The Transportation AM Assessment Guide

Mark F. DeSantis, P.E., PMP
Josh Frohman, P.E.

The Transportation AM Assessment Guide, Edition 1
Mark F. DeSantis, P.E., PMP

To report errors in this text, write to learncivilengineering2012@gmail.com

TABLE OF CONTENTS

INTRODUCTION

The Transportation AM Assessment Guide includes the top 8 questions that will be on the AM portion of the PE Exam. This practice exam also includes an assessment section for you to quickly evaluate your strengths and weaknesses in the different topics. All the questions and solutions are clearly labeled as to what topics they are concentrated on. This allows you to clearly understand what subject matter you are having trouble with or already fully comprehend. This allows you to studying smarter by focusing your efforts on the areas that you really need to.

It is important to note that this practice exam only assesses your ability with quantitative type questions. The actual exam is made up of 70% (+/- 10%) quantitative questions and 30% (+/- 10%) qualitative "word problems" type questions.   The word problems are too extensive to anticipate given that any problem in any topic could be asked about any minor detail.   These problems you really can't study for, you prepare for those just by understanding the overall concepts and theory of each topic.

Several of the qualitative questions and solutions in this assessment guide are longer than on the actual exam. We have incorporated more than one key concept into many of the questions. The difficulty level will be about the same as you will encounter on test day, but the problems will take a little longer to solve.

If you follow the Learn Civil Engineering (LCE) website's study schedule, go through all the topics while doing multiple practice problems, score greater than 75% on this exam you will be ready for the transportation section on the real PE exam and become a Licensed Professional Engineer.

I am always available to answer any questions you have during this exam prep process, please visit my site www.learncivilengineer.com and join the community.

How to Use the Assessment Guide

This Assessment Guide is intended to provide a quick assessment of your understanding in each area. In the real exam if you fail, NCEES will send you a breakdown on how you did, similar to what is provided in this guide.

These questions are more challenging than the actual exam because they cover several different concepts in each problem. Each problem was designed to cover the most important concept(s) for that section. If you understand these concepts you will do very well on the actual exam.

After you take this assessment use the answer key to figure out which problem you got right and wrong. Then go to the assessment guide and using the answer key fill out the guide. Filling in the blank space how many you got correct.

Once the page is all filled out:

→ 50 % or lower : Poor Understanding: You need additional studying and work many more practice problems

→ 50%- 75%: Moderate Understanding: You may need additional studying and should do a few more practice problems in this area.

→ 75 - 100% : High Understanding: You understand this area – only do more practice if time available.

UNDERSTANDING THE TRANSPORTATION PORTION

A big piece of passing the PE Exam is to fully understanding the test you are going to be taking. A lot of students take this for granted and really lose time studying the wrong material. If you make sure you are studying the correct material for the exam there is not that much material to learn.

Below is the full breakdown of the transportation AM section. The Transportation section will have 8 questions on the AM portion of the PE Exam. This is 20% of the AM section. Make sure you understand what each section encompasses and do not study the material that is not on the PE Exam.

Transportation Engineering (8/40) = 20%

The Transportation Section is made up of only six sections (below). The good news is that you know there will at least have one question on each topic. So make sure you know each section.

A. Horizontal Curves

B. Vertical Curves

C. Sight distance

D. Superelevation

E. Vertical and/or horizontal clearances

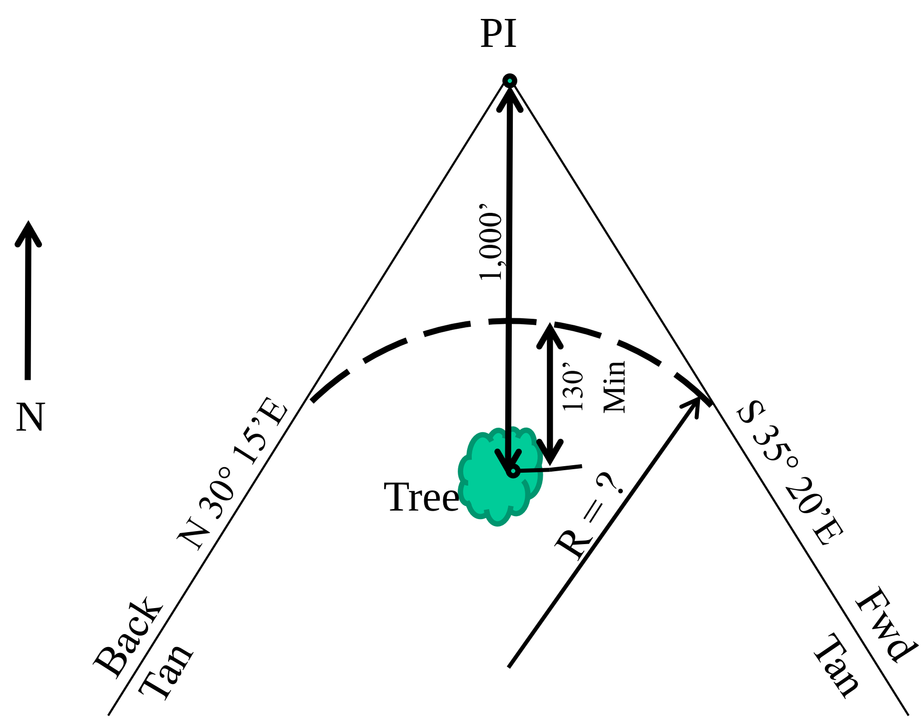
F. Acceleration and deceleration

EXAM ANSWER SHEET

1. (A) (B) (C) (D)
2. (A) (B) (C) (D)
3. (A) (B) (C) (D)
4. (A) (B) (C) (D)
5. (A) (B) (C) (D)
6. (A) (B) (C) (D)
7. (A) (B) (C) (D)
8. (A) (B) (C) (D)

Question #1: You are asked to calculate the roadway radius for a horizontal curve, given the following information: Back/Forward roadway centerline targets as shown. There is an existing historical tree located 1,000' directly south of the PI. You must maintain 130' minimum, center of roadway to center of tree.

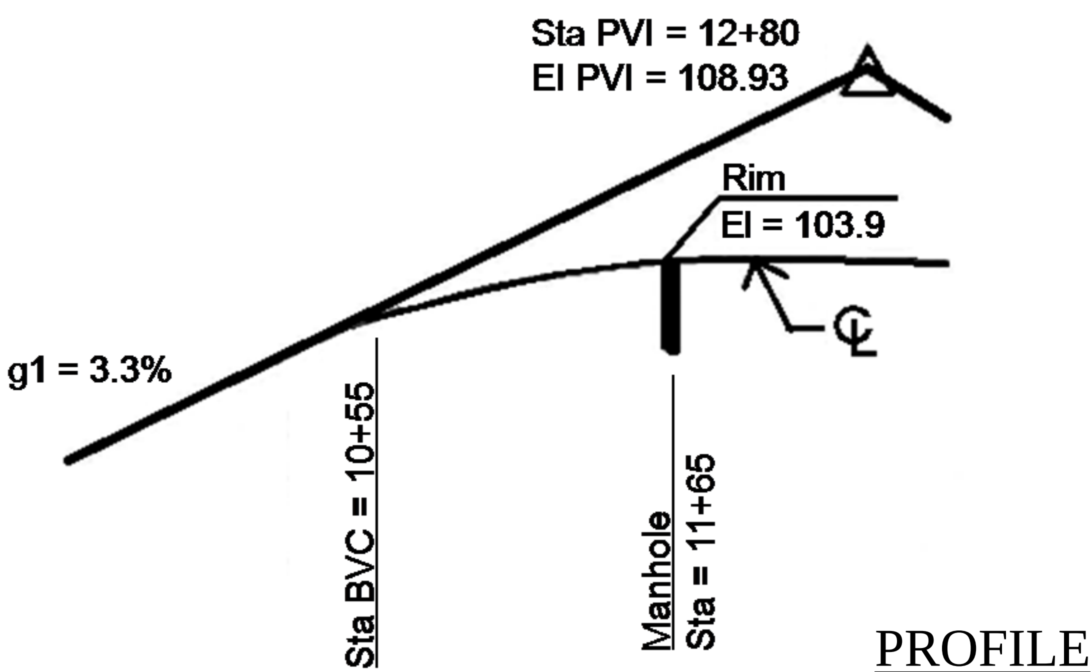
What is the largest radius, in feet you can fit, rounded to the nearest 50'?



Answer # 1

a. 900
b. 950
c. 1,000
d. 1,050

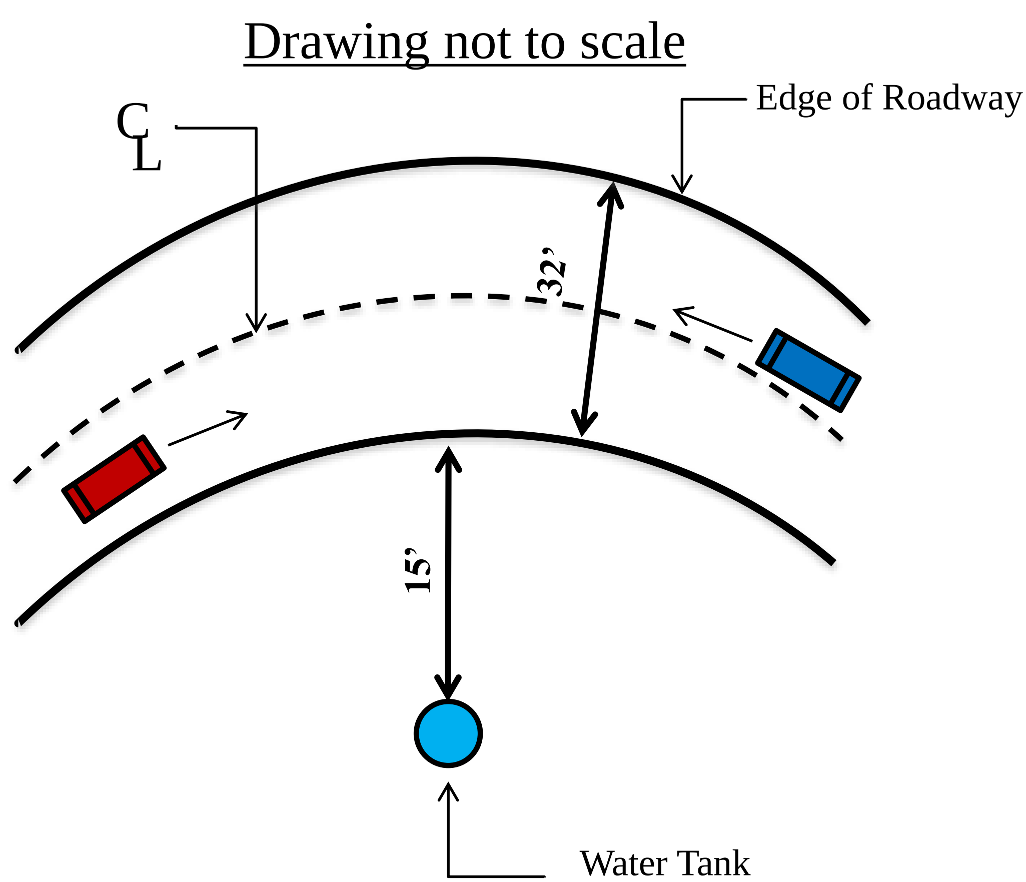
Question #2: You are hired to widen an old street. You've done some research and obtained a copy of the record. As-Built plans. The record plans are over 30 years old and difficult to read. You can make out only the following information from the record drawing's profile. What is g2 (in%) for the street centerline?



Answer #2
A.) -0.8
B.) -1.3
C.) -3.3
D.) -5.8

Question #3: The horizontal curve centerline alignment shown below has a length of curve of 600 ft and a central angle of 40°30'. A water tank is located 15ft from the edge of roadway.

What is the stopping sight distance, in feet, for this curve?

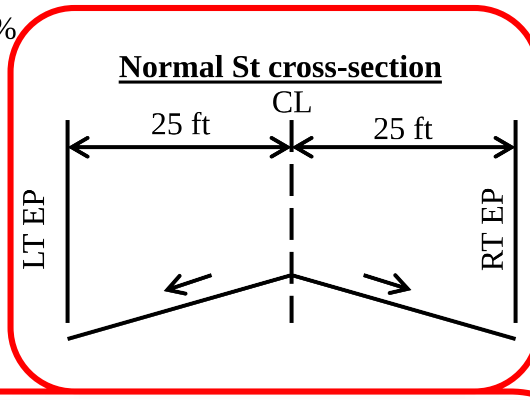


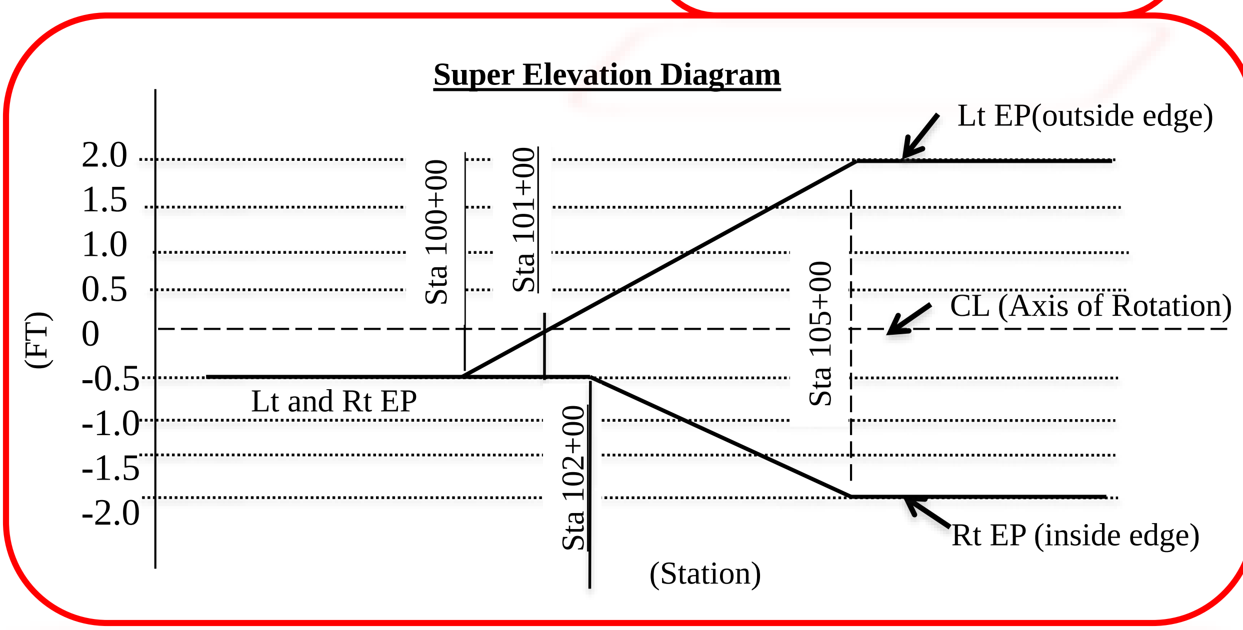
Answer # 3

A.) 318.1
B.) 319.6
C.) 394.2
D.) 396.1

Question #4: Given the superelevation diagram and normal street cross-section below, which statements are true?

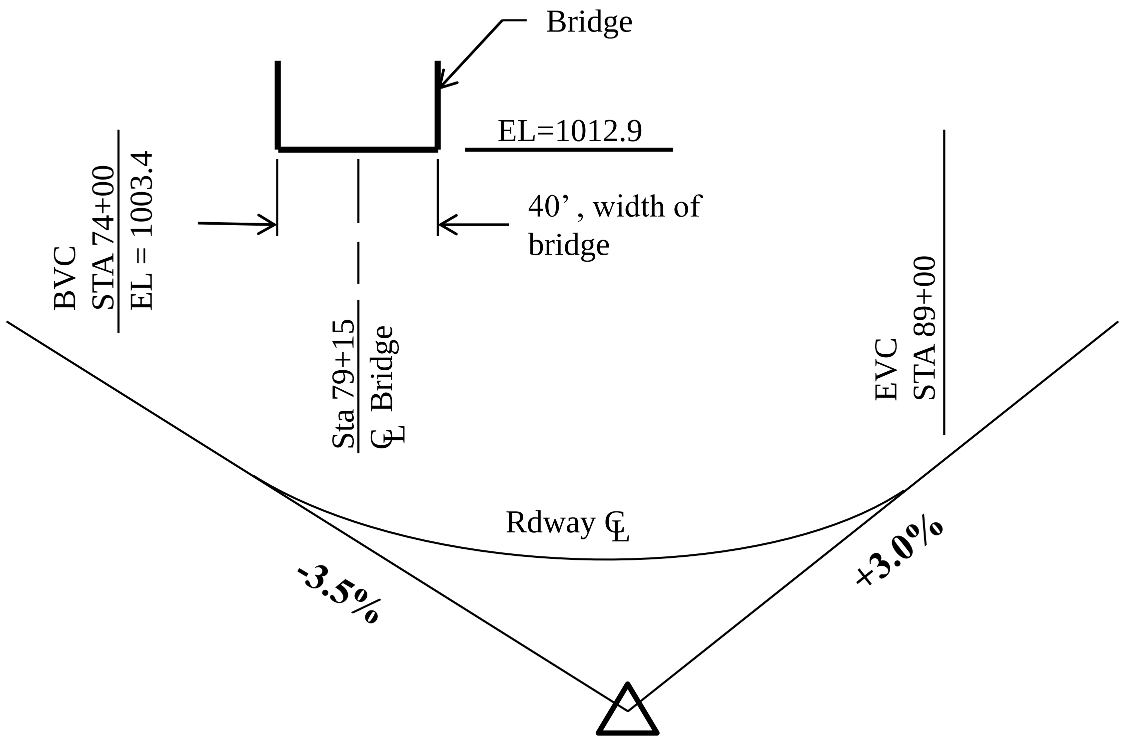
I. The normal street section section cross-slope is 2.5%
II. The maximum superelevation transition rate is 0.5%
III. The tangent runout (TR) is 100 ft
IV. The superelevation runoff (L) is 500 ft
V. The maximum superelevation rate is 8.0%





Answer # 4
A.) I and III
B.) I, IV and V
C.) II, III and V
D.) II, III, IV and V

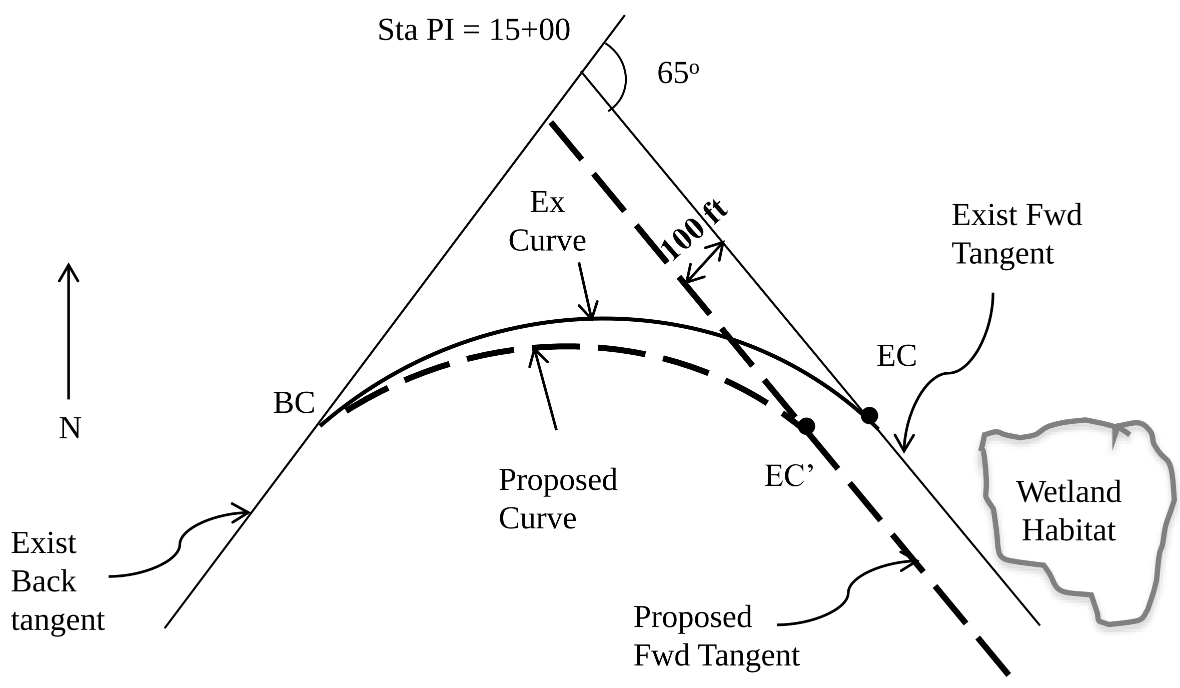
Question #5: Given the following figure, what is the minimum vertical clearance between the bridge and the centerline of the roadway, in feet?



Answer # 5
A.) 21.5
B.) 21.8
C.) 22.0
D.) 22.3

Question #6: An existing roadway is to be offset 100 ft to the southwest to avoid disturbing an environmentally sensitive area. The existing curve and forward tangent are to be adjusted as shown in the diagram.

The existing BC will remain the same. The existing radius is 750 ft. What is the station of the proposed EC(EC')?



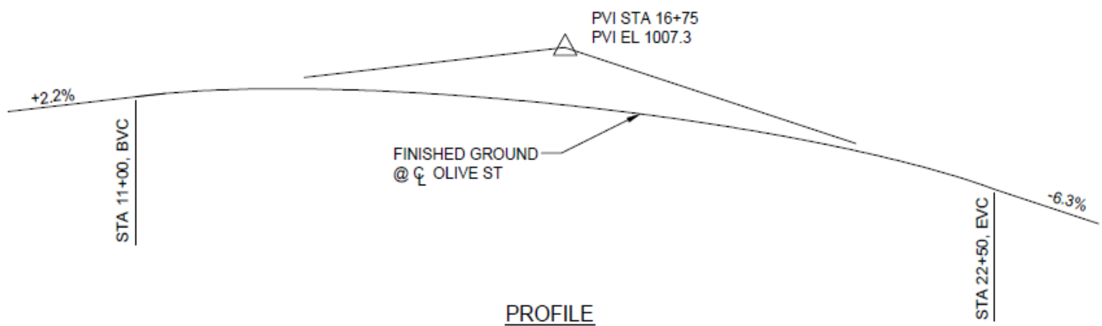
Answer # 6
A.) 16+76.56
B.) 17+57.12
C.) 18+73.05
D.) 19+77.80

Question #7: When the signal turns green, a vehicle at a traffic light starts from rest and accelerates at a rate of 8 ft/s^2. When the vehicle reaches 50 mi/hr, it travels at a steady speed for 2 minutes. As the vehicle approaches the next red traffic light, the driver decelerates at a uniform rate within 10 seconds to a complete stop. What is the distance between the two traffic signals, in miles?

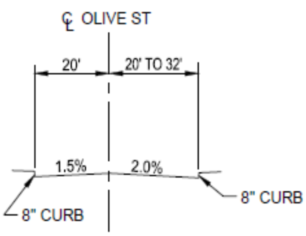
Answer # 7

A.) 0.95
B.) 1.20
C.) 1.80
D.) 2.75

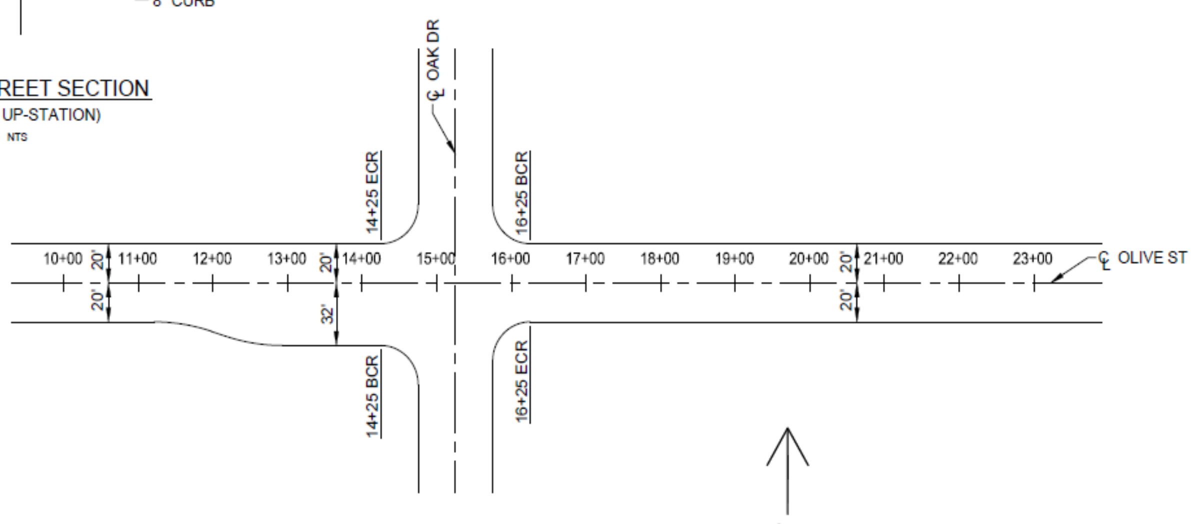
Question #8: Given the profile, plan, and section views, what is the top of curb (TC) elevation of the Begin Curb Return (BCR) at the southwest corner (SWC) of the Olive Street and Oak Drive intersection?



PROFILE
NTS



TYPICAL STREET SECTION
(LOOKING UP-STATION)
NTS



PLAN
NTS

Answer # 8

A.) 997.98
B.) 997.93
C.) 998.30
D.) 998.30

EXAM ANSWER KEY

1. (A) (B) ● (D)
2. (A) (B) (C) ●
3. (A) (B) ● (D)
4. (A) (B) ● (D)
5. ● (B) (C) (D)
6. ● (B) (C) (D)
7. (A) (B) ● (D)
8. (A) ● (C) (D)

Answer #1: c = 1000 ft

Step 1: Solve for Intersection angle (I):

I = (90°-30°15’) + (90°-35°20’)
I = 114°25’ = 114.42°

Step 2: Solve for External Distance Max (E):

E = 1,000' - 130' = 870' Max

Step 3: Solve for radius (R)

E = R - tan(1/2I) - tan(1/4I)
870' = R - tan(1/2 114.42') - tan(1/4 114.42')

solve: R = 1,027.76* → **1000 ft**

***Note:** The "trap answer" is D(1,050 ft). One might be tempted to round 1,028' up to the nearest 50' (1,050') but this would result in a radius larger than calculated, thus violating the 130' min (CL to tree) design requirement.

Answer #2: d = - 5.8%

Step 1: Find relevant equations:

$$El_x = \frac{r^2 x}{2} + g1\,x + El_{BVC} \quad \text{[CERM 13 Eqn 79.47]}$$

$$r = \frac{g2 - g1}{L} \quad \text{[CERM 13 Eqn 79.46]}$$

→A good equation to add to your sheet is to combine the above equations and rearrange to solve for g2.

$$g2 = \frac{g1\,x - 2\,L\,g1\,x - 2\,L\,(ElBVC - Elx)}{2x}$$

Step 2: Solve for unknowns:

El_x = 103.9 (given)
r = unknown – so replaced with combining equations
g1 = 3.3% (given)
x = Sta 11+65 - 10+55 = 110 ft = 1.1 Sta
El_{BVC} = El_{PVI} – ½ g1 L
1/2L = (12+80 - 10+55) = 2.25 sta
So El_{BVC} = 108.93 – (3.3%)(2.25 sta) = 101.5
g2 = unknown
g1 = 3.3 % (given)
L = 2 (1/2L) = 2 (2.25sta) 4.5 sta

** Note:
grades in whole %,
Distances in station
(1sta = 100)

Step 3: Solve for g2

$$g2 = \frac{g1\,x - 2\,L\,g1\,x - 2\,L\,(ElBVC - Elx)}{2x}$$

$$g2 = \frac{(3.3 * 1.1) - (2 * 4.5 * 3.3 * 1.1) - 2 * 4.5\,(101.5 - 103.9)}{2(1.1)}$$

g2 = **-5.8 %**

Answer #3: C = 394.2

Step 1: Find the equation for stopping distance:

$$S = \left(\frac{R}{28.65}\right)\left[\cos^{-1}\left(\frac{R-HSO}{R}\right)\right] \quad \left[\text{CERM 13, Eqn 79.4}\right]$$

S= stopping sight distance, ft
R= Radius of curve to the center of the inside lane = unknown, ft
HSO="Horizontal Sight Line Offset" = Distance from face of obstruction (water tank) to the center of the inside lane = 15 + (1/2)(1/2)(32')=23 ft

Step 2: Solve for radius of curve:

$$L = \frac{2\pi R i^{o}}{360^{o}} \quad \left[\text{CERM 13, Eqn 79.3}\right]$$

$R=360^{o}L/2I^{o}\pi = (360^{o})(600')/(2)(40.5)\,\pi = 848.8$ ft

However, 848.8 is the radius of the curve at the centerline. To get the radius at the inside lane:
R(center inside ln) = 848.8' - (1/2)(1/2)(32') = 840.8

Step 3: Solve for S:

$$S = \left(\frac{840.8}{28.65}\right)\left[\cos\text{-}1\left(\frac{840.8-23}{840.8}\right)\right]$$

S = **394.2'**

Note: wrong answers
A = using HSO = 15'
B = using R=848.8' and HSO = 15'
D = using R=848.8'

Solution #4: **C = II, III and V**

I. From the diagram, we see that the right and left edge of pavement (Rt and Lt EP) are 0.5' lower than the street centerline (CL). A 0.5' drop over 25 ft (width of one side of the roadway)
is 0.5'/25' = 0.02 = 2.0%

→ **I. is not true**

II. The transition rate is measured using the left or right EP and dividing the vertical change by the horizontal distance it takes to go from a normal section to full super-elevation. Using the Lt EP, per the diagram, the LT EP rotates from -0.5' (0.5' below CL) to +2.0' (2' above CL) for a total vertical change of .5 +2.0 = 2.5ft. It does so with in 500 horizontal ft (sta 105+00 - 100+00). The transition rate is 2.5/500 = 0.005 = 0.5%. Using the right EP, we get

$$\frac{(-2)-(-.51)}{\text{Sta } 105-102} = \frac{1.5}{300} = 0.005 = 0.5\%$$

→ **II. is true**

III. The tangent runout (TR) is the horizontal distance needed for the outside lane to rotate from a normal section to 0% see CERM13 pg 79-80 per the diagram. This happens from station 100+00 to 101+00. sta 101+00 - sta 100+00 = 100 ft

→ **III. is true**

IV. The super-elevation runoff (L) is the horizontal distance needed for the outside lane to rotate from 0% to full superelevation. See CERM 13 pg 79-8. Per the diagram this happens from station 101+00 to station 105+00. Sta 105+00 - sta 101+00 = 400 ft

→ **IV. is not true**

V. The maximum superelevation rate is reached when the left and right EPs are at 2.0' above and below the CL, respectively. The cross-slope at full superelevation is calculated by dividing the 2.0' vertical distance by the 25' wide roadway.

2/25 = 0.08 = 8%

→ **V. is true**

Answer #5: A = 21.5 ft

Note: the minimum clearance between the roadway and the bridge will be on the left side of the bridge. Sta 79+15 - 1/2(40') = Sta 78+95

$El_x = (r/2)\,x^2 + (g_1)(x) + El_{BVC}$ [CERM13 Eqn 29.47]

$r = \dfrac{g_2 - g_1}{L}$ [CERM13 Eqn 74.46]

$g_2 = 3.0\%$, $g_1 = -3.5\%$, L = Sta 89+00 – Sta 74+00 = 1500 ft = 15 sta

$r = \dfrac{3 - (-3.5)}{15} = 0.433$

x = (sta 79 +15 – (40/2)) – sta 74+00

= 7895 – 7400 = 495 ft = 4.95 sta

$El_{BVC} = 1003.4$

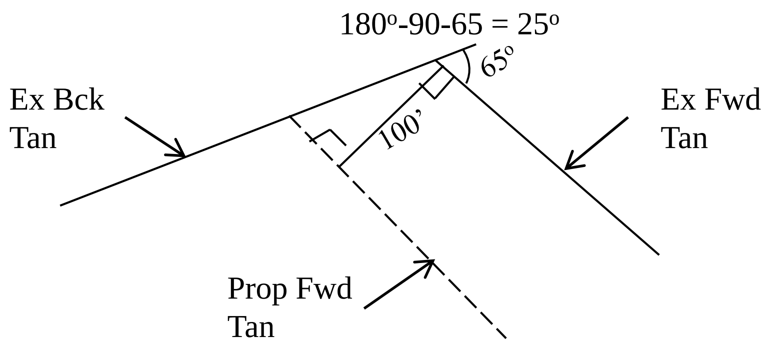
$El_{STA\ 78+95} = (0.433/2)\,(4.95)^2 + (-3.5)(4.95) + 1003.4$
$= 991.4$

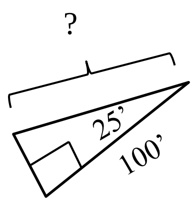
1012.9 – 991.4 = **21.5 ft**

Answer #6: a = 16+76.56

See CERM13 pg 79-2 pr NCEES 8 Handbook pg 164 for Horizontal curve formulas

Calculate Existing Tangent: $T_{EX} = R_{EX} \tan(I/2)$
$T_{EX} = 750' \tan(65/2) = 477.80$ ft
Calculate Proposed Tangent:





$$\cos\theta = \frac{\text{Adjacent}}{\text{Hypotenuse}} \Rightarrow \cos 25° = \frac{100}{H} \qquad H = 110.34'$$

$T_{prop} = T_{EX} - 110.34' = 477.80' - 110.34' = 367.46'$

Calculate Proposed R: $T = R \tan(I/2)$

$$367.46' = R \tan(65/2)$$
$$R_{prop} = 576.80'$$

Calculate Proposed length of curve: $L = (R)(I)(\pi/180)$
$L_{prop} = (R_{prop})(I)(\pi/180)$

$L_{prop} = (576.80')(65)(\pi/180) = 654.36'$

$Sta_{BC} = Sta_{PI} - T_{EX} = 15+00 - 477.80' = 10+22.20$

$Sta_{EC'} = Sta_{BC} + L_{prop} = 10+22.20 + 654.36' =$ **16+76.56**

Answer #7: c = 1.80

There are three areas that need to be analyzed separately – the acceleration, the constant velocity, and the deceleration components. Each area can be solved using common uniform velocity or common uniform acceleration formulas (See acceleration formulas, CERM13 Table 71.1). Remember to watch your units (feet, miles, seconds, minutes, etc.)!

Acceleration Component:

We want to know distance, s, and we are given v_o, v and a.
Use CERM formula:
$s = (v^2 – v_o^2) / 2a$
(s = displacement, or distance, sometimes variable d is used. v = final velocity, sometimes variable v_f is used. v_o = initial velocity, sometimes variable v_i is used. a = uniform acceleration)

$v_o = 0$ ft/s (given)
v = 50mph = 73.33 ft/s
a = 8 ft/s^2 (given)

$s = (73.33^2 – 0^2) / 2(8) =$ **336.08 feet**

Constant Velocity Component:

We want to know distance, s, and we are given final velocity, v, and time, t.
From basic knowledge, we know Distance = Speed x Time, so
s = vt

v = 50mph = 73.33 ft/s
t = 2 min = 120 sec

s = (73.33)(120) = **8,799.6 feet**

Deceleration Component:

We want to know distance, s, and we are given v_o, v and t.
Use CERM formula:
$s = (1/2)\ t\ (v_o + v)$

v_o = 50mph = 73.33 ft/s
v = 0 ft/s (given)
t = 20 seconds (given)

s = (1/2)(10)(73.33 + 0) = **366.65 feet**

Add the distances from each of the three areas:
s_{Total} = 336.08 ft + 8,799.60 ft + 366.65 ft = 9,502.33 feet = **1.80 miles**

Answer #8: **b= 997.93**

To get the (TC) elevation at the (BCR), we must first find the elevation of the street along the centerline (CL) at the BCR station. Then we use the typical street section to calculate the TC elevation. To get the CL station, we use the vertical curve information shown in the profile view.

See CERM13 Vertical Curve (VC) formulas page 79-12

Let's obtain all of the info needed:

Station at the BCR of the SWC = 14+25 (given from the plan view)

g_1 = grade in = +2.2% (given from profile view)
g_2 = grade out = -6.3% (given from profile view)
L = Length of VC = 2250 – 1100 = 1150 ft = 11.50 Sta
$r = (g_2 - g_1)/L = (-6.3 - 2.2)/11.50 = -0.7391$
x = distance from BVC to point of interest on VC = 1425 – 1100 = 325 ft = 3.25 Sta
El_{PVI} = 1007.3 (given from profile view)
$El_{BVC} = El_{PVI} - (g_1)(L/2) = 1007.3 - (2.2\%)(11.5 \text{ Sta} / 2) = 994.65$
$Elx = El_{14+25} = (r/2)x^2 + g_1x + El_{BVC} = (-0.7391/2)(3.25^2) + (2.2)(3.25) + 994.65$

El_{14+25} = 997.90 (the elevation of the finished ground surface along the Olive St CL, at Sta 14+25)

Now all we need to do is use the typical section to get the TC elevation at 14+25. Per the typical section, we see that the street cross slope is 2.0% downward, toward the curb. We see from plan view that the half street width is 32' at Sta 14+25. We know the curb height is 8". Thus:

$El_{TC,\ Sta\ 14+25} = El_{CL,\ Sta\ 14+25}$ – (street slope)(street width) + 8" = 997.90 – (.02)(32) + (8/12)

$El_{TC,\ Sta\ 14+25}$ = **997.93** (the elevation of the TC at the BCR at the SWC of Oliver and Oak)

TRANSPORTATION AM ASSESSMENT GUIDE

Horizontal Curves(12.5%):
Question #1 → ____ / 1 = ____%

Vertical Curves (25%)
Question #2, #8 → ____ / 2 = ____%

Sight Distance (12.5%)
Question #3 → ____ / 1 = ____%

Superelevation (12.5%)
Question #4 → ____ / 1 = ____%

Vertical and/or horizontal clearance (25%)
Question #5, #6 → ____ / 2 = ____%

Acceleration and deceleration (12.5%)
Question #7 → ____ / 1 = ____%

OVERALL → ____ / 8 = ____%

****Congratulations if scored 6 or greater****

LEARN CIVIL ENGINEERING .COM