlet diameters are the same, $V_1 = V_2$.

Also the change in elevation is negligible, $z_1 = z_2$. Thus:

$$P_1/\rho g + h_{\text{pump}} = P_2/\rho g.$$

Outlet Pressure:

$$P_2 = P_1 + \rho g h_{\text{pump}} = 200000 + (1000)(9.81)(101.94) = 200000 + 1000031$$

$$P_2 = 1200031 \text{ Pa or } 1200 \text{ kPa.}$$

53. Problem

Correct Answer: (B) 8 m/s

Explanation:

$$A_1 = \frac{\pi D_1^2}{4} \rightarrow A_2 = \frac{\pi D_2^2}{4} \rightarrow A_1 = \frac{\pi(0.3)^2}{4} \rightarrow A_2 = \frac{\pi(0.15)^2}{4} \rightarrow A_1 = 0.0707m^2 \rightarrow A_2 = 0.0177m^2$$

$$Q = A_1 V_1 = A_2 V_2 \rightarrow \text{Where } Q = \text{Flow Rate} \rightarrow A = \text{Area of the pipe} \rightarrow V = \text{volume}$$

$$V_2 = \frac{A_1 V_1}{A_2} = \frac{0.0707m^2/s}{0.0177m^2} = 8 \text{ m/s}$$

54. Problem

Correct Answer: (C) 111.8 m

Explanation: Solving by Pythagorean theorem:

$$D = \sqrt{(100)^2 + (50)^2}$$

$$D = \sqrt{(10000 + 2500)}$$

$$D = \sqrt{12500}$$

$$D = 111.8 \text{ m}$$

55. Problem

Correct Answer: (C) 36 m^2

Explanation:

$$A = \frac{h}{2} \left(y_0 + 2 \sum_{i=1}^{n-1} y_i + y_n \right) \rightarrow h = 2m \rightarrow A = \frac{2}{2} (3 + 2(5 + 7) + 9) = 36m^2$$

56. Problem

Correct Answer: A) 77.3° W

Calculate the "True" relative to the False Easting:

$$\text{True Easting} = \text{Easting} - \text{False Easting}$$

$$\text{True Easting} = 600,000 \text{ m} - 300,000 \text{ m} = 300,000 \text{ m}$$

Apply the Scale Factor:

$$\text{Adjusted Easting} = \text{True Easting} / \text{Scale Factor}$$

$$\text{Adjusted Easting} = 300,000 \text{ m} / 0.9998 = 300,060 \text{ m (approximately)}$$

We can use the earth's radius and convert to degrees.

$$\text{Longitude Difference (in degrees)} \approx \text{Adjusted Easting} / \text{Earth's Radius} * (180/\pi)$$

$$\text{Longitude Difference (in degrees)} \approx (300,060 \text{ m} / 6,371,000 \text{ m}) * (180/\pi)$$

$$\text{Longitude Difference (in degrees)} \approx 2.7^\circ$$

Calculate the Approximate Longitude:

$$\text{Longitude} \approx \text{Central Meridian} - \text{Longitude}$$

$$\text{Difference Longitude} = 80^\circ \text{ W} - 2.7^\circ$$

$$\text{Longitude} = 77.3^\circ \text{ W}$$

57. Problem

Correct Answer: (B) 24 m^2

Explanation:

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

$$h = 1 \text{ m}$$

$$A = \frac{1}{2} (2 + 2(4 + 6 + 8) + 10)$$

$$A = \frac{1}{2} (2 + 36 + 10)$$

$$A = \frac{1}{2} \times 48$$

$$A = 24 \text{ m}^2$$

58. Problem

Correct Answer: (C) 67.5 m^2

Explanation:

$$A = \frac{h}{2} \left(y_0 + 2 \sum_{i=1}^{n-1} y_i + y_n \right) \rightarrow h = 2.5 \text{ m} \rightarrow A = \frac{2.5}{2} (1 + 2(3 + 6 + 10) + 15)$$

$$A = \frac{2.5}{2} (1 + 38 + 15) \rightarrow A = \frac{2.5}{2} \times 54 \rightarrow A = 67.5 \text{ m}^2$$

59. Problem

Correct Answer: (B) 23.67 m^2

Explanation:

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

$$h = 1 \text{ m}$$

$$A = 1/3 (1 + 4(4 + 8) + 2(6) + 10)$$

$$A = 1/3 (1 + 48 + 12 + 10)$$

$$A = 1/3 \times 71$$

$$A = 23.67 \text{ m}^2$$

60. Problem

Correct Answer: (D) -9577487.3 m

Explanation:

$$\lambda_0 = -87^\circ, k_0 = 0.9996, \lambda = -90^\circ, \phi = 45^\circ$$

$$\Delta\lambda = \lambda - \lambda_0 \rightarrow \Delta\lambda = -90^\circ - (-87^\circ) = -3^\circ$$

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

$$N = \frac{a}{\sqrt{1-e^2 \sin^2 \phi}} = \frac{6378137}{\sqrt{1-0.081819191^2 \sin^2 45^\circ}} \rightarrow = 6388838.29$$

$$X = 0.9996 \cdot 6388838.29 \cdot (-3) \cdot \cos 45^\circ \rightarrow X = 0.9996 \cdot 6388838.29 \cdot (-3) \cdot 0.707$$

$$X = -13537619.1 \times 0.707 = -9577487.3 \text{ m}$$

61. Problem

Correct Answer: (A) 192 kPa

Explanation: Using Bernoulli equation

$$\begin{aligned} \frac{v_1^2}{2} + \frac{P_1}{\rho} + z_1 &= \frac{v_2^2}{2} + \frac{P_2}{\rho} + z_2 \\ \frac{3^2}{2} + \frac{200000}{1000} &= \frac{5^2}{2} + \frac{P_2}{1000} \\ 4.5 + 200 &= 12.5 + \frac{P_2}{1000} \\ 204.5 &= 12.5 + \frac{P_2}{1000} \\ P_2 &= (204.5 - 12.5) \times 1000 \\ P_2 &= 192000 P_a \\ P_2 &= 192 \text{ kPa} \end{aligned}$$

62. Problem

Correct Answer: (C) 1.05 m

Explanation:

$$h_f = \frac{10.67 L Q^{1.85}}{C^{1.85} D^{4.87}}, L = 150 \text{ m}, Q = 0.4 \text{ m}^3/\text{s}, C = 130, D = 0.5 \text{ m}$$

$$h_f = \frac{10.67 \times 150 \times (0.4)^{1.85}}{(130)^{1.85} \times (0.5)^{4.87}} = \frac{10.67 \times 150 \times 0.183}{8143.2 \times 0.0341} = \frac{292.9}{277.68} = 1.05 \text{ m}$$

63. Problem

Correct Answer: (D) 11.40 m³/s

Explanation: Using Manning equation

$$Q = \frac{1}{n} AR^{\frac{2}{3}} S^{\frac{1}{2}}$$

$$A = by$$

$$A = 3 \times 2$$

$$A = 6\text{m}^2$$

$$P = b + 2y$$

$$P = 3 + 2 \times 2$$

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

$$R = \frac{A}{P}$$

$$R = \frac{6}{7}$$

$$R = 0.857\text{m}$$

$$Q = \frac{1}{0.015} \times 6 \times (0.857)^{\frac{2}{3}} \times (0.001)^{\frac{1}{2}}$$

$$Q = 66.67 \times 6 \times 0.9022 \times 0.0316$$

$$Q = 11.40 \text{ m}^3/\text{s}$$

64. Problem

Correct Answer: (D) 6.27 m/s

Explanation:

$$V = \sqrt{2g(h_1 - h_2)}$$

$$h_1 = 3\text{m}$$

$$h_2 = 1\text{m}$$

$$g = 9.81\text{m/s}^2$$

$$V = \sqrt{2 \times 9.81 \times (3 - 1)}$$

$$V = \sqrt{2 \times 9.81 \times 2}$$

$$V = \sqrt{39.24}$$

$$V = 6.27\text{m/s}$$

65. Problem

Correct Answer: (B) 833.1 kPa

Explanation: Using Darcy-Weisbach equation

$$\Delta P = f \frac{L}{D} \frac{\rho V^2}{2}$$

where:

ΔP = pressure drop, f = friction factor, L = length of pipe, D = diameter, and ρ = density of the fluid

$$A = \frac{\pi D^2}{4} \rightarrow \frac{\pi(0.3)^2}{4} \rightarrow 0.0707 \text{ m}^2$$

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

$$\Delta P = 0.02 \frac{500}{0.3} \frac{1000 \times (7.07)^2}{2}$$

$$\Delta P = 0.02 \times 1666.67 \times 24992.45$$

$$\Delta P = 833.1$$

66. Problem

Correct Answer: (B) 2.91 m

Explanation:

$$h_f = f \frac{L}{D} \frac{V^2}{2g}$$

$$A = \frac{\pi D^2}{4}$$

$$A = \frac{\pi(0.4)^2}{4}$$

$$A = 0.1256 \text{ m}^2$$

$$V = \frac{Q}{A}$$

$$V = \frac{0.3}{0.1256}$$

$$V = 2.39 \text{ m/s}$$

$$h_f = 0.02 \frac{200}{0.4} \frac{(2.39)^2}{2 \times 9.81}$$

$$h_f = 0.02 \times 500 \times 0.291$$

$$h_f = 2.91 \text{ m}$$

67. Problem

Correct Answer: (A) 8.41 kW

Explanation: Using the pump power equation

$$\begin{aligned}P &= \frac{\rho g Q H}{\eta} \\ \rho &= 1000 \text{ kg/m}^3 \\ g &= 9.81 \text{ m/s}^2 \\ Q &= 0.02 \text{ m}^3/\text{s} \\ H &= 30 \text{ m} \\ \eta &= 0.70 \\ P &= \frac{1000 \times 9.81 \times 0.02 \times 30}{0.70} \\ P &= \frac{5886}{0.70} \\ P &= 8408.57 \text{ W} \\ P &= 8.41 \text{ kW}\end{aligned}$$

68. Problem

Correct Answer: (D) 147.15%

Explanation:

$$\begin{aligned}\eta &= \frac{\rho g Q H}{P} \\ \rho &= 1000 \text{ kg/m}^3 \\ g &= 9.81 \text{ m/s}^2 \\ Q &= 0.05 \text{ m}^3/\text{s} \\ H &= 15 \text{ m} \\ P &= 5000 \text{ W} \\ \eta &= \frac{1000 \times 9.81 \times 0.05 \times 15}{5000} \\ \eta &= \frac{7357.5}{5000}\end{aligned}$$

$$\eta = 1.4715 \Rightarrow \eta = 1.4715 \times 100 = 147.15\%$$

Note: The calculated efficiency exceeds 100%, which is not physically possible. The values in this problem are hypothetical and intended solely for practice.

69. Problem

Correct Answer: (C) $1.06 \text{ m}^3/\text{s}$

Explanation: Using Hazen-Williams equation

$$Q = 0.278CD^{2.63}S^{0.54}$$

$$S = \frac{h_f}{L}$$

$$S = \frac{5}{100}$$

$$S = 0.05$$

$$Q = 0.278 \times 120 \times (0.5)^{2.63} \times (0.05)^{0.54}$$

$$Q = 0.278 \times 120 \times 0.1615 \times 0.1983 \Rightarrow 1.06 \text{ m}^3/\text{s}$$

70. Problem

Correct Answer: (A) 1.24 m

Explanation:

$$A = by + my^2$$

$$A = 4 \times 2 + 2 \times 2^2$$

$$A = 8 + 8$$

$$A = 16\text{m}^2$$

$$P = b + 2y\sqrt{1 + m^2}$$

$$P = 4 + 2 \times 2\sqrt{1 + 2^2}$$

$$P = 4 + 4 \times \sqrt{5}$$

$$P = 4 + 8.94$$

$$P = 12.94\text{m}$$

$$R = \frac{A}{P}$$

$$R = \frac{16}{12.94}$$

$$R = 1.24\text{m}$$

71. Problem

Correct Answer: (D) 225 kN

Explanation:

Nominal block shear strength: $V_n = 0.6 \times A_v \times F_y + A_t \times F_u$

$$V_n = 0.6 \times 400 \times 250 + 600 \times 400 = 60,000 + 240,000 = 300,000 \text{ N} = 300 \text{ kN}$$

Design block shear strength: $\phi V_n = 0.75 \times 300 = 225 \text{ kN}$

72. Problem

Correct Answer: B) 0.27

Determine Stiffness of Members at B

For moment distribution method, the stiffness of each span is determined as follows:

For AB (Fixed to Intermediate Joint)

$$K_{AB} = \frac{4EI}{L} = \frac{4EI}{5}$$

For BC (Intermediate to Simply Supported Joint)

$$K_{BC} = \frac{3EI}{L} = \frac{3EI}{10}$$

Since EI is constant, it cancels out in the distribution factor calculations.

Compute Distribution Factors at Joint B

The distribution factor for BC at B:

$$DF_{BC} = \frac{K_{BC}}{K_{AB} + K_{BC}} = DF = \frac{3/10}{(4/5) + (3/10)} = 0.27$$

73. Problem

Correct Answer: A) 750 lb/ft

Calculate the volume of concrete per linear foot of the beam:

$$\text{Thickness} = 6 \text{ inches} = 0.5 \text{ feet}$$

$$\text{Width} = 10 \text{ feet (tributary width)}$$

$$\text{Volume} = 0.5 \text{ ft} \times 10 \text{ ft} \times 1 \text{ ft} = 5 \text{ ft}^3$$

Calculate the dead load:

$$\text{Density of concrete} = 150 \text{ lb/ft}^3$$

$$\text{Dead load} = 150 \text{ lb/ft}^3 \times 5 \text{ ft}^3 = 750 \text{ lb/ft}$$

Calculate Dead Load per Square Foot

Dead load (ws) is calculated as:

$$w = \text{Density} \times \text{Thickness} = 150 \times 0.5 = 75 \text{ psf}$$

Convert to Load per Linear Foot of Beam

The beam carries the load from its tributary width (10 ft), so:

$$w_{\text{beam}} = w \times \text{Tributary Width} = 75 \times 10 = 750 \text{ lb/ft}$$

74. Problem

Correct Answer: A) 84.18 kips

The design shear strength is calculated as:

$$\phi_v V_n = \phi_v 0.6 F_y A_w C_v$$

Calculate the web area (A_w):

$$A_w = h \times t_w = 12.2 \times 0.23 = 2.806 \text{ in}^2$$

Substitute the values:

$$\phi_v V_n = 1.0 \times 0.6 \times 50 \times 2.806 \times 1.0 = 84.18 \text{ kips}$$

75. Problem

Correct Answer: (B) 221.6 kN

Explanation:

Nominal shear strength: $V_c = 0.17\sqrt{f'_c}bd$

$$V_c = 0.17\sqrt{35} \times 0.35 \times 0.6 = 221.6 \text{ kN}$$

76. Problem

Correct Answer: (B)

Explanation:

$$M_{AB} = \frac{EI}{L}(2\theta_A + \theta_B) + M_f$$

77. Problem

Correct Answer: (A) $\Phi = 0.90$

Explanation:

$$\text{Reduction factor: } \phi = 0.65 + \frac{(0.005 - 0.002)}{(0.005 - 0.002)} \times (0.9 - 0.65) = 0.9$$

78. Problem

Correct Answer: B) $I_x < I_y$

A column buckles about the axis with the smaller moment of inertia since buckling occurs in the weaker direction.

The weaker axis means smaller moment of inertia.

Thus, the correct relation is:

$$I_x < I_y$$

79. Problem

Correct Answer: (B) 243 kN

Explanation:

Nominal tensile strength: $T_n = A_e \times F_y = 900 \times 300 = 270,000 \text{ N} = 270 \text{ kN}$

Design tensile strength: $\phi T_n = 0.9 \times 270 = 243 \text{ kN}$

80. Problem

Correct Answer: (B) $\frac{625}{2EI}$

Explanation:

Load on conjugate beam: Linear varying load from 0 at free end to wL/EI at the fixed end.

Moment at the free end of the conjugate beam:

$$M = \frac{1}{2} \times 5 \times \frac{2 \cdot 5}{EI} = \frac{25}{EI}$$

Deflection at the free end:

$$\delta = \frac{M_{max} L^2}{2EI} = \frac{25 \cdot 5^2}{2 \cdot EI} = \frac{625}{2EI}$$

81. Problem

Correct Answer: (A) 150 kN

Explanation:

Nominal strength: $T_n = \text{number of bolts} \times \text{shear strength per bolt} = 4 \times 50 = 200 \text{ kN}$

Design strength: $\phi T_n = 0.75 \times 200 = 150 \text{ kN}$

82. Problem

Correct Answer: (A) $R_f = 4.17\%$

Explanation: The friction ratio (R_f) is given by:

$$R_f = \frac{f_s}{q_c} \times 100\%$$

$$R_f = \frac{0.5 \text{ MPa}}{12 \text{ MPa}} \times 100\% = 4.17\%$$

83. Problem

Correct Answer: (B) A-4

Explanation: Using the AASHTO Soil Classification System: - 45% passing the No. 200 sieve, liquid limit = 30%, and plasticity index = 10% classifies the soil as A-4. See table on page 266 of the FE Reference Handbook 10.4

Additional Notes:

- Group Index (GI): This value is used to further evaluate the quality of the soil and is calculated based on the soil's particle size distribution and plasticity. Lower values indicate better quality for road and pavement construction.
- Plasticity Index (PI): This value measures the plasticity of the soil. $PI = \text{Liquid Limit} - \text{Plastic Limit}$.

Explanation of Terms:

- Granular Materials: Soils with a significant proportion of particles larger than 0.075 mm (retained on a No. 200 sieve).
- Fine-Grained Soils: Soils with a significant proportion of particles smaller than 0.075 mm (passing the No. 200 sieve).
- PI (Plasticity Index): The range of moisture content over which the soil remains plastic.

- Liquid Limit (LL): The water content at which soil changes from a plastic state to a liquid state.
- Plastic Limit (PL): The water content at which soil changes from a semi-solid state to a plastic state.

84. Problem

Correct Answer: (D) 0.209

Explanation: The compression index (C_c) is given by:

$$C_c = \frac{\Delta e}{\log\left(\frac{\sigma_2}{\sigma_1}\right)}$$

$$\Delta e = 0.85 - 0.75 = 0.10, \sigma_1 = 50kPa, \sigma_2 = 150kPa$$

$$\log\left(\frac{\sigma_2}{\sigma_1}\right) = \log\left(\frac{150}{50}\right) = \log(3) = 0.477$$

$$C_c = \frac{0.10}{0.477} = 0.209$$

85. Problem

Correct Answer: (A) 0.6

Explanation: The degree of saturation S_r is given by:

$$S_r = \frac{V_w}{V_v} \times 100\%$$

where V_w is the volume of water and V_v is the volume of voids.

$$S_r = \frac{0.15}{0.25} = 0.6$$

86. Problem

Correct Answer: B) $q_a = 56.5 \text{ kN/m}^2$

The ultimate bearing capacity q_{ult} is given by:

$$q_{ult} = cN_c + qN_q + 0.5\gamma BN_\gamma$$

Where:

$$q = \gamma \times D = (18 \times 1.5) = 27 \text{ kN/m}^2 \text{ (overburden pressure)}$$

$$q_{ult} = (25 \times 5.7) + (27 \times 1) + (0.5 \times 18 \times 2.0 \times 0)$$

$$q_{ult} = 142.7 + 27 + 0$$

$$q_{ult} = 169.5 \text{ kN/m}^2$$

The Allowable Bearing Capacity (q_a)

$$q_a = \frac{q_{ult}}{FS}$$

$$q_a = \frac{169.5}{3}$$

$$q_a = 56.5 \text{ kN/m}^2$$

87. Problem

Correct Answer: (C) 96.22%

Explanation: Relative compaction (RC) is given by:

$$RC = \frac{\text{Field dry density}}{\text{Maximum dry density}} \times 100$$

$$RC = \frac{1.78 \text{ g/cm}^3}{1.85 \text{ g/cm}^3} \times 100 = 96.22\%$$

88. Problem

Correct Answer: (B) $\phi = 36.87^\circ$

Explanation: Using the Mohr-Coulomb equation:

$$\tau = c + \sigma \tan \phi \rightarrow \tau = 75 \text{ kPa}, \sigma = 100 \text{ kPa}$$

Assuming zero cohesion for simplicity($c=0$):

$$75 = 0 + 100 \tan \phi \rightarrow \tan \phi = \frac{75}{100} = 0.75 \rightarrow \phi = \tan^{-1}(0.75) = 36.87^\circ$$

89. Problem

Correct Answer: (A) $c=0, \phi=23.2^\circ$

Explanation: The Mohr-Coulomb equation is given by:

$$\tau = c + \sigma \tan \phi, \tau = \frac{\sigma_1 - \sigma_3}{2}, \sigma = \frac{\sigma_1 + \sigma_3}{2}$$

Given:

$$\sigma_1 = 100 + 150 = 250 \text{ kPa}, \sigma_3 = 100 \text{ kPa}, \tau = \frac{250-100}{2} = 75 \text{ kPa}, \sigma = \frac{250+100}{2} = 175 \text{ kPa}$$

Without further data, assuming zero cohesion for simplicity($c=0$):

$$75 = 0 + 175 \tan \phi = \frac{75}{175} = 0.4286 = \tan^{-1}(0.4286) = 23.2^\circ$$

90. Problem

Correct Answer: C) 11.3

Available shearing resistance along slip surface is given by:

$$T_{FF} = cL_s + W_M \cos \alpha_s \tan \phi$$

$$T_{FF} = 500 \times 20 + 3000 \times \cos 20^\circ \times \tan 30^\circ$$

$$T_{FF} = 11,628 \text{ lb}$$

Mobilized shear force along slip surface is given by:

$$T_{MOB} = W_M \sin \alpha_s$$

$$T_{MOB} = 3000 \times \sin 20$$

$$T_{MOB} = 1,026 \text{ lb}$$

The factor of safety against slope instability is given by:

$$FS = T_{FF}/T_{MOB}$$

$$FS = 11,628/1,026$$

$$FS = 11.3$$

91. Problem

Correct Answer: (B) 26.19 kPa

Explanation: The undrained shear strength (τ_u) is given by:

$$\tau_u = \frac{T}{\pi D^2 H/2 + \pi D^3/6} \quad \tau_u = \frac{12}{\pi(0.05)^2(0.10)/2 + \pi(0.05)^3/6} \quad \tau_u = \frac{12}{0.0004581} \approx 26.19 \text{ kPa}$$

92. Problem

Correct Answer: (C) 33.33%

Explanation: The water content w is given by:

$$w = \frac{M_w}{M_s} \times 100\%$$

where M_w is the mass of water and M_s is the mass of solids.

$$M_w = \text{Total mass} - \text{Mass of solids} = 400 - 300 = 100 \text{ kg}$$

$$w = \frac{100}{300} \times 100\% = 33.33\%$$

93. Problem

Correct Answer: (B) 2.5 m

Explanation: The shoulder width for rural highways is influenced by factors such as traffic volume, road type, and safety considerations. According to AASHTO guidelines:

- For rural highways with AADT less than 400 vehicles, narrower shoulders (1.0-2.0 meters) may be acceptable.
- For rural highways with AADT between 400 and 1500 vehicles, a shoulder width of 1.5-2.5 meters is recommended.
- For rural highways with AADT between 1500 and 6000 vehicles, a shoulder width of 2.0-3.0 meters is recommended.
- For rural highways with AADT greater than 6000 vehicles, a shoulder width of 3.0-3.6 meters is recommended.

Given that the AADT in this problem is 5000 vehicles, we fall into the range of 1500 to 6000 vehicles. Taking the average value, the shoulder width will be 2.5 meters.

94. Problem

Correct Answer: (A) 573.57 m

Explanation:

$$L = \frac{\pi}{180} \times R \times \Delta \Rightarrow R = \frac{L \times 180}{\pi \times \Delta} = \frac{200 \times 180}{\pi \times 20} = \frac{36000}{62.83} = 573.57m$$

95. Problem

Correct Answer: (D) 133.95 m

Explanation:

$$T = R \times \tan\left(\frac{\Delta}{2}\right) = 500 \times \tan\left(\frac{30}{2}\right) = 500 \times \tan(15) = 500 \times 0.2679 = 133.95 m$$

96. Problem

Correct Answer: (C) 183.13 m

Explanation:

$$SSD = V \times t + \frac{V^2}{2(a+0.04g)} = \left(\frac{100}{3.6}\right) \times 2.5 + \frac{\left(\frac{100}{3.6}\right)^2}{2 \times (3.0 + 0.04 \times 9.81)} = 69.45 + \frac{771.24}{6.7848} = 183.13m$$

97. Problem

Correct Answer: (C) 157.5 m

Explanation: $g_1 = 0.05$, $g_2 = -0.03$, $L = 500$ m, $y_0 = 150$ m

At midpoint, $x = L/2 = 250$ m.

$$Y = y_0 + g_1 x - \frac{(g_1 - g_2)x^2}{2L} = 150 + 0.05 \times 250 - \frac{(0.05 + 0.03) \times (250)^2}{2 \times 500} = 150 + 12.5 - 5 = 157.5m$$

98. Problem

Correct Answer: (B) 30.52 m

Explanation:

$$Subchord = 2R \sin\left(\frac{\Delta}{2}\right) = 2 \times 350 \times \sin\left(\frac{5}{2}\right) = 700 \times \sin(2.5) = 700 \times 0.0436 = 30.52m$$

99. Problem

Correct Answer: (B) 103.5 m

Explanation: $g_1 = 0.03$, $g_2 = -0.02$, $L = 400$ m, $y_0 = 100$ m

At midpoint, $x = L/2 = 200$ m

$$Y = y_0 + g_1 x - \frac{(g_1 - g_2)x^2}{2L} = 100 + 0.03 \times 200 - \frac{(0.03 + 0.02) \times (200)^2}{2 \times 400} =$$

$$Y = 100 + 6 - \frac{0.05 \times 40000}{800} = 100 + 6 - 2.5 = 103.5m$$

100. Problem

Correct Answer: A) 12000 m³

Using the earthwork formula

$$V = L \times \frac{A_1 + A_2}{2}$$

$$V = 300 \times \frac{30+50}{2}$$

$$V = 12,000 \text{ m}^3$$

101. Problem

Correct Answer: (A) 49.2 m

Explanation:

$$E = R \left(\sec\left(\frac{A}{2}\right) - 1 \right) = 600 \left(\sec\left(\frac{45}{2}\right) - 1 \right) = 600 (\sec(22.5) - 1) = 600 (1.082 - 1) = 49.2 \text{ m}$$

102. Problem

Correct Answer: (A) \$5,560.80

Explanation:

Volume in cubic feet = Length $\times$ Width $\times$ Thickness = 50 feet $\times$ 30 feet $\times$ 0.5 feet = 750 cubic feet

Volume in cubic yards = 750 cubic feet / 27 = 27.78 cubic yards

Cost of concrete = 27.78 cubic yards $\times$ \$110/cubic yard = \$3,055.80

Weight of rebar = 27.78 cubic yards $\times$ 120 pounds / 2,000 pounds per ton

= 1.67 tons

Cost of rebar = 1.67 tons $\times$ \$1,500/ton = \$2,505

Total cost = Cost of concrete + Cost of rebar

= \$3,055.80 + \$2,505 = \$5,560.80

103. Problem

Correct Answer: (A) 6.33 days, 1 day

Explanation:

$$T_E = \frac{O+4M+P}{6} = \frac{4+4(6)+10}{6} = \frac{4+24+10}{6} = \frac{38}{6} \approx 6.33 \text{ days}$$

$$\sigma = \frac{P-O}{6} = \frac{10-4}{6} = \frac{6}{6} = 1 \text{ day}$$

104. Problem

Correct Answer: (B) \$205,600

Explanation:

Total cost of pipe sections = 200 sections $\times$ \$500/section = \$100,000

Total length in feet = 2 miles $\times$ 5,280 feet/mile = 10,560 feet

Labor cost = Total length $\times$ Labor cost per foot = 10,560 feet $\times$ \$10/foot
= \$105,600

Total cost = Total cost of pipe sections + Labor cost = \$100,000 + \$105,600
= \$205,600

105. Problem

Correct Answer: (A) \$2,500

Explanation:

$$\text{Total time} = \frac{\text{Total volume}}{\text{Production rate}} = \frac{5,000 \text{ cubic yards}}{300 \text{ cubic yards per hour}} = 16.67 \text{ hours}$$

Total cost = Total time $\times$ Cost per hour = 16.67 hours $\times$ \$150/hour = \$2,500

106. Problem

Correct Answer: (D) \$20,000

Explanation: Area = Length × Width = 500 feet × 24 feet = 12,000 square feet

$$\text{Area in square yards} = \frac{12,000 \text{ square feet}}{9} = 1,333.33 \text{ square yards}$$

Total cost = Area in square yards × Unit cost = 1,333.33 square yards × \$15/square yard = \$20,000

107. Problem

Correct Answer: (C) \$92,000

Explanation:

Total cost = (Cost of materials + Labor cost) × Total area

$$= (\$5 + \$3) \times 10,000 \text{ square feet} = \$80,000$$

$$\text{Profit margin} = 15\% \times \$80,000 = \$12,000$$

$$\text{Bid price} = \text{Total cost} + \text{Profit margin} = \$80,000 + \$12,000 = \$92,000$$

108. Problem

Correct Answer: C) 8 Days

Activity F has 2 two predecessors i.e. C and D

Early Start Date for Activity F will be the larger of Early Finish Date of 2 Predecessors

$$ES_F = \text{larger of } EF_C = 8 \text{ days and } EF_D = 7 \text{ days}$$

Therefore, $ES_F = 8 \text{ Days}$

109. Problem

Correct Answer: A) CV = -60,000, SV = -80,000

Calculate BCWP (Earned Value) for each work package

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

- Excavation: $100\% \times 300,000 = 300,000$
- Concrete Work: $40\% \times 500,000 = 200,000$
- Mechanical: $25\% \times 400,000 = 100,000$
- Electrical: $15\% \times 200,000 = 30,000$

$$BCWP_{Total} = 300,000 + 200,000 + 100,000 + 30,000 = 630,000$$

Calculate BCWS (Planned Value) for each work package

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

- Excavation: $100\% \times 300,000 = 300,000$
- Concrete Work: $50\% \times 500,000 = 250,000$
- Mechanical: $30\% \times 400,000 = 120,000$
- Electrical: $20\% \times 200,000 = 40,000$

$$BCWS_{Total} = 300,000 + 250,000 + 120,000 + 40,000 = 710,000$$

And ACWP:

$$ACWP_{Total} = 320,000 + 210,000 + 110,000 + 50,000 = 690,000$$

So, CV and SV:

$$CV = BCWP - ACWP$$

$$CV = 630,000 - 690,000 = -60,000$$

$$SV = BCWP - BCWS$$

$$SV = 630,000 - 710,000 = -80,000$$

110. Problem

Correct Answer: (C) Both Method A and Method B

Explanation: Total cost for Method A = Fixed cost + (Variable cost $\times$ Volume)
 $= \$8,000 + (\$100/\text{cubic yard} \times 200 \text{ cubic yards}) = \$28,000$

Total cost for Method B = Fixed cost + (Variable cost × Volume) = \$12,000 + (\$80/cubic yard × 200 cubic yards) = \$28,000

Both Method A and Method B are equally cost-effective for a 200-cubic-yard pour, with a total cost of \$28,000.