

MAY 2015

DR. Z's CORNER

Conquering the FE & PE exams

Examples & Applications

Topics covered in this month's column:

- PE Exam Specifications
(Water Resources & Environmental)
- Mathematics (Analytic Geometry, radical Equations)
- Hydraulics, Fluid Pressure
- Transportation (Compound Curves)
- Transportation (Horizontal Curves-Inaccessible PI)
- Structural Design (Simple Beams)
- Statics and Mechanics of Materials
- Determinate Beams and Frames
- Indeterminate Beams (Continuous Beams)
- Geotechnical (Retaining Wall Pressure Diagrams)
- Technology Usage (Calculator, Casio-115-ES-PLUS)

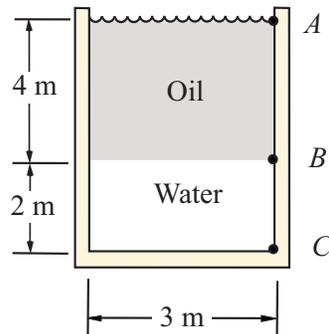
***PE Civil WATER RESOURCES and
ENVIRONMENTAL
Afternoon Depth Exam Specifications
Effective April 2015 Examinations***

A typical breakdown with approximate number of questions:

- **Analysis and Design:** 4 questions,
- **Hydraulics–Closed Conduit:** 5 questions,
- **Hydraulics–Open Channel:** 5 questions,
- **Hydrology:** 7 questions,
- **Groundwater and Wells:** 3 questions,
- **Wastewater Collection and Treatment:** 6 questions,
- **Water Quality:** 3 questions,
- **Drinking Water Distribution and Treatment:** 6 questions,
- **Engineering Economics Analysis:** 1 question.

Problem: (Fluid Pressure)

FE
EXAM



Densities

$$\begin{aligned}\rho_{\text{oil}} &= 850 \text{ kg/m}^3 \\ \rho_{\text{water}} &= 1000 \text{ kg/m}^3\end{aligned}$$

The **square** tank is filled with oil and water as shown in the figure. Using the listed data answer the following questions:

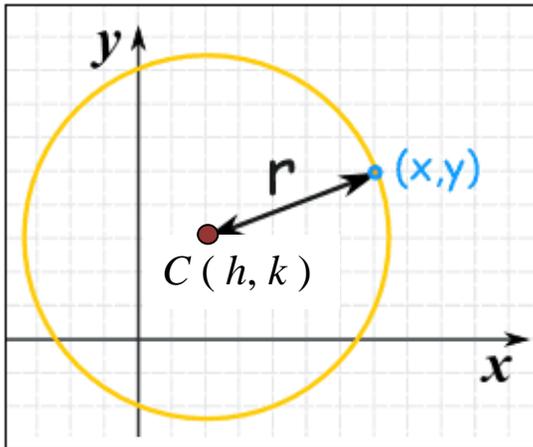
- (1) the fluid pressure (kN/m^2) at point *B* is most nearly
 - (A) 23
 - (B) 35
 - (C) 44
 - (D) 52
- (2) the fluid pressure (kN/m^2) at point *C* is most nearly
 - (A) 71
 - (B) 64
 - (C) 53
 - (D) 48
- (3) the resultant horizontal force (kN) on face *ABC* is most nearly
 - (A) 275
 - (B) 380
 - (C) 408
 - (D) 460
- (4) the location (m) of the resultant from the bottom is most nearly
 - (A) 1.8
 - (B) 2.0
 - (C) 2.5
 - (D) 2.8

FUNDAMENTALS OF ENGINEERING

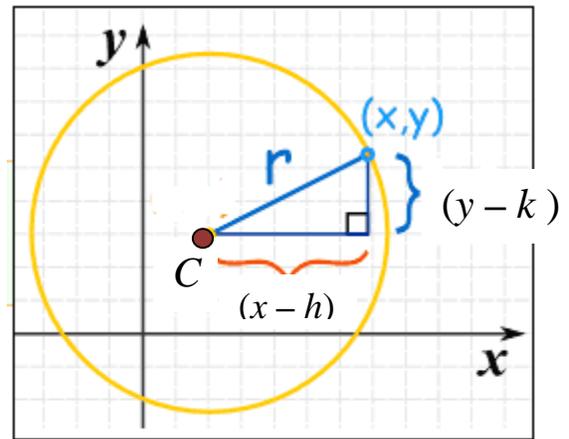
DOMAIN: MATHEMATICS

EQUATION OF A CIRCLE

(NCEES-Ref Handbook / Page-23)



Center: $C(h, k)$



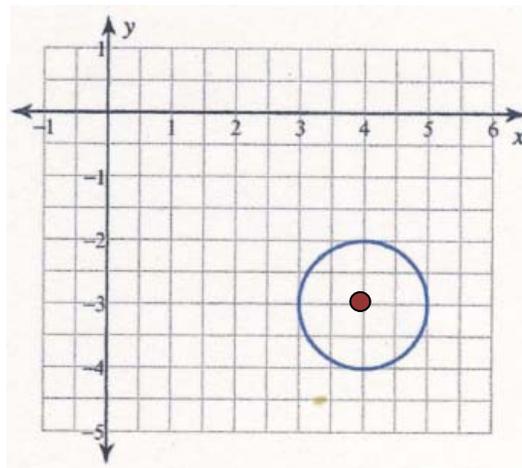
Radius: r

Standard form of Equation of a Circle

$$(x - h)^2 + (y - k)^2 = r^2$$

$$r = \text{SQRT} (x - h)^2 + (y - k)^2$$

Example:



Center: $C(4, -3)$

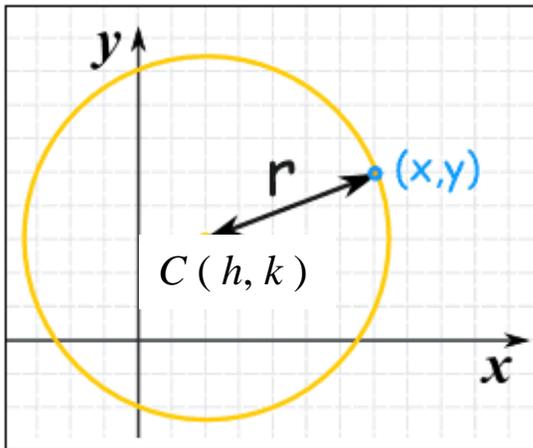
$$(x - 4)^2 + (y + 3)^2 = 1$$

FUNDAMENTALS OF ENGINEERING

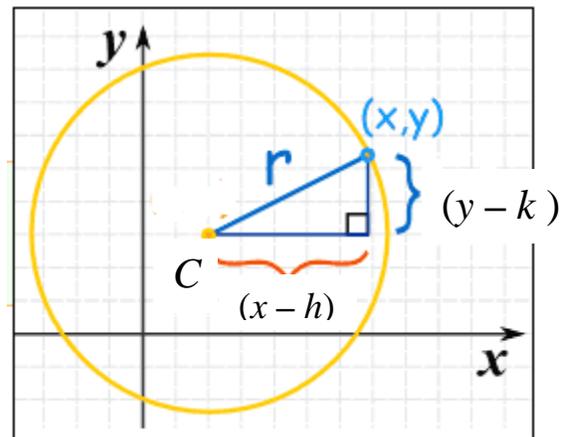
DOMAIN: MATHEMATICS

CIRCLE EQUATIONS

(NCEES-Ref Handbook / Page-23)



Center: $C(h, k)$



Radius: r

Standard form of a Circle Equation:

$$(x - h)^2 + (y - k)^2 = r^2$$

$$r = \text{SQRT} (x - h)^2 + (y - k)^2$$

Example:

The equation of a circle with center at $C(-7, 9)$ and a radius of 5 is:

- (A) $(x - 7)^2 + (y - 9)^2 = 5$
- (B) $(x + 7)^2 + (y - 9)^2 = 5$
- (C) $(x - 7)^2 + (y + 9)^2 = 25$
- ⇒ (D) $(x + 7)^2 + (y - 9)^2 = 25$

RADICAL EQUATIONS

- (1) $x + 3 = \sqrt{5x + 11}$ $x = ?$
- (2) $\sqrt{x} - 1 = 1$
- (3) $\sqrt{x + 1} + \sqrt{x + 6} = 5$
- (4) $y - 2 = \sqrt{y + 4}$
- (5) $\sqrt{-2x + 3} = 2 - x$
- (6) $x - 1 = \sqrt{-4x + 9}$
- (7) $\sqrt{y} + 1 = 5$
- (8) $\sqrt{x - 1} + \sqrt{x + 4} = 5$
- (9) $\sqrt[3]{x - 3} - 2 = 0$
- (10) $\sqrt{y + 1} - \sqrt{2y - 6} = 2$
- (11) $\sqrt{x + 10} - \sqrt{x - 10} = 10$
- (12) $\sqrt{x + 1} - \sqrt{2x + 3} = -1$

$$(13) \quad \sqrt{x+5} + \sqrt{x+2} = 3$$

$$(14) \quad 3 - \sqrt{x} = 2$$

$$(15) \quad \sqrt[3]{5x+17} + 1 = 4$$

$$(16) \quad \sqrt{x+4} + \sqrt{x+1} = 3$$

$$(17) \quad \sqrt{x+8} + \sqrt{x} = 2$$

$$(18) \quad \sqrt{8x-1} = \sqrt{4x+15}$$

$$(19) \quad \sqrt{6x+6} - \sqrt{21-4x} = 5$$

$$(20) \quad \sqrt{8-2x} - \sqrt{4x+17} = 3$$

Answers:

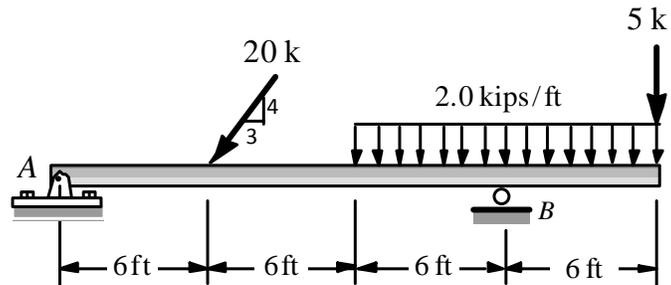
(1) -2, 1 (2) 4 (3) 3 (4) 5 (5) 1

(6) 2 (7) 16 (8) 5 (9) 11 (10) 3

(11) No sol. (12) -1, 3 (13) -1 (14) 1 (15) 2

(16) 0 (17) No sol. (18) 4 (19) 5 (20) -4

STATICS / MECHANICS OF SOLIDS
DETERMINATE BEAMS
SUPPORT REACTIONS



A determinate beam is loaded as shown. Knowing that A is a pin support and B is a roller, answer the following questions:

(1) The horizontal support reaction (kips) at A is most nearly:

- (A) 10.00
- (B) 11.25
- (C) 12.00
- (D) 15.00

$$A_x = ?$$

(2) The vertical support reaction (kips) at B is most nearly:

- (A) 48.55
- (B) 44.00
- (C) 42.30
- (D) 36.00

$$B_y = ?$$

(3) The vertical support reaction (kips) at A is most nearly:

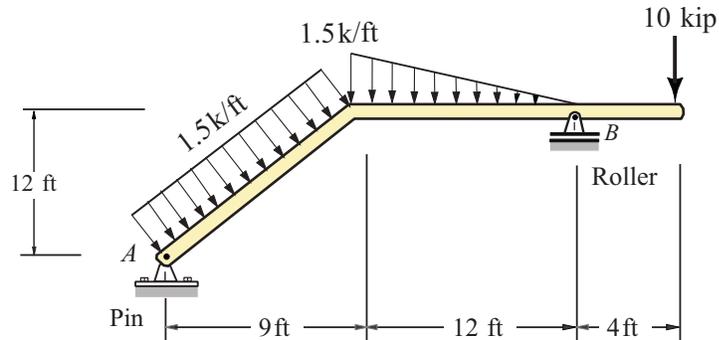
- (A) 8.00
- (B) 9.00
- (C) 10.50
- (D) 12.30

$$A_y = ?$$

STATICS & MECHANICS OF SOLIDS

DETERMINATE FRAMES

SUPPORT REACTIONS



FE/PE
EXAM

Support A : Pin
Support B : Roller

A determinate frame is loaded as shown in the figure. Using the listed support conditions, answer the following questions:

- (1) the magnitude of the horizontal support reaction (kips) at the left support is most nearly, A_x

- (A) 13.0
(B) 14.6
(C) 16.4
(D) 18.0

$$A_x = ?$$

- (2) the magnitude of the vertical support reaction (kips) at the right support is most nearly, B_y

- (A) 15.2
(B) 20.6
(C) 25.5
(D) 38.0

$$B_y = ?$$

- (3) the magnitude of the vertical support reaction (kips) at the left support is most nearly, A_y

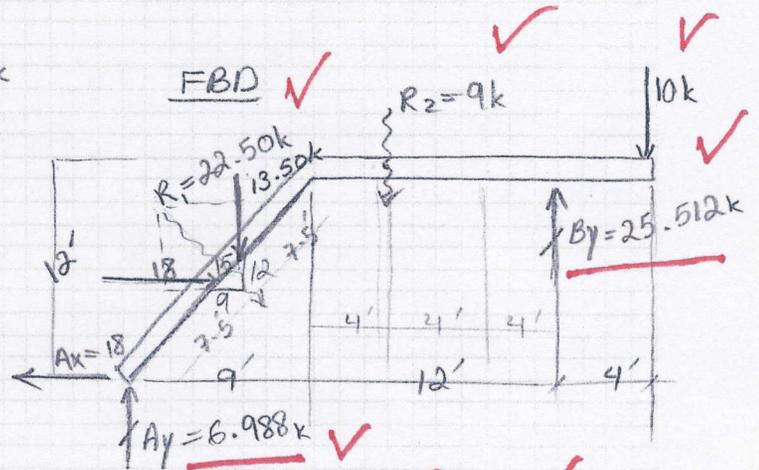
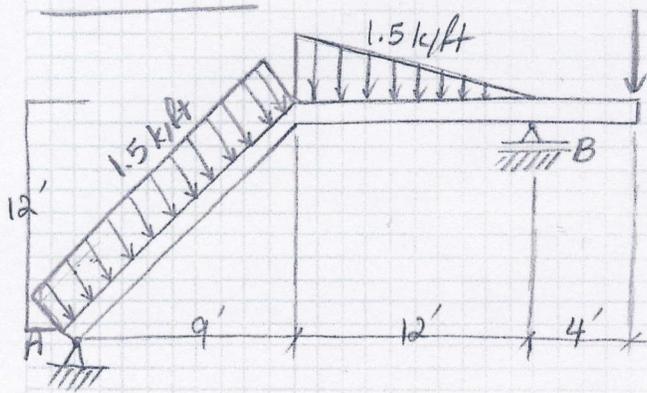
- (A) 5.2
(B) 7.0
(C) 9.1
(D) 12.0

$$A_y = ?$$



COMPLETE
SOLUTION

Problem 48



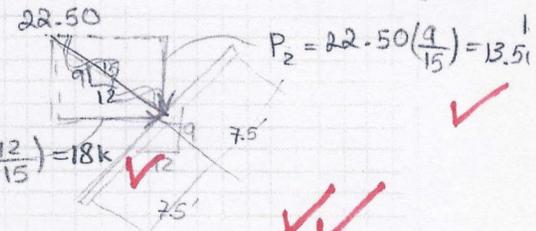
$$R_2 = \frac{(1.5)(12)}{2} = 9k$$

$$R_1 = (1.5)(15) = 22.50k$$

$$\sum F_x = 0;$$

$$18 - A_x = 0$$

$$A_x = 18k \leftarrow$$



$$\sum M_A = 0;$$

$$(22.50)(7.5) + (9)(13) + (10)(25) - 21B_y = 0$$

$$168.750 + 117 + 250 - 21B_y = 0$$

$$B_y = 25.512k \uparrow$$

$$\sum M_B = 0;$$

$$(-10)(4) + (9)(8) + (13.50)(16.5) + (18)(6) - (18)(12) - 21A_y = 0$$

$$-40 + 72 + 222.750 + 108 - 216 - 21A_y = 0$$

$$A_y = 6.988k \uparrow$$

check:

$$A_y + B_y = 10 + 9 + 13.5$$

$$6.988 + 25.512 = 32.500$$

$$32.500 = 32.500 \checkmark$$

O.K.

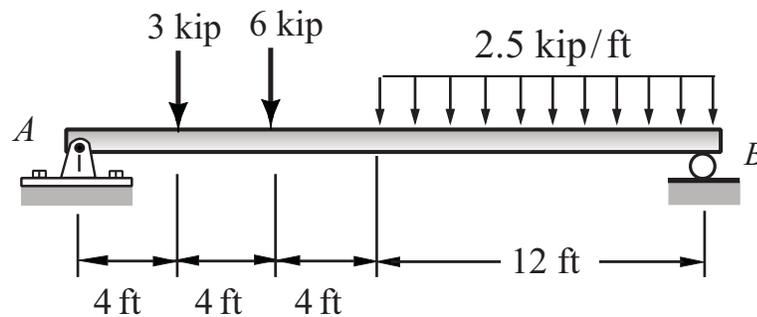
$$\begin{aligned} A_x &= 18k \leftarrow \\ A_y &= 6.99k \uparrow \\ B_y &= 25.51k \uparrow \end{aligned}$$

PERFECT SOLUTION!

MECHANICS OF SOLIDS

BEAM DESIGN

FE/PE
EXAM



Support A : Pin
Support B : Roller

A36 STEEL

A simply supported beam is made of A36 steel and loaded as shown in the figure. Knowing that there is no inplane buckling and using the listed data, answer the following questions:

- (1) the magnitude of the maximum bending moment (k-ft) is most nearly:

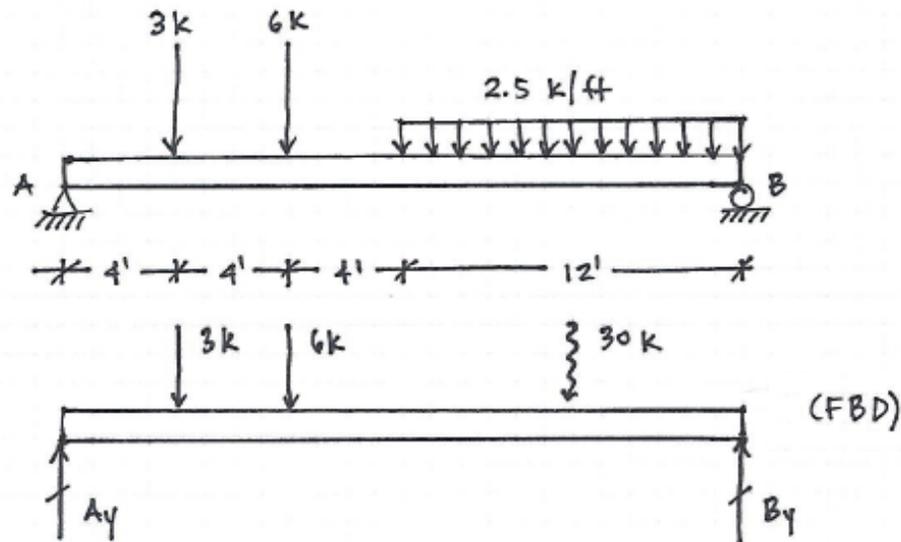
(A) 105
(B) 110
(C) 125
(D) 145

$$M_{\max} = ?$$

- (2) Using the new NCEES Reference Manual (V.9.2) the most economical W-shape is most nearly:

- (A) W 10 x 54
(B) W 12 x 40
(C) W 14 x 43
(D) W 16 x 40

FULL SOLUTION
NEXT PAGE



(a) DETERMINE THE SUPPORT REACTIONS.

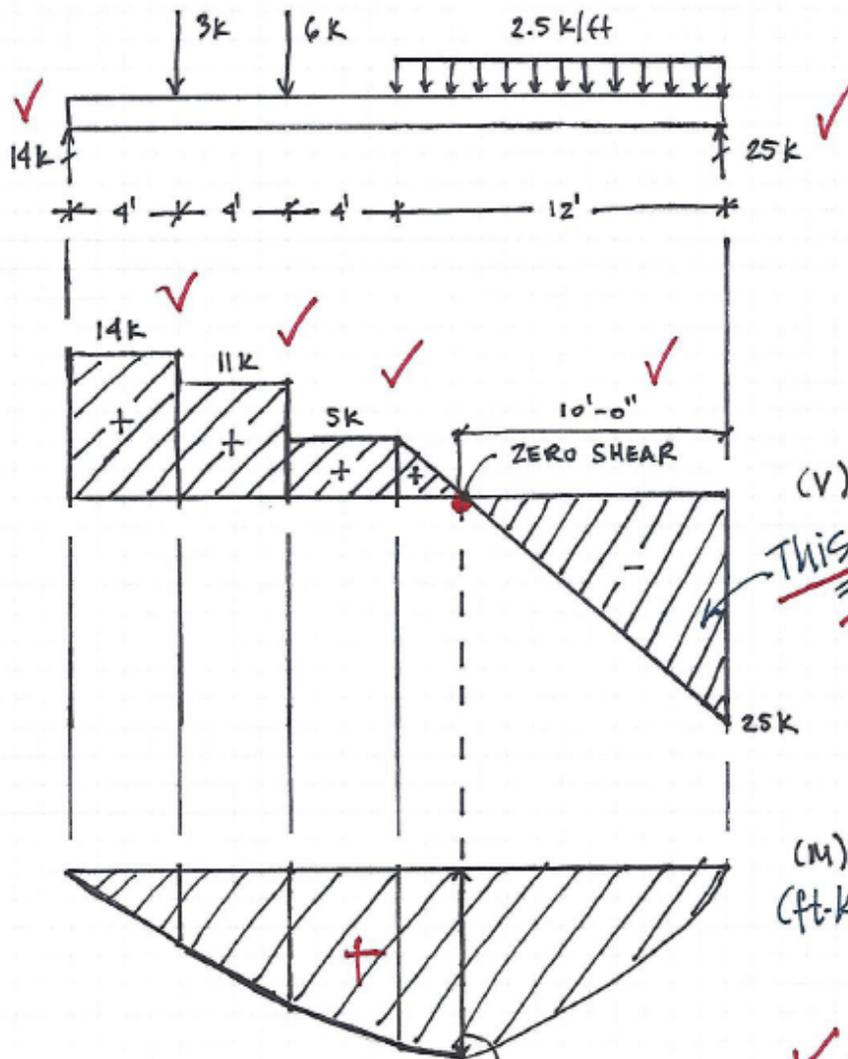
$$\begin{aligned} \sum M_B = 0 & \quad \checkmark \quad \checkmark \quad \checkmark \quad \checkmark \\ (30k)(6') + (6k)(16') + (3k)(20') - 24A_y = 0 \\ 180 + 96 + 60 - 24A_y = 0 & \quad \checkmark \\ 24A_y = 336 & \quad \checkmark \\ \boxed{A_y = 14k} & \quad \checkmark \checkmark \end{aligned}$$

$$\begin{aligned} \sum M_A = 0 & \quad \checkmark \\ (3k)(4') + (6k)(8') + (30k)(18') - 24B_y = 0 & \quad \checkmark \\ 12 + 48 + 540 - 24B_y = 0 & \quad \checkmark \\ 24B_y = 600 & \quad \checkmark \\ \boxed{B_y = 25k} & \quad \checkmark \checkmark \end{aligned}$$

$$\begin{aligned} \text{CHECK: } A_y + B_y & \stackrel{?}{=} 3 + 6 + 30 & \checkmark \\ 14 + 25 & \stackrel{?}{=} 39 \\ 39 & = 39 \quad \text{OK} \checkmark \end{aligned}$$



- (b) DRAW THE SHEAR FORCE DIAGRAM.
(c) DRAW THE MOMENT DIAGRAM.



(V)
This area = M_{max}

$$M_{max} = \frac{1}{2} (10') (25k)$$

$$M_{max} = 125 k \cdot ft \quad \checkmark$$

(M)
(ft-k)

$$S = \frac{M_{max}}{f_{allow}} \quad \checkmark$$

$$S = \frac{(125 k \cdot ft)(12 in.)}{24 k/in^2}$$

$$S = 62.5 in^3 \quad \checkmark$$

SECTION
MODULUS \checkmark

(d) DESIGN THE BEAM.

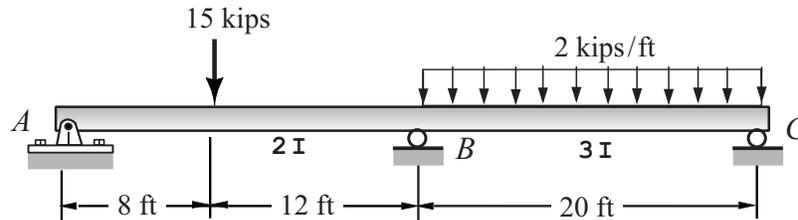
M_{max} = 125 ft-k $\checkmark \checkmark$

- W 16 x 40 (S = 64.7) ← \checkmark
 W 14 x 43 (S = 62.6) \checkmark
 W 12 x 53 (S = 70.6)
 W 10 x 60 (S = 66.7)
 W 10 x 54 (S = 60.0)

EXCELLENT
SOLUTION!
bf.z

STRUCTURAL ANALYSIS

INDETERMINATE BEAM ANALYSIS



FE/PE
EXAM

$$M_B = -70.24 \text{ ft-kips}$$



Support A : Pin
Support B : Roller
Support C : Roller

An indeterminate beam is loaded as shown in the figure. Knowing that the bending moment at support B is given as listed, answer the following questions:

(1) The magnitude of the support reaction at A is most nearly, A_y

- (A) 7.27 kips
- (B) 4.18 kips
- (C) 6.29 kips
- (D) 5.49 kips

$$A_y = ?$$

(2) The magnitude of the support reaction at C is most nearly, C_y

- (A) 18.24 kips
- (B) 17.38 kips
- (C) 16.49 kips
- (D) 15.49 kips

$$C_y = ?$$

(3) The magnitude of the support reaction at B is most nearly, B_y

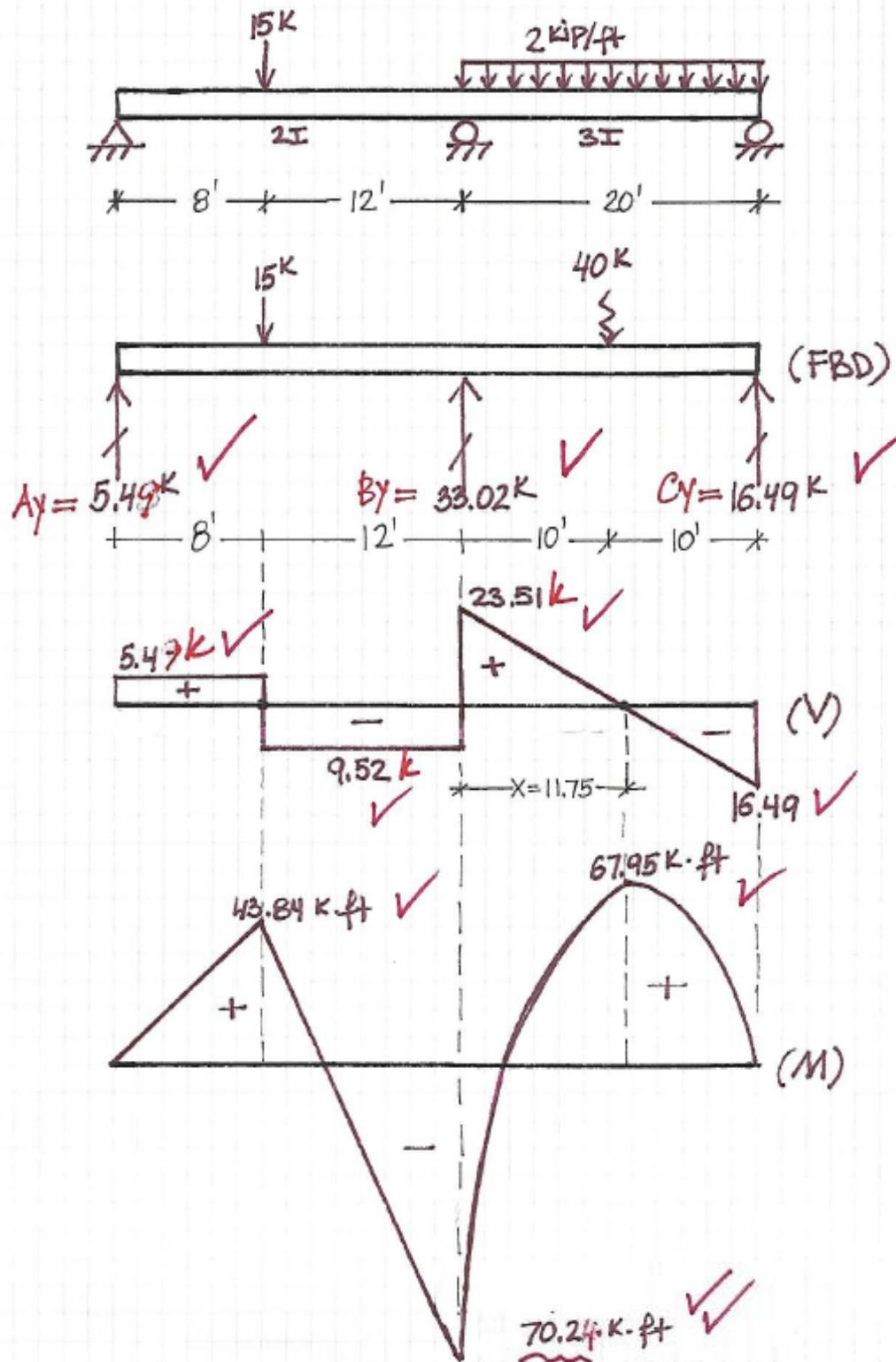
- (A) 42.52 kips
- (B) 33.02 kips
- (C) 26.48 kips
- (D) 20.05 kips

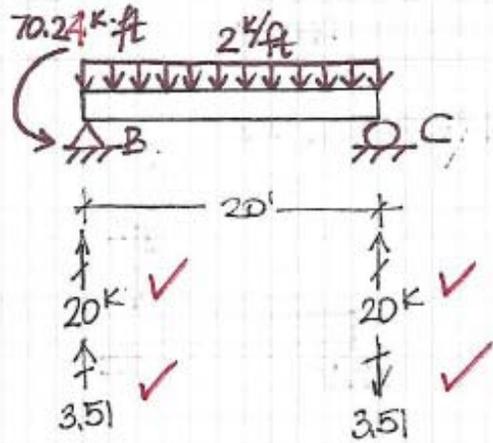
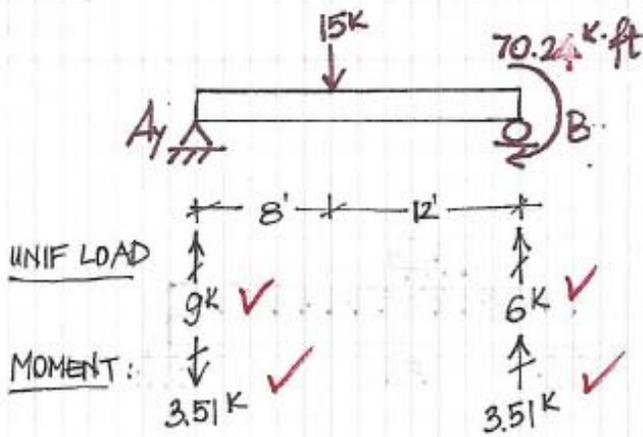
$$B_y = ?$$



COMPLETE
SOLUTION

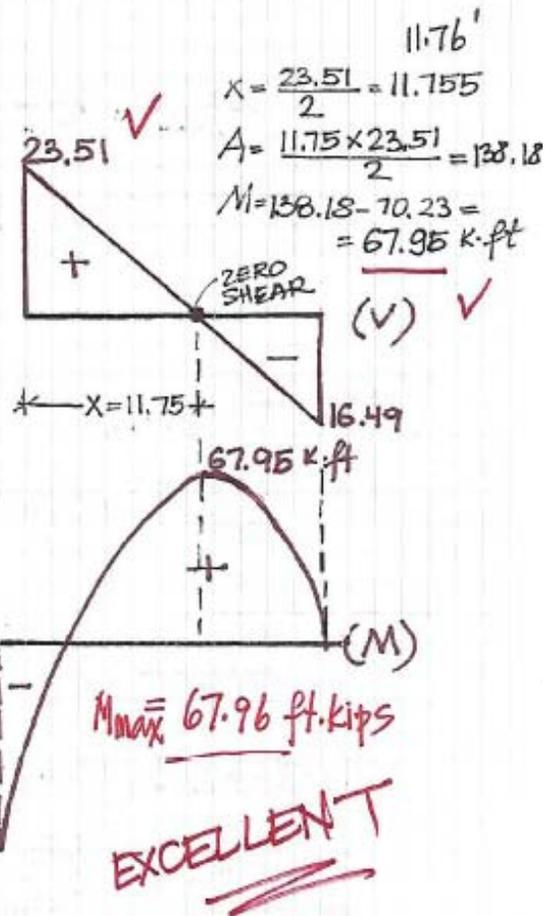
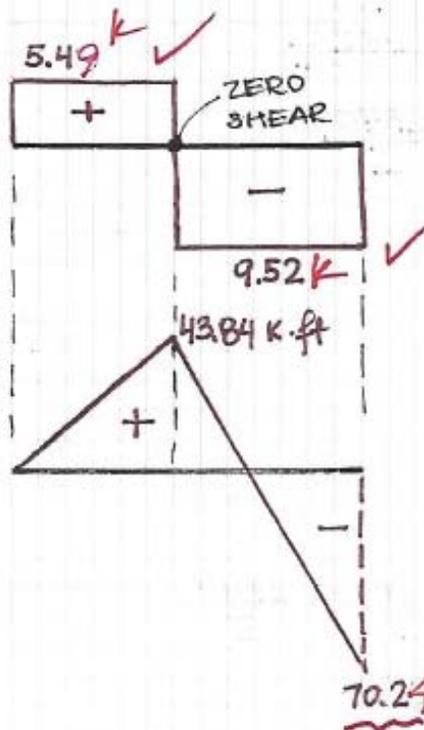
PROBLEM # 3





$$A_y = (15) \left(\frac{12}{20} \right) = 9K \uparrow \checkmark$$

$$B_y = (15) \left(\frac{8}{20} \right) = 6K \uparrow \checkmark$$



$$A_y = 9K - 3.51K = 5.49K \uparrow \checkmark$$

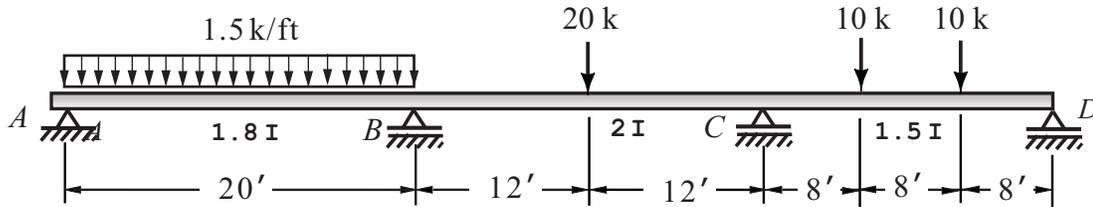
$$B_y = 6K + 3.51K + 20K + 3.51K = 33.02K \uparrow \checkmark$$

$$C_y = 20K - 3.51K = 16.49K \uparrow \checkmark$$

STRUCTURAL ANALYSIS

CONTINUOUS BEAM ANALYSIS

FE/PE
EXAM



$$M_B = -64.49 \text{ ft-kips}$$

$$M_C = -70.47 \text{ ft-kips}$$

Support A : Pin
Support B : Roller
Support C : Roller
Support D : Roller

An indeterminate beam is loaded as shown in the figure. Knowing that the bending moment at supports B and C are given as listed, answer the following questions:

(1) The magnitude of the support reaction at A is most nearly, A_y

- (A) 13.42 kips
- (B) 11.78 kips
- (C) 10.35 kips
- (D) 8.00 kips

$$A_y = ?$$

(2) The magnitude of the support reaction at B is most nearly, B_y

- (A) 16.90 kips
- (B) 20.45 kips
- (C) 23.14 kips
- (D) 27.98 kips

$$B_y = ?$$

(3) The magnitude of the support reaction at C is most nearly, C_y

- (A) 25.72 kips
- (B) 23.19 kips
- (C) 21.16 kips
- (D) 15.22 kips

$$C_y = ?$$

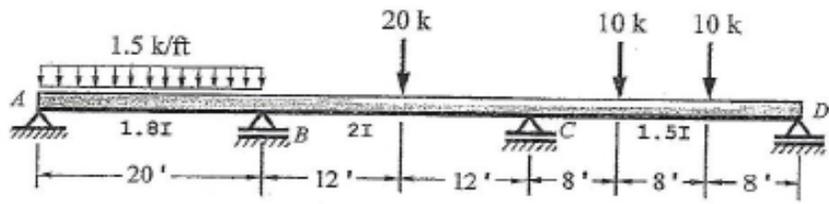


COMPLETE
SOLUTION

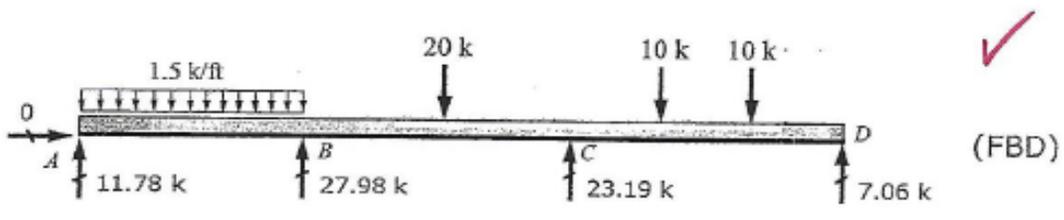
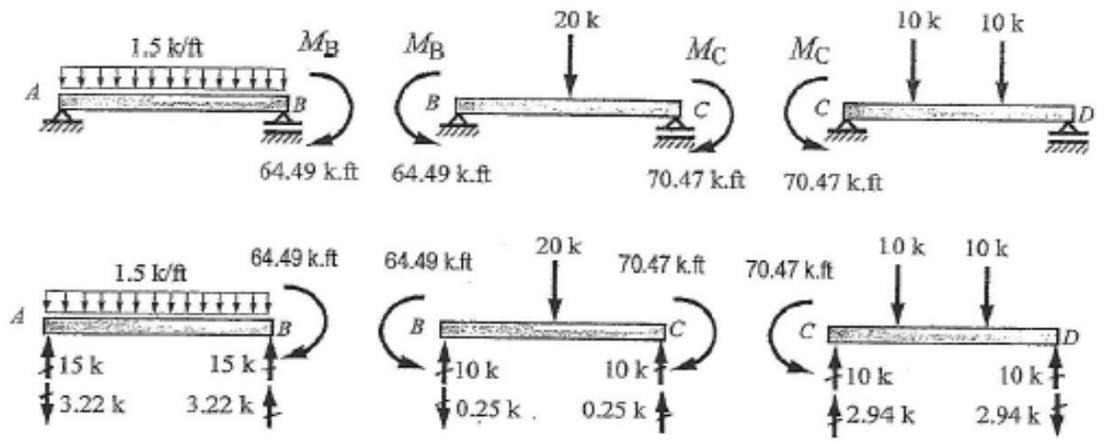
CONTINUOUS BEAMS

$$M_B = -64.49 \text{ k.ft}$$

$$M_C = -70.47 \text{ k.ft}$$



The support moments at B and C are given as listed:
Using this data, determine all support reactions and draw the FBD.



$$A_y = 15 - 3.22 = 11.78 \text{ k} \quad \checkmark$$

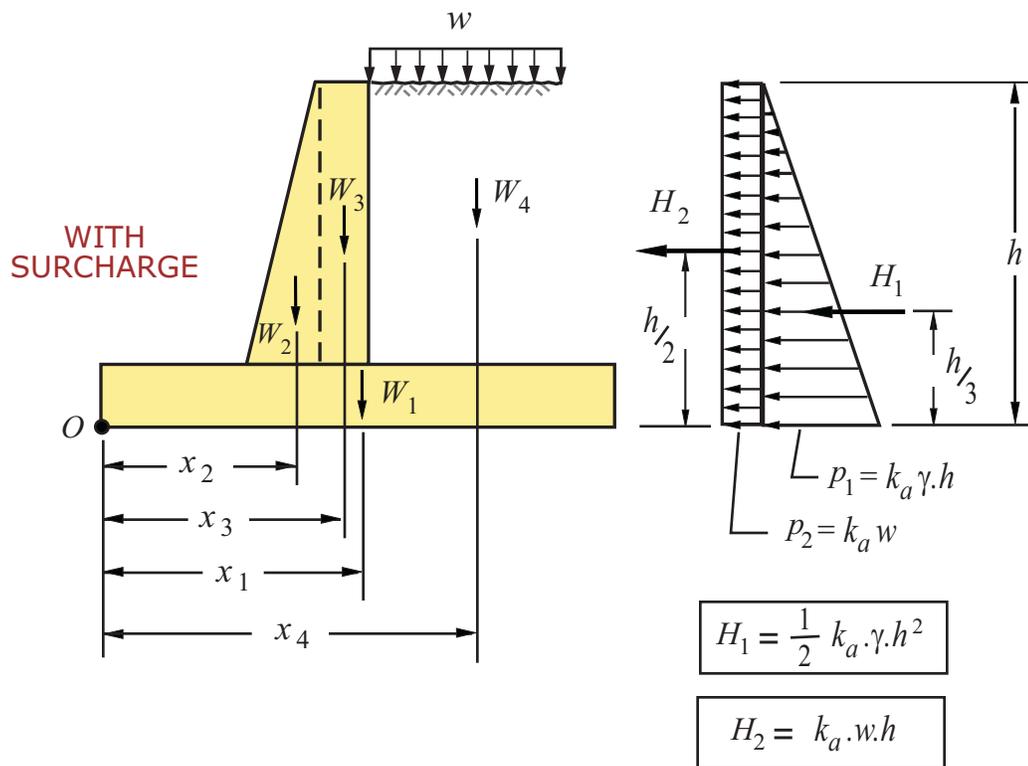
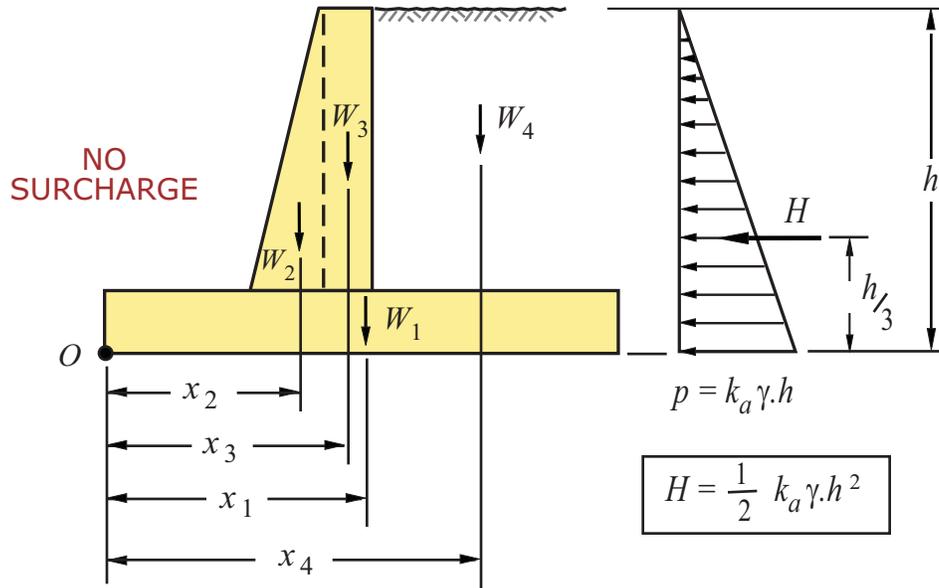
$$B_y = 15 + 3.22 + 10 - 0.25 = 27.98 \text{ k} \quad \checkmark$$

$$C_y = 10 + 0.25 + 10 + 2.94 = 23.19 \text{ k} \quad \checkmark$$

$$D_y = 10 - 2.94 = 7.06 \text{ k} \quad \checkmark$$

CANTILEVER RETAINING WALLS

PRESSURE DIAGRAMS



TRANSPORTATION

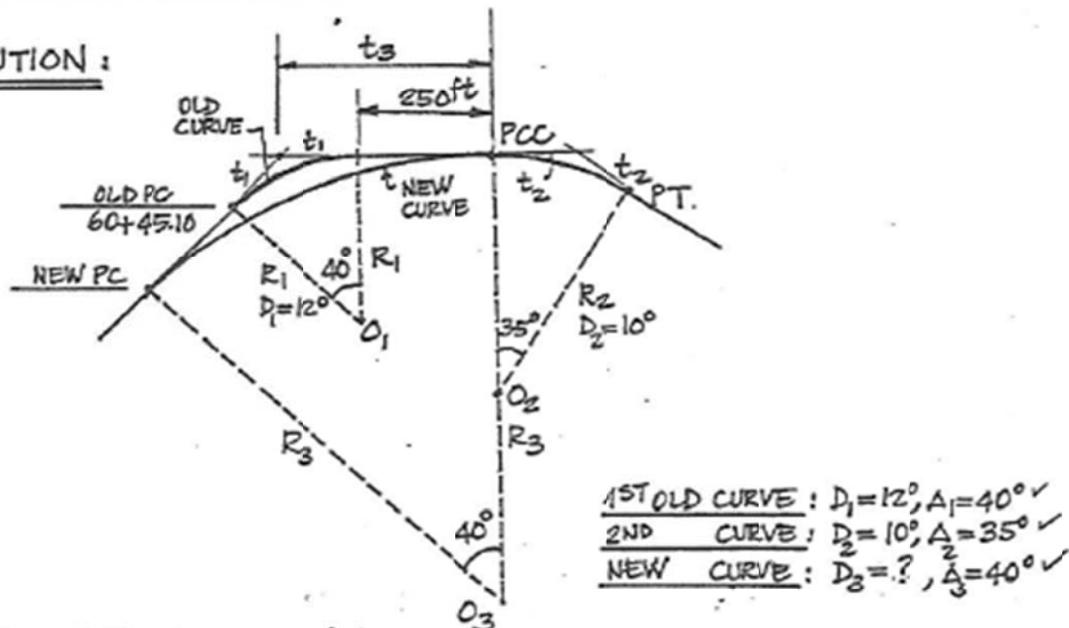
Course : Surveying
 Coordinator : Zeytinci

Problem: (Compound Curve) (W)

A broken back curve consists of a 12° curve with a central angle of $40^\circ 00' 00''$ and PC station of $60+45.10$ and a 10° curve with a central angle of $35^\circ 00' 00''$, connected by 250.00 ft tangent. It is proposed to eliminate the 12° curve and replace with a new curve compounded at the beginning of the 10° curve.

- Find the degree of the proposed new curve.
- Find the station of the new PC.
- Find the station of PCC.
- Find the station of PT.

SOLUTION :



Radius of the old curve: (R_1)

$$R_1 = 5729.58 / D_1 = 5729.58 / 12 = 477.46 \text{ ft } \checkmark$$

Radius of the 2nd curve: (R_2)

$$R_2 = 5729.58 / D_2 = 5729.58 / 10 = 572.96 \text{ ft } \checkmark$$

Tangent distance 1st curve: (t_1)

$$t_1 = R_1 \tan(\Delta_1/2) = (477.46)(\tan 40/2) = 173.78 \text{ ft } \checkmark$$

Tangent distance 2nd curve: (t_2)

$$t_2 = R_2 \tan(\Delta_2/2) = (572.96)(\tan 35/2) = 180.65 \text{ ft } \checkmark$$

Course : Surveying
Coordinator : Zeytinci

Tangent distance of the proposed new curve: (t_3)

$$t_3 = t_1 + 250.00 = 173.78 + 250.00 = 423.78 \text{ ft}$$

Radius of the new proposed curve: (R_3)

$$R_3 = t_3 / \tan(\Delta_3/2) = 423.78 / \tan(40/2) = 1164.33 \text{ ft}$$

Curve length of the 2nd curve: (L_2)

$$L_2 = \frac{\pi}{180} \Delta_2 R_2 = \frac{\pi}{180} (35.00)(572.96) = 350.00 \text{ ft}$$

Curve length of the new curve: (L_3)

$$L_3 = \frac{\pi}{180} \Delta_3 R_3 = \frac{\pi}{180} (40.00)(1164.33) = 812.86 \text{ ft}$$

Degree of curve (new proposed curve): (D_3)

$$D_3 = 5729.58 / R_3 = 5729.58 / 1164.33 = 4.9209^\circ$$

$$D_3 = 4^\circ 55' 15''$$

Station of the new PC

$$\text{Sta new PC} = (\text{Sta old PC}) - (2+50.00) = (60+45.10) - (2+50.00)$$

$$\text{Sta new PC} = (59+45.10) - (2+50.00)$$

$$\text{Sta new PC} = 57+95.10$$

Station at point of compound curve: (PCC)

$$\text{Sta (PCC)} = \text{Sta New PC} + \text{Curve Length (L}_3)$$

$$\text{Sta (PCC)} = (57+95.10) + (8+12.86)$$

$$\text{Sta (PCC)} = 66+07.96$$

Station at point of tangency: (PT)

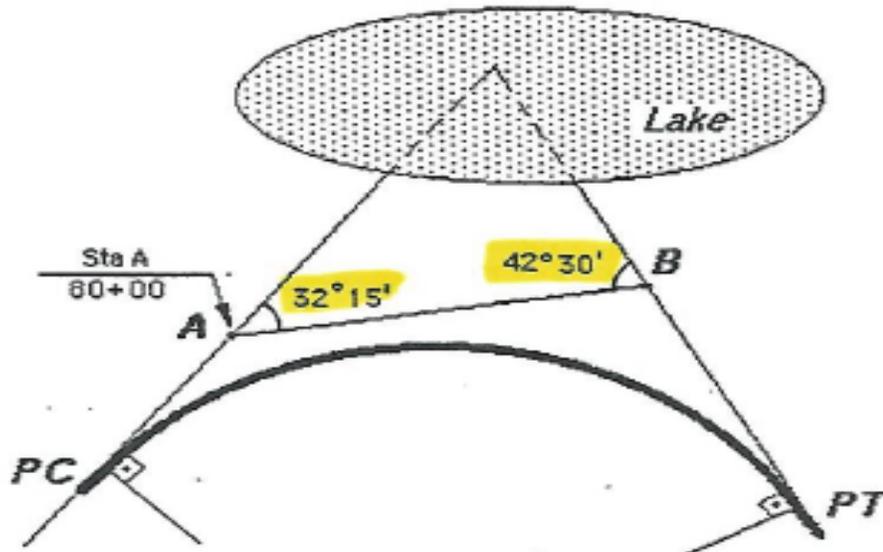
$$\text{Sta (PT)} = \text{Sta (PCC)} + \text{Curve Length (L}_2)$$

$$\text{Sta (PT)} = (66+07.96) + (3+50.00)$$

$$\text{Sta (PT)} = 69+57.96$$

Course : Surveying
 Coordinator : Zeytinci

PROBLEM : (Inaccessible PI)

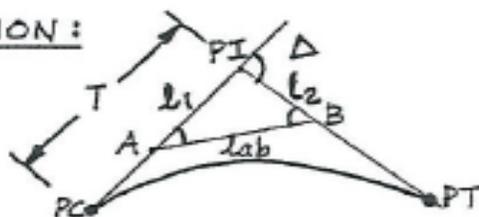


Two tangents of a simple horizontal curve with the degree of curvature of (4°) intersect in a lake which makes the PI inaccessible. Point A has been set at sta. 80+00 on the back tangent and point B has been set on the forward tangent so that it is visible from point A.

The distance AB is measured as 980.00 ft and the angles at A and B are measured and shown in the figure.

- Find the station of the PC.
- Find the station of the PT.

SOLUTION :



$$\begin{aligned} \hat{A} &= 32^\circ 15' = 32.25^\circ \\ \hat{B} &= 42^\circ 30' = 42.50^\circ \\ l_{ab} &= 980.00 \text{ ft} \\ D &= 4^\circ \end{aligned}$$

Angle of Intersection : (Δ)

$$\Delta = A + B = 32.25 + 42.50 = 74.75^\circ \checkmark$$

Radius of the curve : (R).

$$R = \frac{18,000}{\pi D} = \frac{18,000}{\pi(4.0)} = 1432.39 \text{ ft} \checkmark$$

Tangent distance : (T)

$$T = R \tan(\Delta/2) = (1432.39) \left(\tan \frac{74.75}{2} \right) = 1094.15 \text{ ft} \checkmark$$

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Length of the curve : (L)

$$L = \frac{\pi}{180} \Delta R = \frac{\pi}{180} (74.75)(1432.39) = 1868.74 \text{ ft.} \checkmark$$

Distance from (PI) to point (A) : (l_1)

$$l_1 = \text{From (PI) to (A)} = \frac{lab}{\sin \Delta} \cdot \sin B = \frac{980.00}{\sin 74.75} (\sin 42.50) = 686.24 \text{ ft}$$

Distance from (PI) to (B) : (l_2)

$$l_2 = \frac{lab}{\sin \Delta} \sin A = \frac{980.00}{\sin 74.75} (\sin 32.25) = 542.03 \text{ ft.} \checkmark$$

Distance from (A) to (PC) :

$$A \text{ to PC} = T - l_1 = 1094.15 - 686.24 = 407.91 \text{ ft.} \checkmark$$

Distance from (B) to (PT) :

$$B \text{ to PC} = T - l_2 = 1094.15 - 542.03 = 552.12 \text{ ft} \checkmark$$

Station (PC)

$$\begin{aligned} \text{Station (PC)} &= \text{Sta (A)} - (4 + 07.91) = (80 + 00.00) - (4 + 07.91) \\ &= (79 + 100.00) - (4 + 07.91) \checkmark \end{aligned}$$

$$\boxed{\text{Sta (PC)} = 75 + 92.09} \checkmark$$

Station (PT)

$$\begin{aligned} \text{Station (PT)} &= \text{Sta (PC)} + \text{Curve Length (L)} \\ &= (75 + 92.09) + (18 + 68.74) \checkmark \end{aligned}$$

$$\boxed{\text{Sta (PT)} = 94 + 60.83} \checkmark$$

ANSWERS:

$$\boxed{\text{Sta (PC)} = 75 + 92.09} \checkmark$$

$$\boxed{\text{Sta (PT)} = 94 + 60.83} \checkmark$$