

$$F = G \frac{m_1 m_2}{d^2}$$

$$\phi(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

$$i\hbar \frac{\partial}{\partial t} \psi = \hat{H} \psi$$

Grade Stakes, Layout & Plan Reading

$$E = mc^2$$

$$ds \geq 0$$

$$\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$$

$$\frac{df}{dt} = \lim_{h \rightarrow 0} \frac{f(t+h) - f(t)}{h}$$

INTERNET SEARCH

KAHOOT.IT OR SCAN THE QR CODE

ENTER CODE SHOWN ON SCREEN

CLASSROOM APPROPRIATE NAME



GOOD MORNING

- Introduction of Instructor
 - Al Bernhardt
- Student Questionnaire
 - Let's find out about you

Grades Stakes, Layout & Plan Reading

DATE OF CLASS ____ / ____ / ____ - ____ / ____ / ____

YOUR NAME _____

WHO DO OR DID YOU WORK FOR LAST? _____

WHAT DO YOU OPERATE? _____

HOW DID YOU USE GRADES & STAKES ON THE JOB? _____

HAVE YOU EVER BEEN CONFUSED BY GRADE STAKES? IF SO, EXPLAIN: _____

WHAT WOULD YOU LIKE TO LEARN THIS WEEK? _____

HOW WOULD THAT APPLY TO YOUR JOB? _____

IN CASE YOU ARE NERVOUS

- Here is an anonymous quote from a previous student who took the class online..
- “AI was able to teach someone like me who has never had any experience the basics, and more. I am a hands-on learner with a need for visuals. AI was able to give the fundamentals and then paint a picture of the whole process. Providing visual examples and real-world examples made it so much easier to understand. Even with being over Zoom, AI made the class feel hands on. By having us follow each step, showing the details in the process, and what to do with that information. Made it that much easier to understand the subject. AI also made it a very fun class. Some of the zoom courses get boring, but AI kept us all engaged and laughing all week long!! 10/10”

IDEAS TO FOLLOW FOR THE WEEK

- Have fun while learning
- Organize your thinking by taking notes
- Follow the Formula
- Try! Show me the effort and I will help you succeed!
- Double check your work



Grades & Stakes Formulas

CONVERT INCHES TO DECIMAL FEET $8'' - 8/12 = 0.666 = 0.67'$ $1\frac{1}{4}'' - 1/4 = /12 = 0.020 = 0.02'$ $8-1\frac{1}{4}'' - 1/4 = +8 = /12 = 0.687 = 0.69'$		"GOLD"EN RULES RISE / RUN = FT/FT (NEVER ROUND) % / 100 = FT/FT (NEVER ROUND) FT/FT X 100 = % RUN / RISE = SLOPE RATIO	
CONVERT DECIMAL FEET TO INCHES $0.25' = 0.25 \times 12 = 3''$		STATIONING EXAMPLES - 16+45 & 14+50 1645.00 - 1450.00 = 195.00' APART NEGATIVE OFFSET = LEFT & POSITIVE OFFSET = RIGHT	
BASIC QUANTITIES FEET X FEET = SQUARE FEET (SQ FT) SQ FT / 9 = SQUARE YARDS (SQ YDS) FEET X FEET X FEET = CUBIC FEET (CU FT) CU FT / 27 = CUBIC YARDS (CU YDS)		FG CUT/FILLS TO SUBGRADE SECTION + CUT = TOTAL CUT SECTION - FILL = POSITIVE # = CUT SECTION - FILL = NEGATIVE # = FILL	
$A^2 + B^2 = C^2$  (28 X 28) + (30 X 30) 784 + 900 = 1684 $\sqrt{1684} = C = 41.04'$		SURVEYING 1 ACRE = 43560 SQ FT (66' X 660') 640 ACRES IN A SECTION SECTION DIMENSION - 1 MILE X 1 MILE 36 SECTIONS PER TOWNSHIP TOWNSHIP DIMENSION - 6 MILE X 6 MILE	
INCHES & DECIMAL FEET 12 INCHES OR 96 EIGHTHS PER FOOT 10 TENTHS OR 100 HUNDREDTHS PER FOOT 5280 FEET - 1 MILE			
LEVEL LOOPING		BENCHMARK (BM) + BACKSIGHT (BS) = HEIGHT OF INSTRUMENT (HI) HI - FORESIGHT (FS) = ELEVATION (EL) HI - EL = FORESIGHT ROD READING	
Stake Reading with Section-Grade Rod			
Example	STAKE INFO F-1.56 To FG	SECTION THICKNESS 4" Concrete 4" Sand	ROD READING ON HUB (RR) 5.06 (5.06-1.56) 3.50
			RR+CUT RR-FILL = FG RR (3.50+0.67) 4.17
			FG RR + Section = SG RR 4.17
			SG RR = GROUND RR = (-) = Fill (+) = Cut F-1.08 SG
Stake Reading with Section-Lenker Rod			
Example	STAKE INFO F-1.56 To FG	SECTION THICKNESS 4" Concrete 4" Sand	ROD READING ON HUB (RR) 3.72 (3.72+1.56) 5.28
			RR-CUT RR+FILL = FG RR (5.28-0.67) 4.61
			FG RR - Section = SG RR 4.61
			GROUND RR = SG RR = (-) = Fill (+) = Cut F-1.10 SG
PRORATION			
SOLVING FOR STEPS = $\frac{35 \text{ (STEPS)}}{100'} \times \frac{X \text{ (STEPS)}}{60'} = 35 \times 60 = /100 = 21 \text{ STEPS}$			
SOLVING FOR RISE = $\frac{1' \text{ (RISE)}}{4' \text{ (RUN)}} = \frac{X \text{ (RISE)}}{14' \text{ (RUN)}} = 14 \times 1 = /4 = X = 3.5' \text{ RISE}$			
SOLVING FOR RUN = $\frac{1' \text{ (RISE)}}{4' \text{ (RUN)}} = \frac{5' \text{ (RISE)}}{X \text{ (RUN)}} = 5 \times 4 = /1 = X = 20' \text{ RUN}$ 20 X 2 (SIDES) - + DITCH BOTTOM - TOTAL TRENCH			

Common Abbreviations

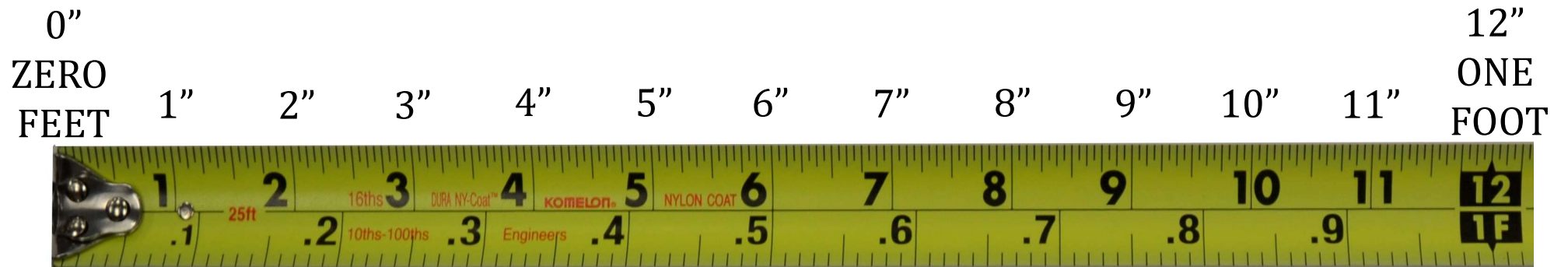
• BC/PC	Begin Curve	• @ or O/S	Offset
• BM	Bench Mark	• PI	Point of Intersection
• C	Centerline	• PL	Property Line
• C	Cut	• RAD	Radius Point
• CP	Catch Point	• R/W	Right-of-Way
• EC/PT	End Curve	• SG	Sub Grade
• EL	Elevation	• SS	Slope Stake
• F	Fill	• STA	Station
• FG	Finished Grade	• TBM	Temporary Bench Mark
• FL	Flow Line	• TC	Top of Curb
• HP	High Point	• TOE	Toe of Slope
• INV	Invert of Drain	• TOP	Top of Slope
• L/O	Line Only	• TP	Turning Point
• MH	Manhole	• TBC	Top Back of Curb



SECTION I

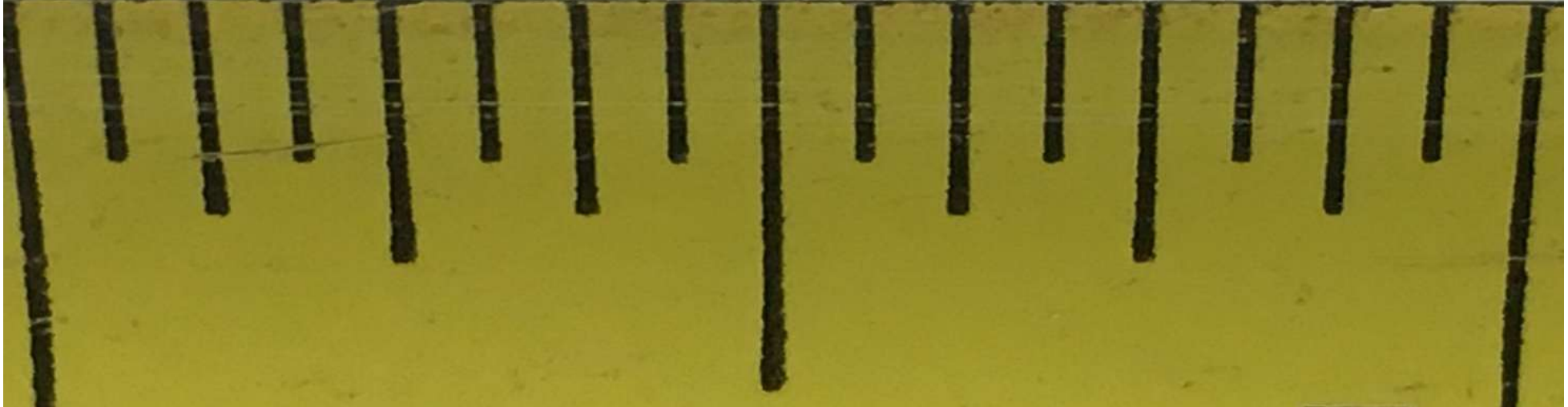
Tape Reading, Conversions and Grade Rod Reading

READING INCHES OF A FOOT

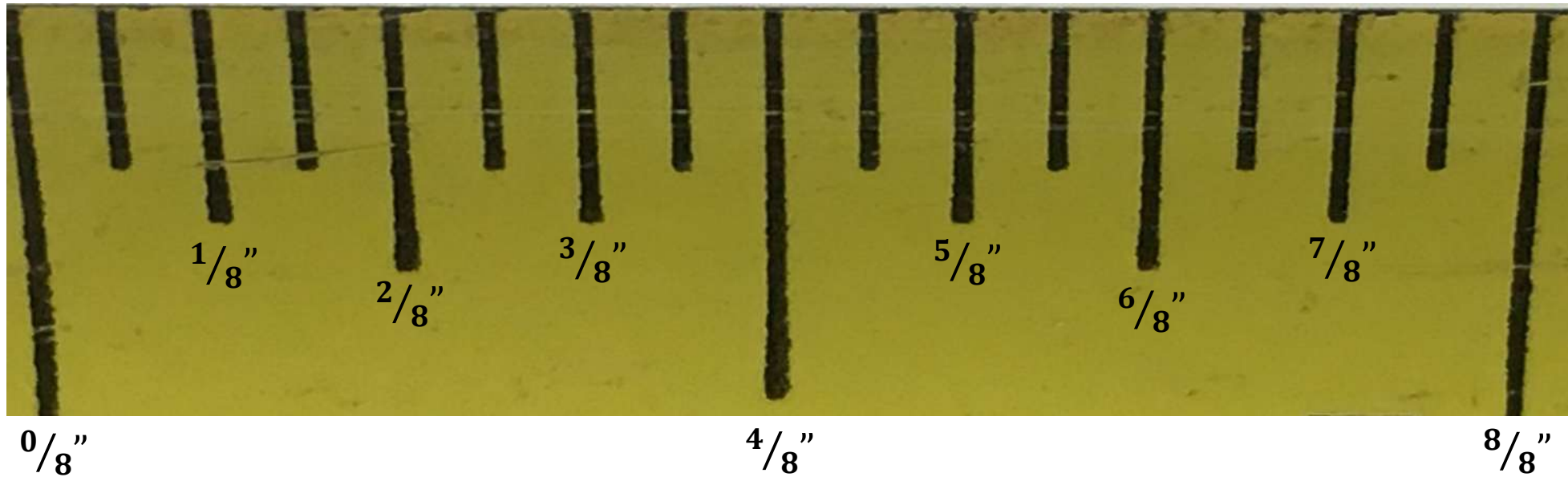


READING SIXTEENTHS OF AN INCH

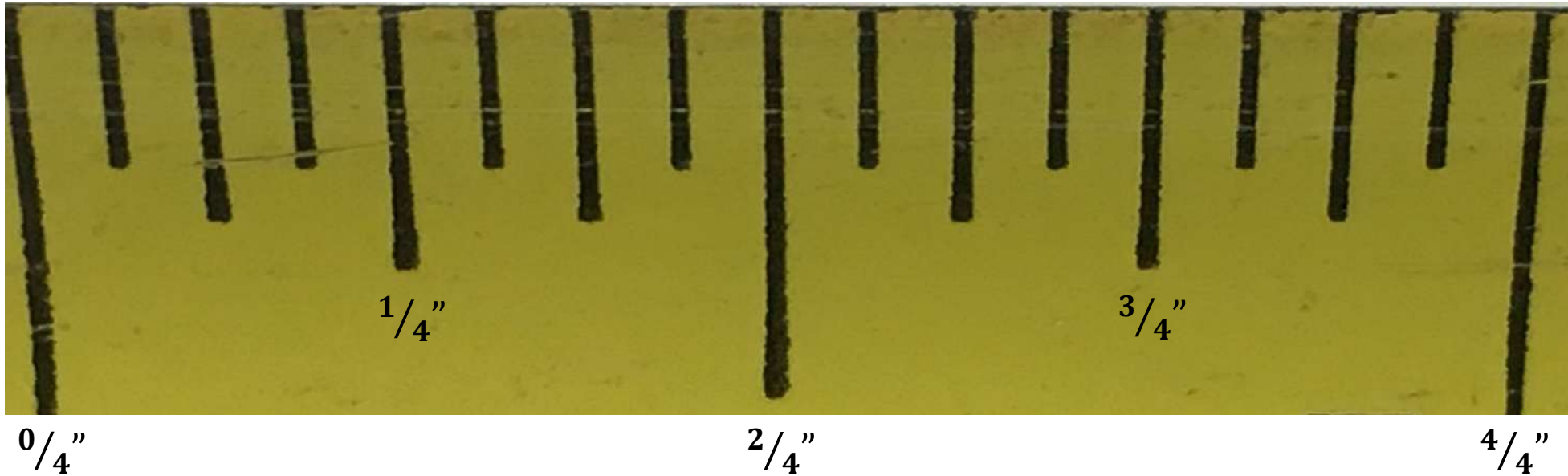
$0/16''$ $1/16''$ $2/16''$ $3/16''$ $4/16''$ $5/16''$ $6/16''$ $7/16''$ $8/16''$ $9/16''$ $10/16''$ $11/16''$ $12/16''$ $13/16''$ $14/16''$ $15/16''$ $16/16''$



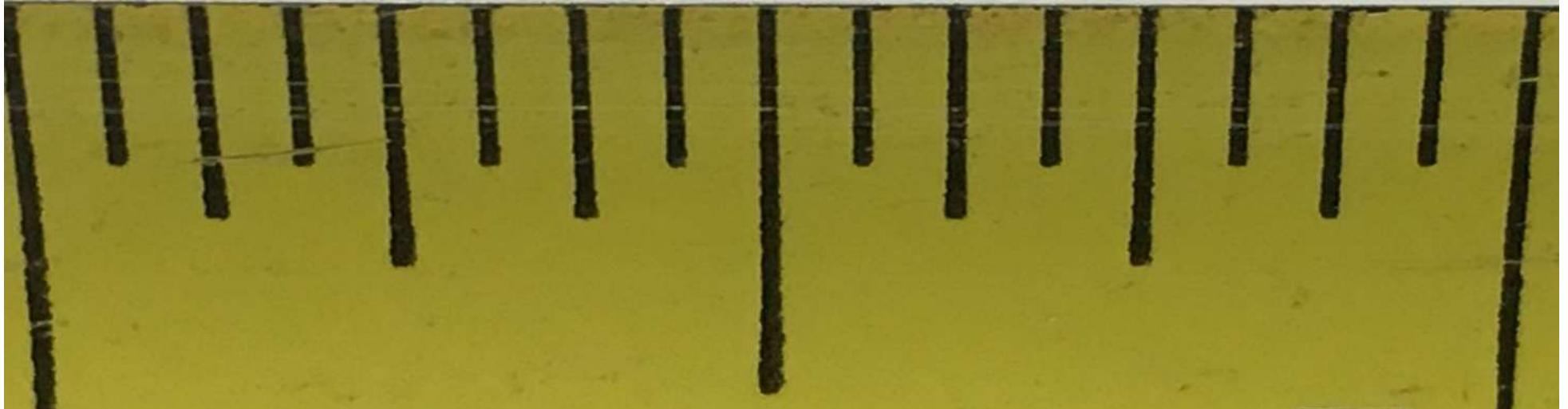
READING EIGHTHS OF AN INCH



READING QUARTERS OF AN INCH



READING HALVES OF AN INCH



0"
0/2"

1/2"

1"
2/2"

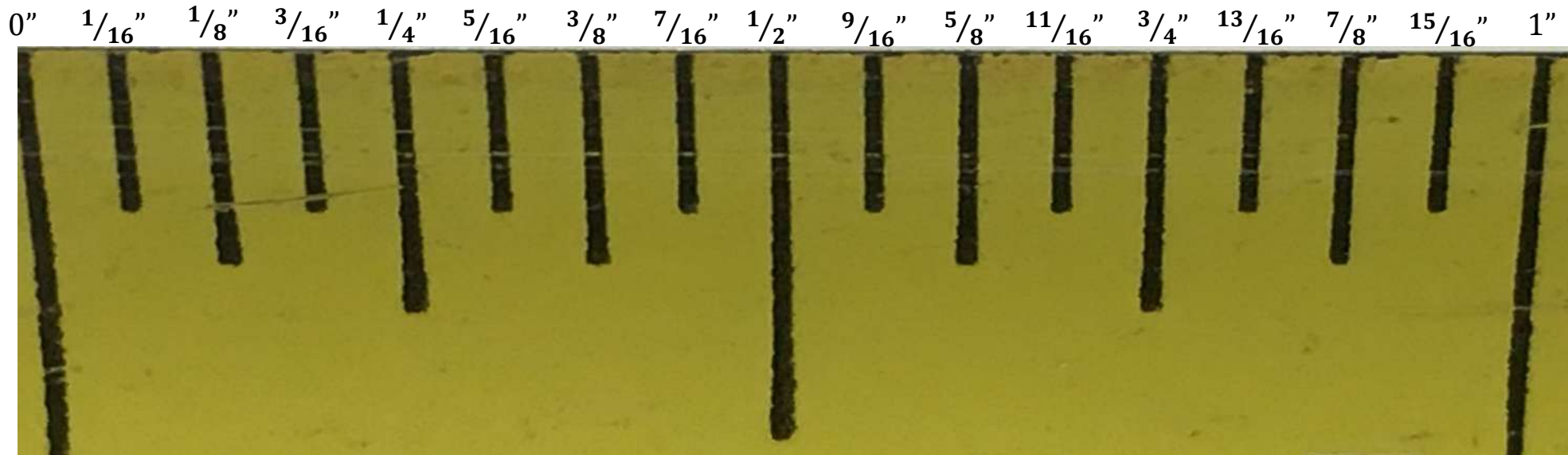
REDUCING FRACTIONS

- $\frac{8}{16}$ "
- $\frac{10}{16}$ "
- $\frac{8}{8} = 1$
- $\frac{10}{2} = 5$
- $\frac{16}{8} = 2$
- $\frac{16}{2} = 8$
- $\frac{8}{16}" = \frac{1}{2}"$
- $\frac{10}{16}" = \frac{5}{8}"$

$$\frac{6}{12} \div 6 = \frac{1}{2}$$
$$\frac{24 \div 8}{32 \div 8} = \frac{3}{4}$$
$$\frac{24}{32} = \frac{3}{4}$$

wikiHow

PROPERLY REDUCED FRACTIONS OF AN INCH



DETERMINING DECIMAL FEET

In the number 6.42...

The **6** represents **Feet (F)**

The **4** represents **Tenth (T)**

The **2** represents **Hundredth (H)**

Its 6 Feet, 4 Tenths and 2 Hundredths

Or commonly said in the field as

6 Feet and 42 Hundredths

Proper way to read a tape or grade rod:

First, find the Foot

Then the Tenth you are at or above

Finally, count how many hundredths it is above the tenth

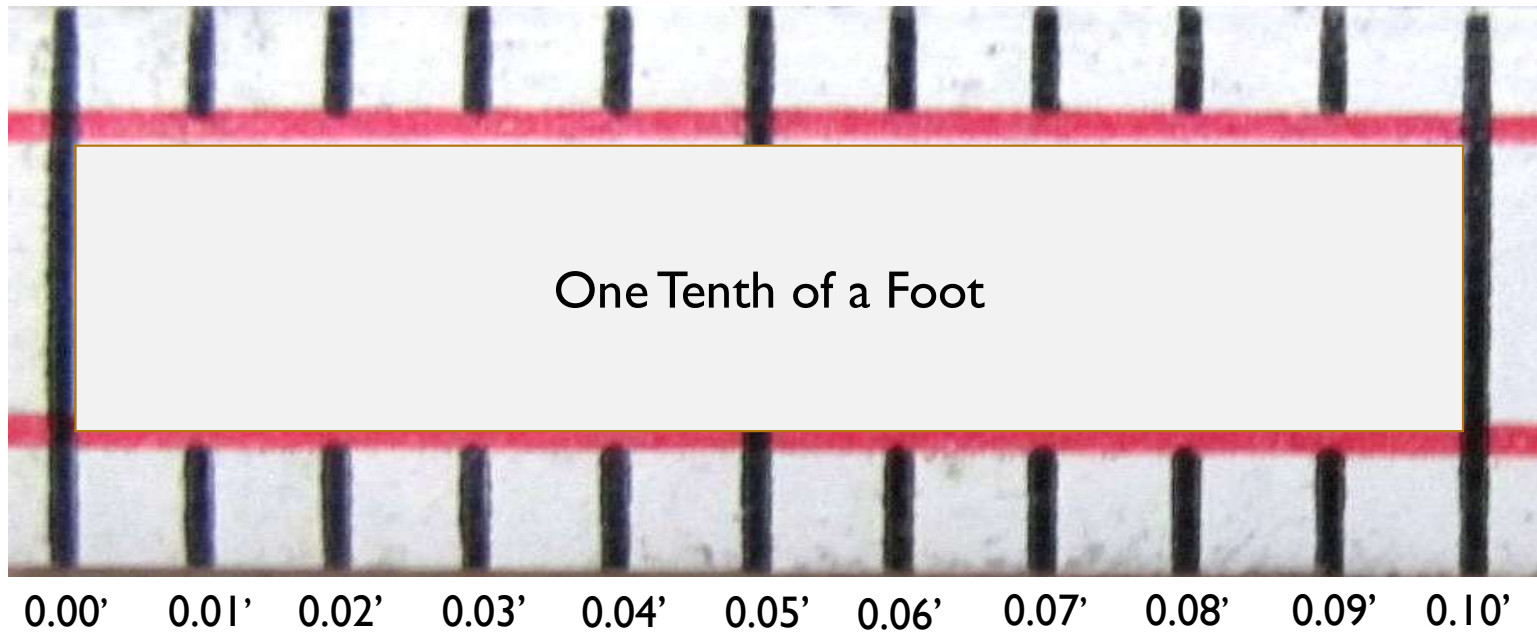
Remember, F/T/H

For elevations or converting inches, round to the nearest hundredth of a foot.

READING TENTHS OF A FOOT

[illegible]

HUNDREDTHS OF A TENTH



#5
1-5/8"

#4
3-1/4"

#3
5-3/4"

#2
1'-1/2"
12-1/2"

#1
1'2"
14"



0.12'
#10

#15
0.17'

0.38'
#9

#14
0.49'

0.62'
#8

#13
0.85'

0.94'
#7

#12
1.01'

1.25'
#6

#11
1.31'



0.07'
#20

#25
1-3/8"

0.33'
#19

#24
5-1/4"

0.89'
#18

#23
11-3/8"

1.19'
#17

#16
1.34' #21
1'2-5/8" 1'4-1/8"
14-5/8" 16-1/8"



#30
3-1/8"

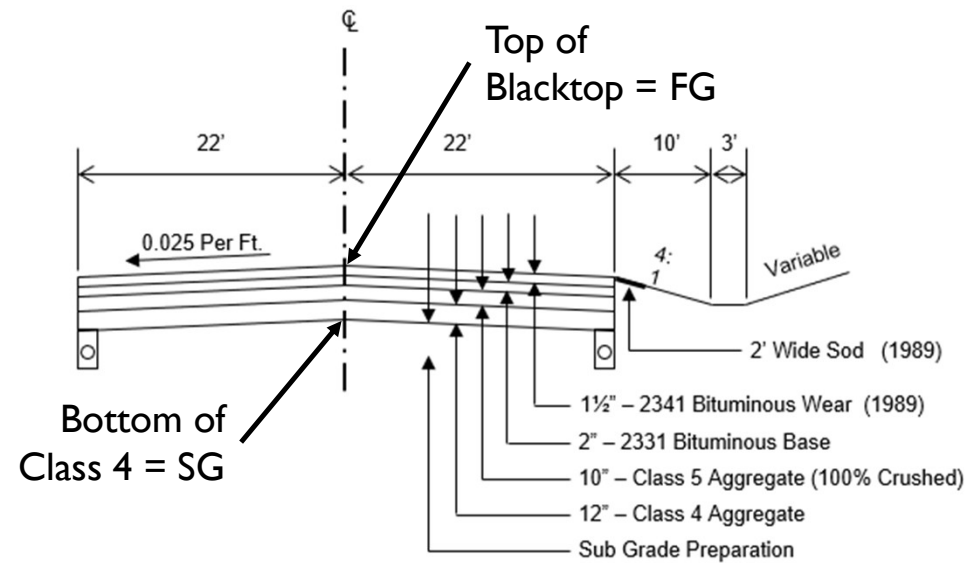
#29
4-3/8"

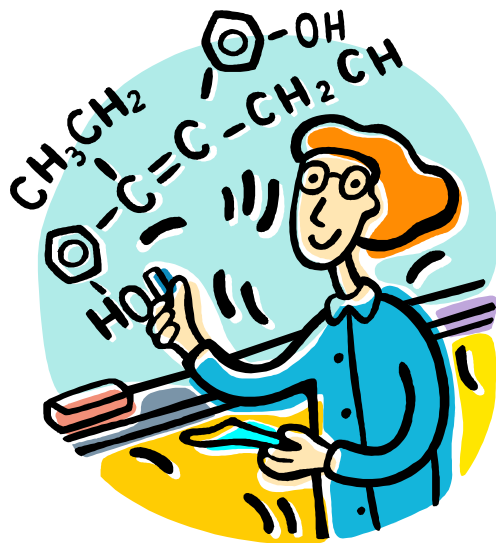
#28
10"

#27
1'1-3/4"
13-3/4"

#26
1'3-3/8"
15-3/8"

CONVERTING INCHES TO DECIMAL FEET





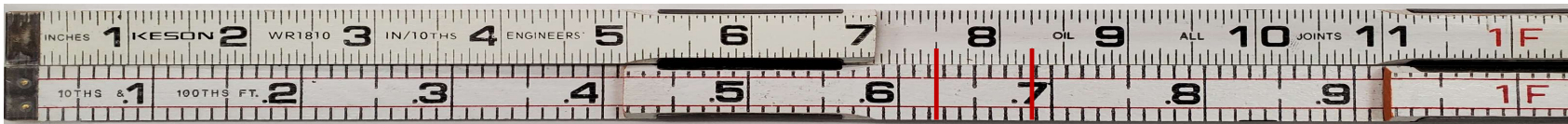
DIFFERENT WAYS TO CONVERT INCHES TO DECIMAL FEET

- Folding Ruler
- Formula

FOLDING RULER

$8\frac{1}{4}"$	<u>0.69'</u>	$\frac{1}{2}"$	<u>0.04'</u>
$7\frac{1}{2}"$	<u>0.63'</u>	$\frac{7}{8}"$	<u>0.07'</u>
$6\frac{1}{2}"$	<u>0.54'</u>	$4\frac{1}{2}"$	<u>0.37'</u>
5"	<u>0.42'</u>	$2\frac{3}{4}"$	<u>0.23'</u>
$3\frac{3}{4}"$	<u>0.31'</u>	10"	<u>0.83'</u>
$9\frac{1}{8}"$	<u>0.76'</u>	$25\frac{1}{2}"$	<u>2.13'</u>

Feet, Inch and Fractions



Decimal Feet

CONVERTING A BASIC INCH TO TENTHS

Formula inch / 12 =

Let's do the first one together...

- $12 / 12 = 1$
- Always show answers in F/T/H format = 1.00'

Let's do the next one together...

- 11"
- $11 / 12 =$
- 0.916
- Looking at the 3rd digit after the decimal, 5 or higher we round up and 4 and lower, we keep it the same
- 0.92'

**Basic Inch Converted
Inch / 12 =**

INCHES	DECIMALS
12"	1.00'
11"	0.91 <u>6</u> '
10"	0.83 <u>3</u> '
9"	0.75'
8"	0.66 <u>6</u> '
7"	0.58 <u>3</u> '
6"	0.50'
5"	0.41 <u>6</u> '
4"	0.33 <u>3</u> '
3"	0.25'
2"	0.16 <u>6</u> '
1"	0.08 <u>3</u> '
0"	0.00'

= 0.92'

= 0.83'

= 0.67'

= 0.58'

= 0.42'

= 0.33'

= 0.17'

= 0.08'

Properly
Rounded
Answers

PRACTICE CONVERTING JUST A FRACTION

Let's do the second one together...

- $1/4 =$
- $/12 =$
- $0.02\underline{0}$
- Round to the nearest hundredth
- $0.02'$

Conversion Chart

FRACTIONS	DECIMALS
$1/8''$	0.01'
$1/4''$	0.02'
$3/8''$	0.03'
$1/2''$	0.04'
$5/8''$	0.05'
$3/4''$	0.06'
$7/8''$	0.07'
$8/8''$	0.08'
$1/16''$	0.005'

Let's do the second one together...

- $1/4 =$

- $+2 =$

- $/12 =$

- $0.187\underline{}$

- Round to the nearest hundredth

- $0.19'$

CONVERTING INCH & FRACTIONS

Conversion Chart

FRACTIONS	DECIMALS
$9 \frac{1}{8}"$	0.76'
$2 \frac{1}{4}"$	0.19'
$3 \frac{3}{8}"$	0.28'
$4 \frac{1}{2}"$	0.38'
$1 \frac{5}{8}"$	0.14'
$6 \frac{3}{4}"$	0.56'
$15 \frac{7}{8}"$	1.32'
$7 \frac{8}{8}"$	0.67'
$10 \frac{1}{16}"$	0.84'

PRACTICE CONVERTING

1. 8 inches = 0.67'
2. 2 inches = 0.17'
3. 23 inches = 1.92'
4. 32 inches = 2.67'
5. 12 feet 11 inches = 12.92'
6. 6 1/2 inches = 0.54'
7. 53 feet 9 inches = 53.75'
8. 13 inches = 1.08'
9. 1 foot 10 inches = 1.83'
10. 63 inches = 5.25'

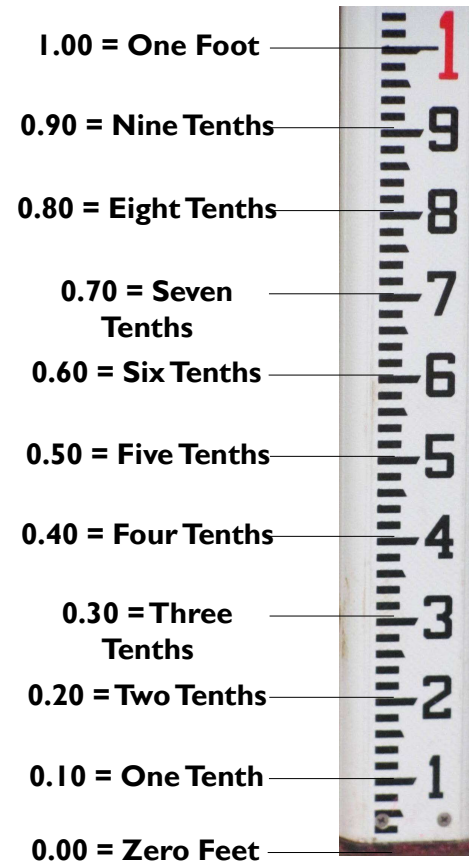
11. 17 inches = 1.42'
12. 30 inches = 2.50'
13. 40 inches = 3.33'
14. 7 inches = 0.58'
15. 39 inches = 3.25'
16. 3/4 inch = 0.06'
17. 8 1/4 inches = 0.69'
18. 9 feet 10 inches = 9.83'
19. 100 inches = 8.33'
20. 82 1/2 inches = 6.88'

READING A GRADE ROD - TENTHS

1.00' foot and divide it into:

10 equal parts

We call each one of those parts a Tenth



Each Tenth is divided into **10 equal parts.**

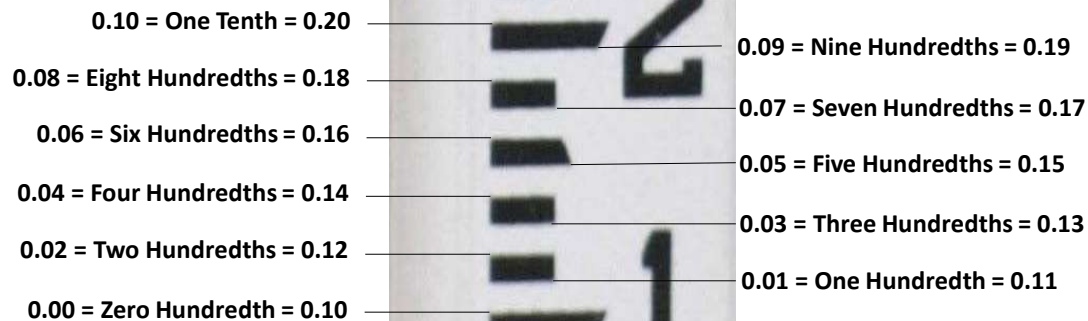
We call each one of those parts a **Hundredth**

Notice a Pattern?

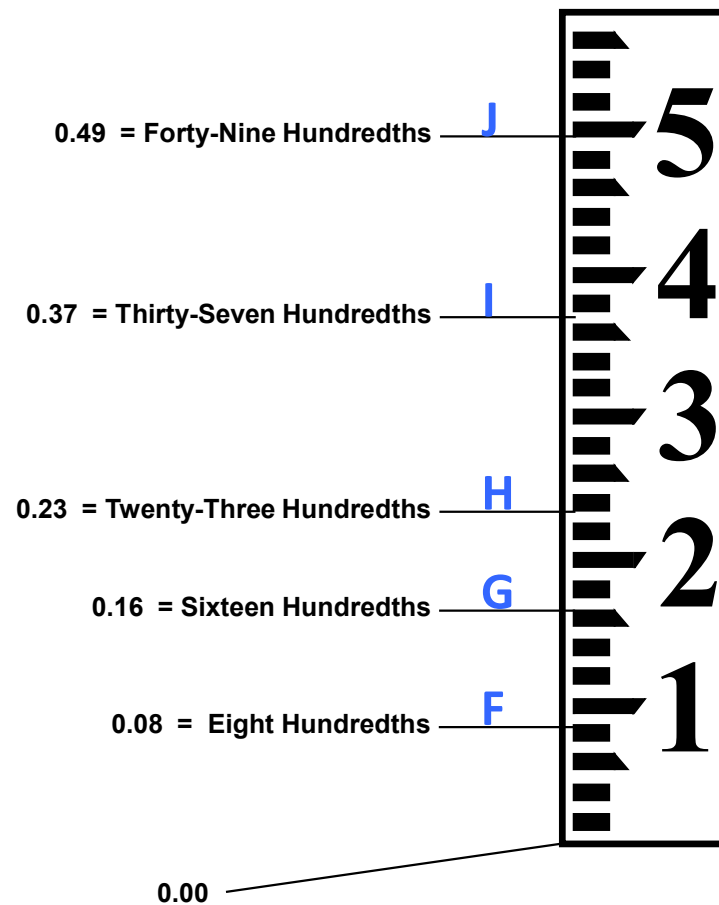
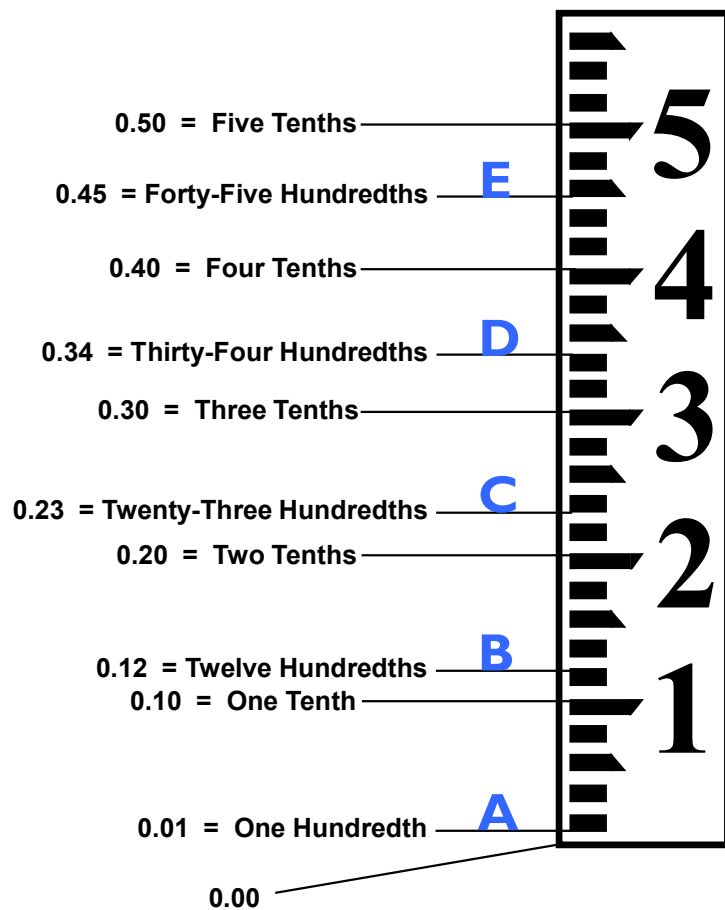
The Top of every Black Bar is an Even Number

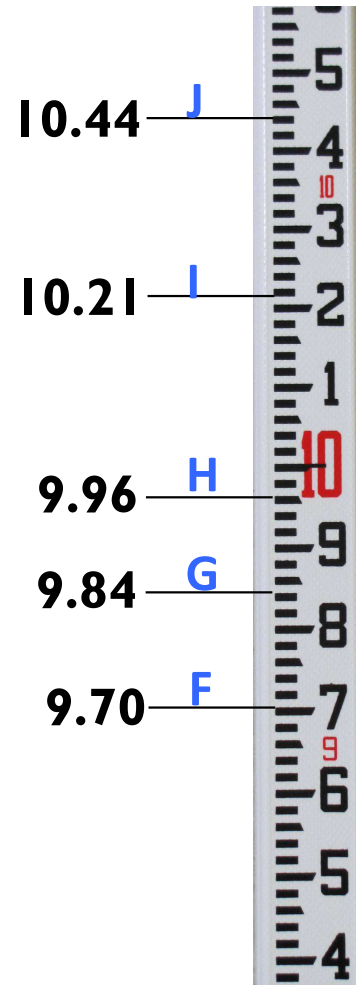
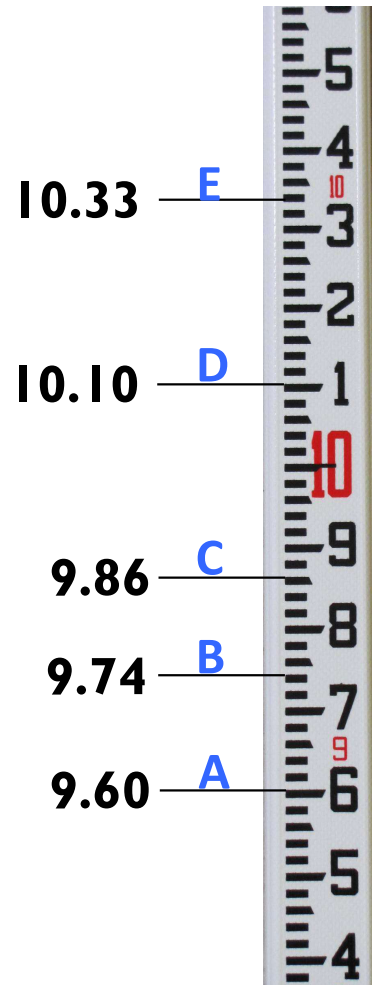
The Bottom of every Black Bar is an Odd Number

READING A GRADE ROD - HUNDREDTHS



PRACTICE





SECTION 2

General Information

- BC/PC Begin Curve
- BM Benchmark
- C_L Centerline
- C Cut
- CP Catch Point
- EC/PT End Curve
- EL Elevation
- F Fill
- FG Finished Grade
- FL Flow Line
- HP High Point
- INV Invert of Drain
- L/O Line Only
- MH Manhole
- © or O/S Offset
- PI Point of Intersection
- PL Property Line
- RAD Radius Point
- R/W Right-of-Way
- SG Sub Grade
- SS Slope Stake
- STA Station
- TBM Temporary Benchmark
- TC Top of Curb
- TOE Toe of Slope
- TOP Top of Slope
- TP Turning Point
- TBC Top Back of Curb

20' O/S BLDG COR // C-3.50 TO FFE

10+25 MH32 L/O

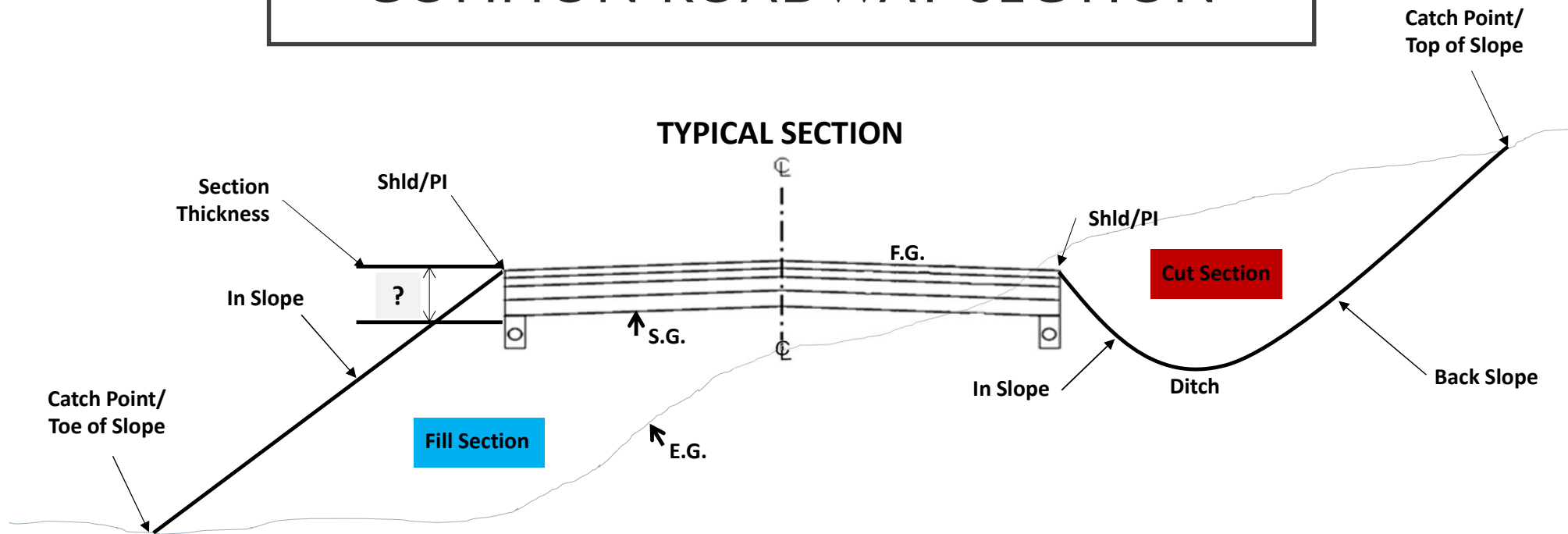
3' O/S TBC @ PC // F-1.45 TO FL // F-1.95 TO TC

10+25 MH32 O/S 15' // C-2.15 TO INV

GENERAL DEFINITIONS

- ☐ **Bench Mark:** A point of known elevation, used as a reference in determining and recording other elevations.
- ☐ **Blue Tops:** Grade hubs whose tops indicate finish or sub grade.
- ☐ **Catch Point:** Where Proposed construction meets Existing ground
- ☐ **Center Line:** The middle or crown of a roadway, dividing separate sections of a roadway, usually where station labels are attached to.
- ☐ **Cut:** Lowering the elevation of the ground, marked C on a stake, plus the number of feet (and tenths) of earth to be removed.
- ☐ **Fill:** Raising the elevation of the ground. Marked F on the lath plus the number of feet (and tenths) of earth to be added.
- ☐ **Elevation:** An established point that is a definite vertical distance above sea level
- ☐ **Fall or Rise/Ft.** The vertical fall or rise for each horizontal foot.
- ☐ **Slope Ratio:** The ratio of the horizontal run distance to the vertical rise distance.
- ☐ **Super:** A continuous slope in one direction of a road.

COMMON ROADWAY SECTION



Finish Grade: The final grade required by the plans and specifications.

Sub Grade: The surface produced by grading native earth, or cheap imported materials, which serves as a base for a more expensive paving.

Existing Grade: The natural surface of the earth before being disturbed.

STANDARD DIRT TOLERANCES

Dirt

0.10' plus (+) or minus (-)

Gravel

0.05' plus (+) or minus (-)

Black Top

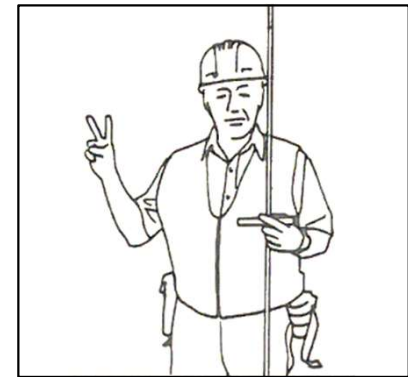
0.01' plus (+) or minus (-)



COMMON HAND SIGNALS



Cut Two Tenths



Fill Two Tenths



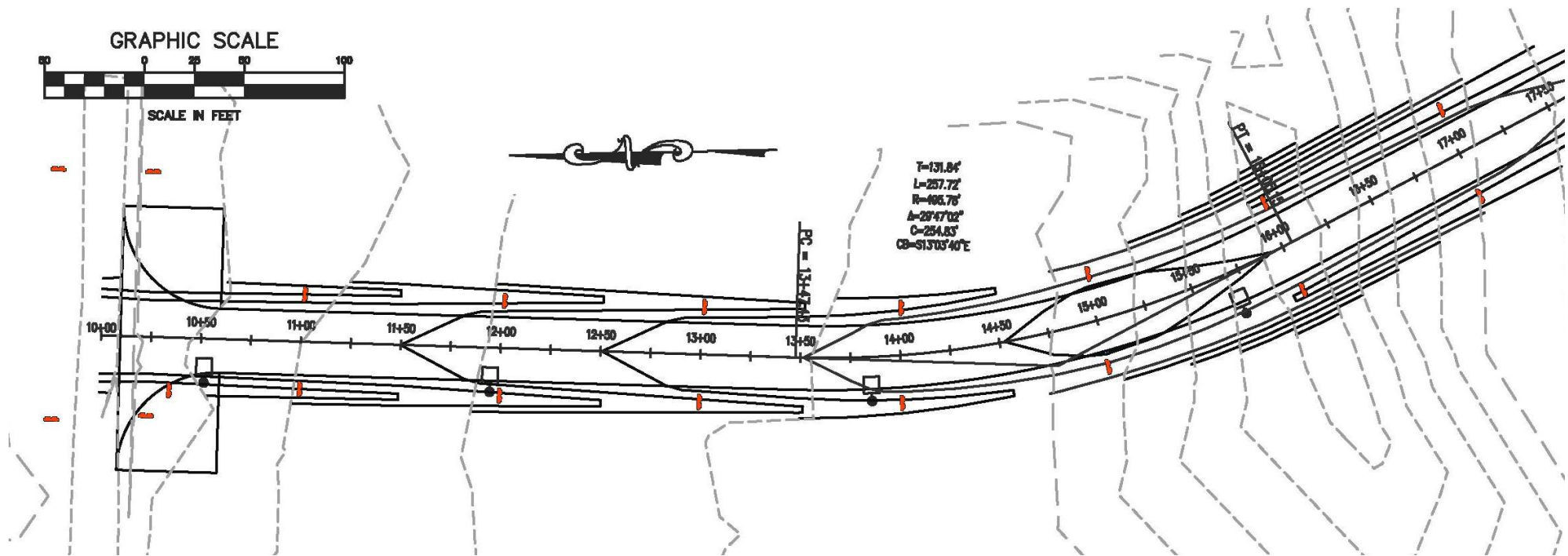
Cut One Foot



Grade

SECTION 3

Stationing



- ☐ For this alignment, Sta 10+00 is the begin station and station values increase as you head South.
- ☐ Once you know which way the station values are increasing, you now can determine which side is left and right of the Centerline. Left and right of station are determined with you back toward the begin station and with you facing up station.
- ☐ Remember, negative offsets are left, and positive offsets are right of the baseline

STATIONING QUIZ

1. Begin Station is 10+00 and you are standing at Centerline of Sta 16+45, how many feet are you along the alignment?

$$1645.00 - 1000.00 = 645.00'$$

2. If you are standing -16.5' offset of Sta 20+10, are you left or right of Centerline?

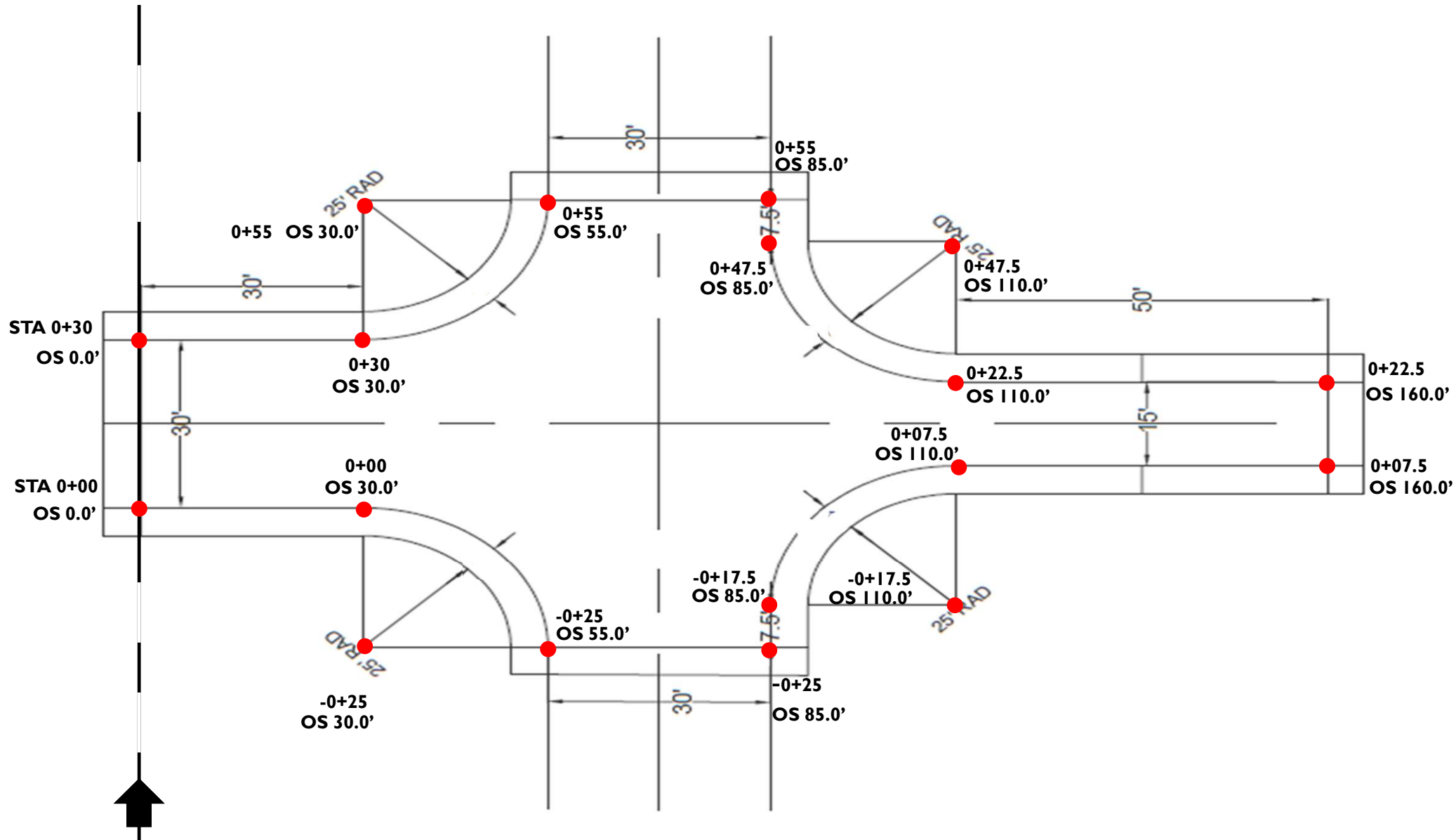
Negative Offset = Left & Positive Offset = Right

3. How many feet apart are Stations 12+48.35 and 21+98.68?

$$2198.68 - 1248.35 = 950.33'$$

4. If you are at Sta 21+00 Offset -25.52', how far is it to Centerline?

$$25.52'$$



SECTION 4

Stake Reading

Least Expendable Stakes

- Horizontal Control
- Vertical Control

More Expendable Stakes

- Reference
- Temporary

Expendable Stakes

- Centerline



**Do Not Run Any Stake Over
Anytime!**

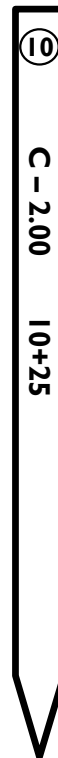
**The integrity of the stake and its
location must be maintained at all
times!**

WHAT INFORMATION CAN BE FOUND ON STAKES?

Horizontal - Offset

Vertical – Cut or Fill

Location - Stationing

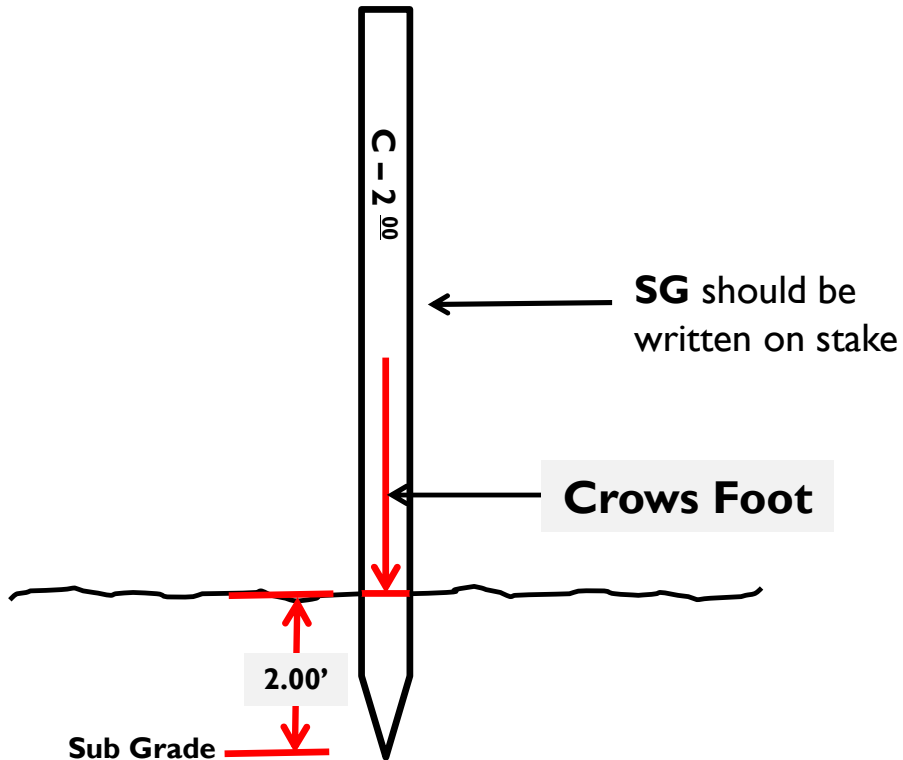


More Info

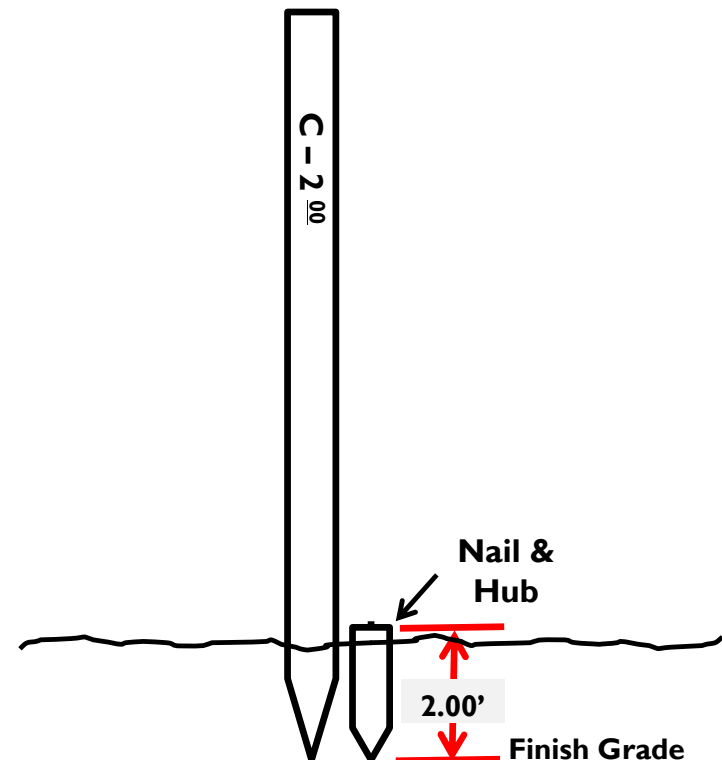


DIFFERENT TYPES OF GRADE STAKES

One type is set by the grade person in your company



The other type of grade stake is set by a surveyor.



STAKE READING QUESTIONS

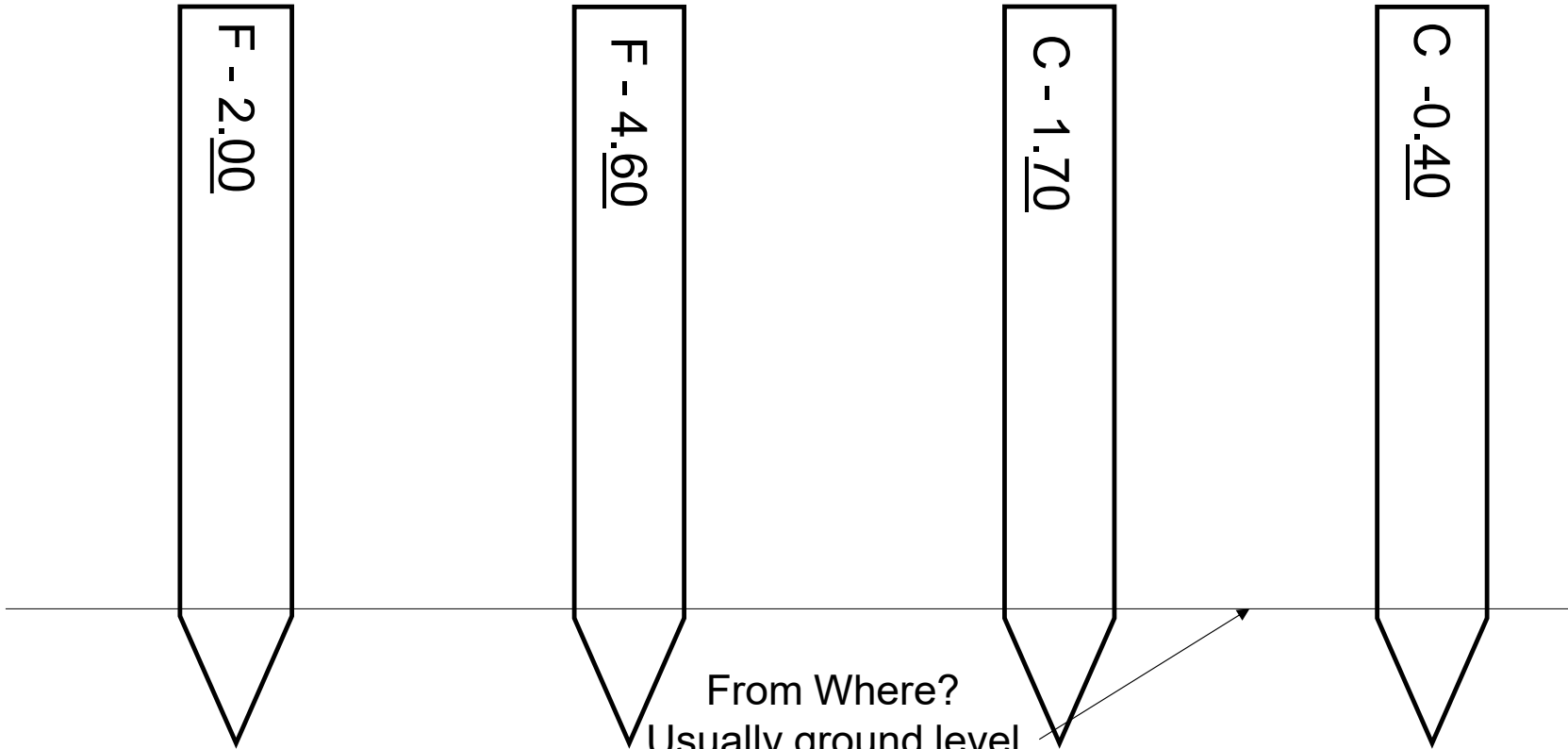
F - 2.00

F - 4.60

C - 1.70

C - 0.40

From Where?
Usually ground level
To SG or FG?



STAKE READING QUESTIONS

Sta 1 + 50 C - 2.5
K

—
K

MH #3 Line Only

Sta 3 + 75 MH #3
C - 0.97 T.C.
K

GR —
K

F - 3.8

F - 3.08

C - 2.56

C - 2.56

F - 4.6

C - 2.0

STAKE READING QUIZ

1. 4 Feet equals how many Tenths? 40
2. 100 Hundredths equals how many Tenths? 10
3. 0.5 Feet is how many Inches? 6"
4. 2 Feet & 2 Tenths is how many Tenths? 22
5. How many Hundredths is that? 220
6. 3^4 is how many Tenths? 34
7. 3^{45} is how many Hundredths? 345
8. 30 Tenths is how many feet? 3'
9. What is the symbol for Cut? C Fill? F

10. What does this Stake mean?



Cut 4.70'

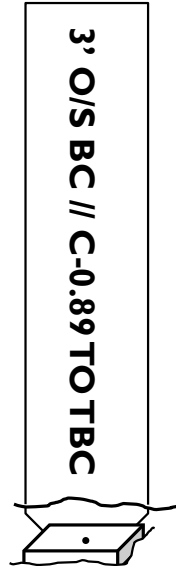
11. What does this Stake mean?



Fill 0.85'

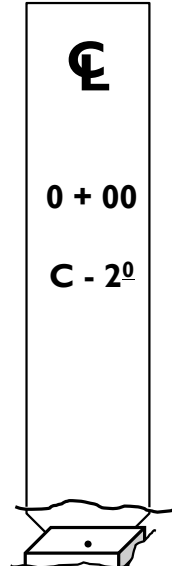
STAKE READING WITH VISUALIZATION

Curb Stake



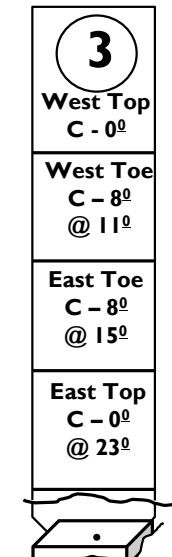
Hub

Street Stake



Hub

Ditch Channel Stake



Hub

CURB STAKE VISUAL

3' O/S BC // C-0.89 TO TBC

3' Horizontally

0.89' Vertically
Down For Cut - FG

TBC – Top Back of Curb = FG

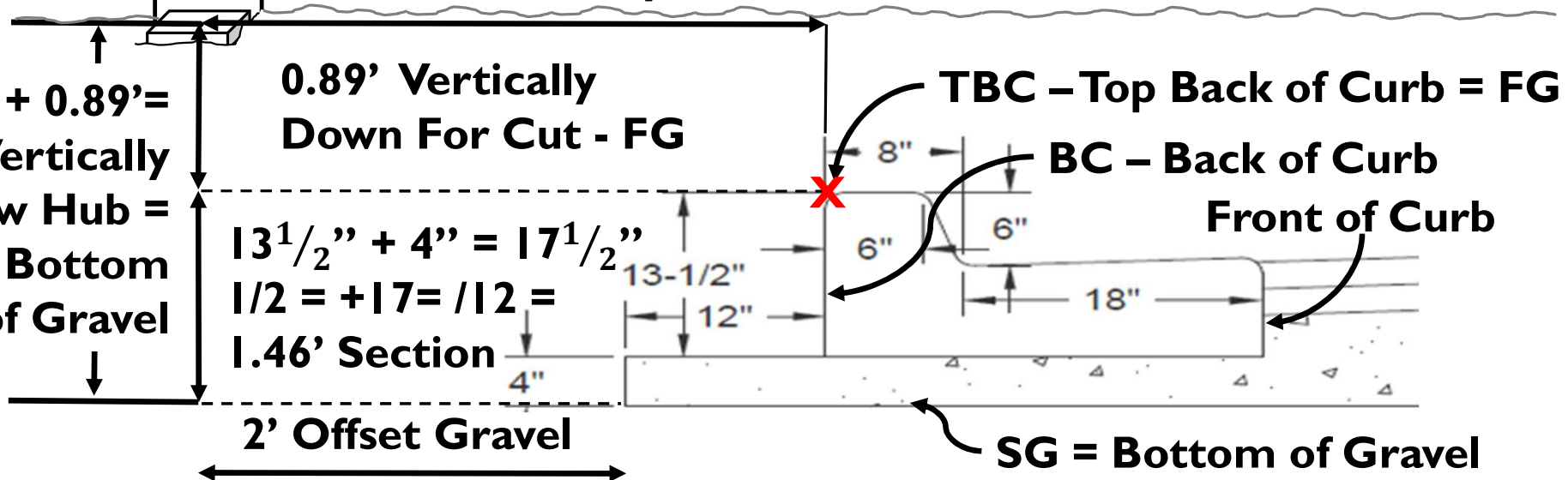
BC – Back of Curb
Front of Curb

1.46' + 0.89' =
2.35' Vertically
Below Hub =
SG Bottom
of Gravel

$13\frac{1}{2}'' + 4'' = 17\frac{1}{2}''$
 $1\frac{1}{2} = +17 = 12 =$
1.46' Section

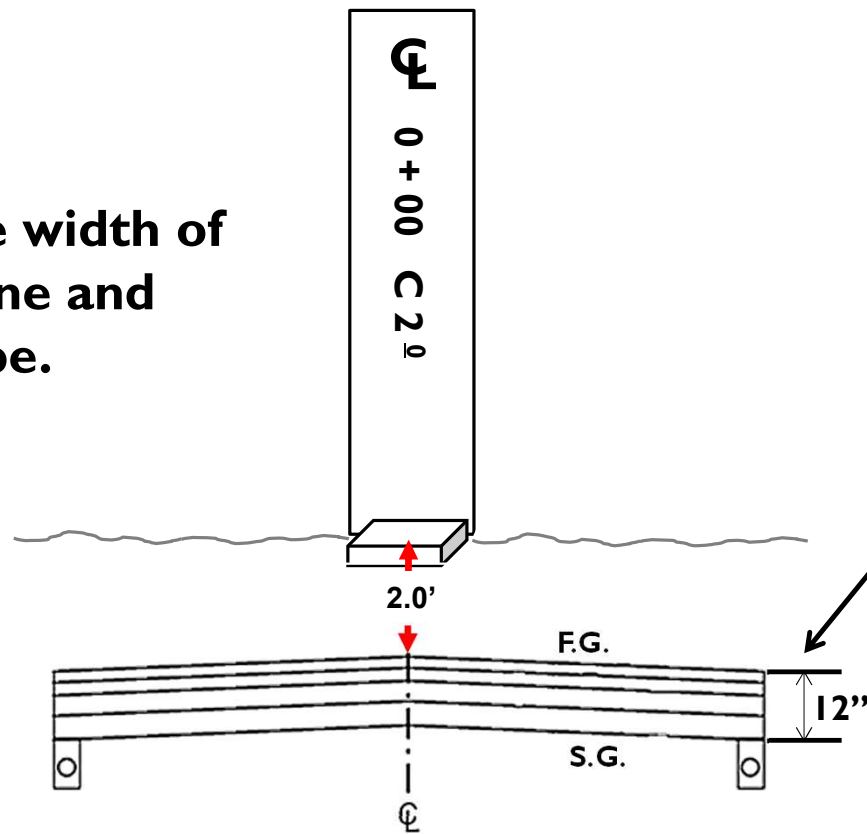
2' Offset Gravel

SG = Bottom of Gravel



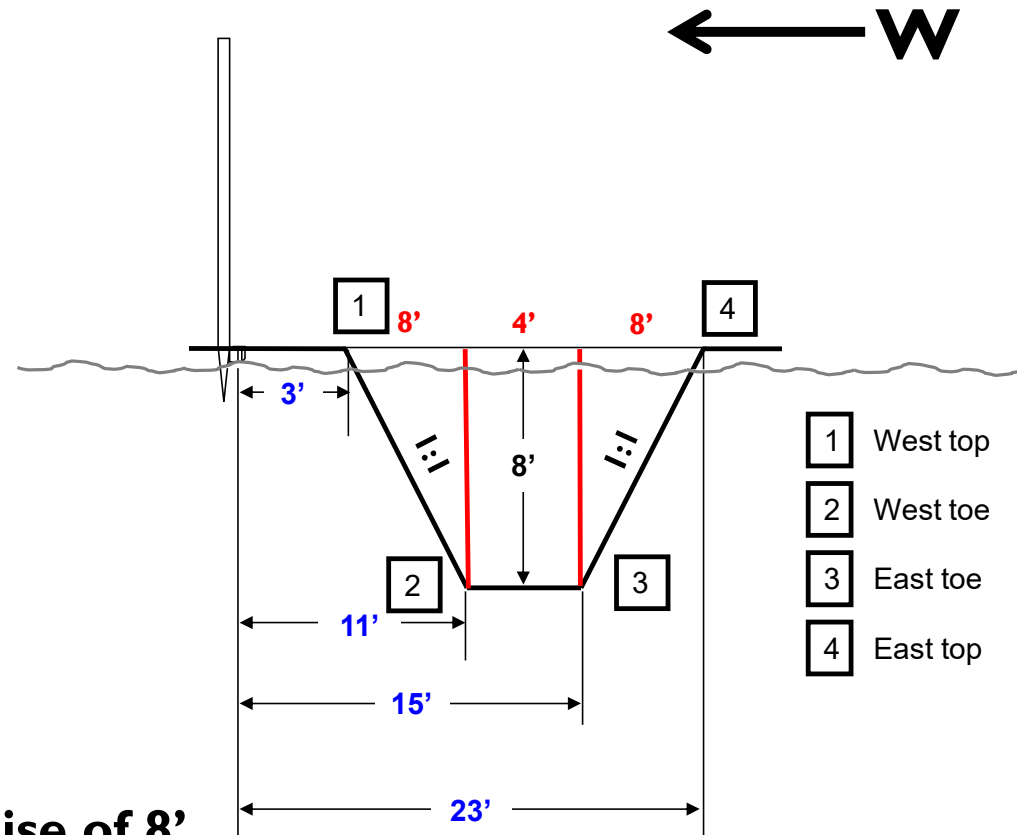
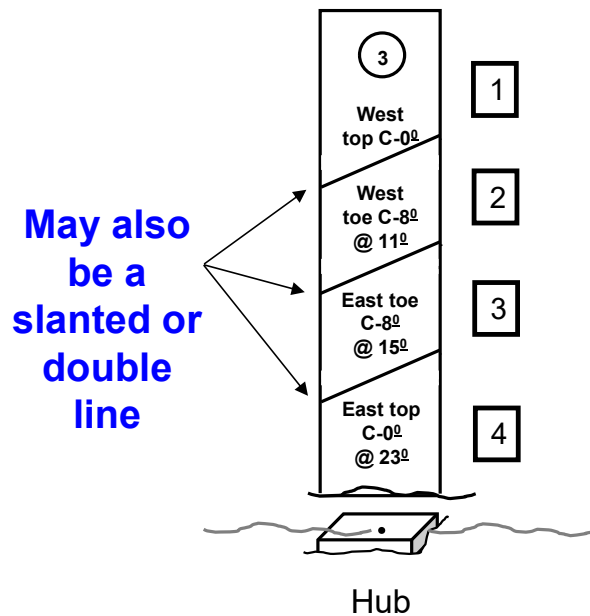
ROAD STAKE VISUAL

You need to know the width of road from centerline and percent of slope.



What is the section thickness for SG?

DITCH CHANNEL STAKE VISUAL

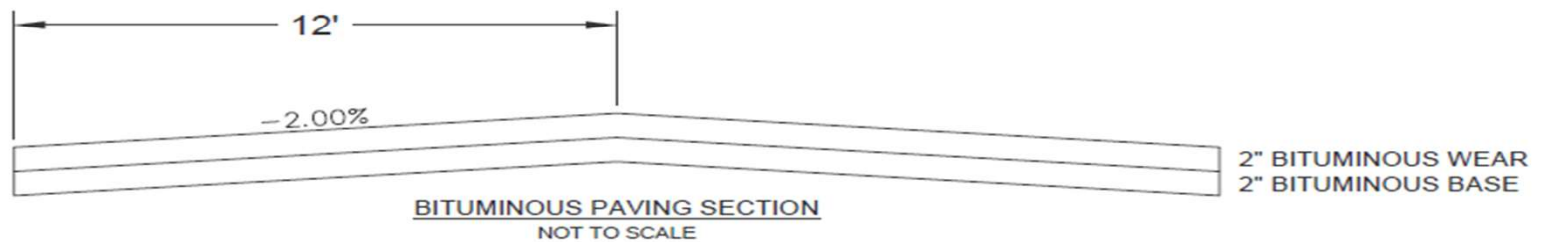
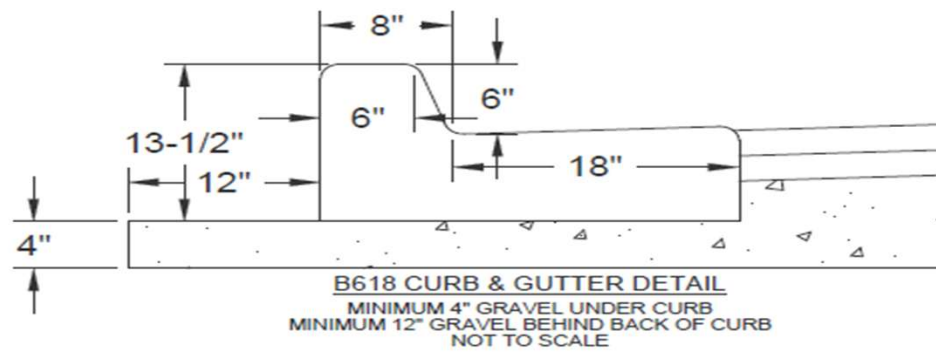
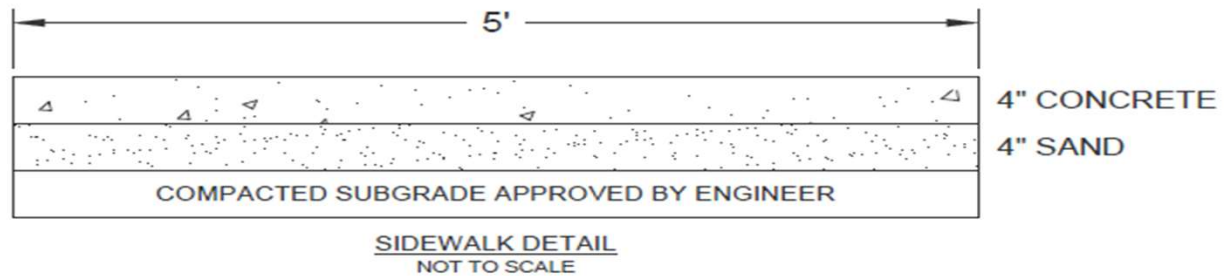


Run / Rise = Slope Ratio

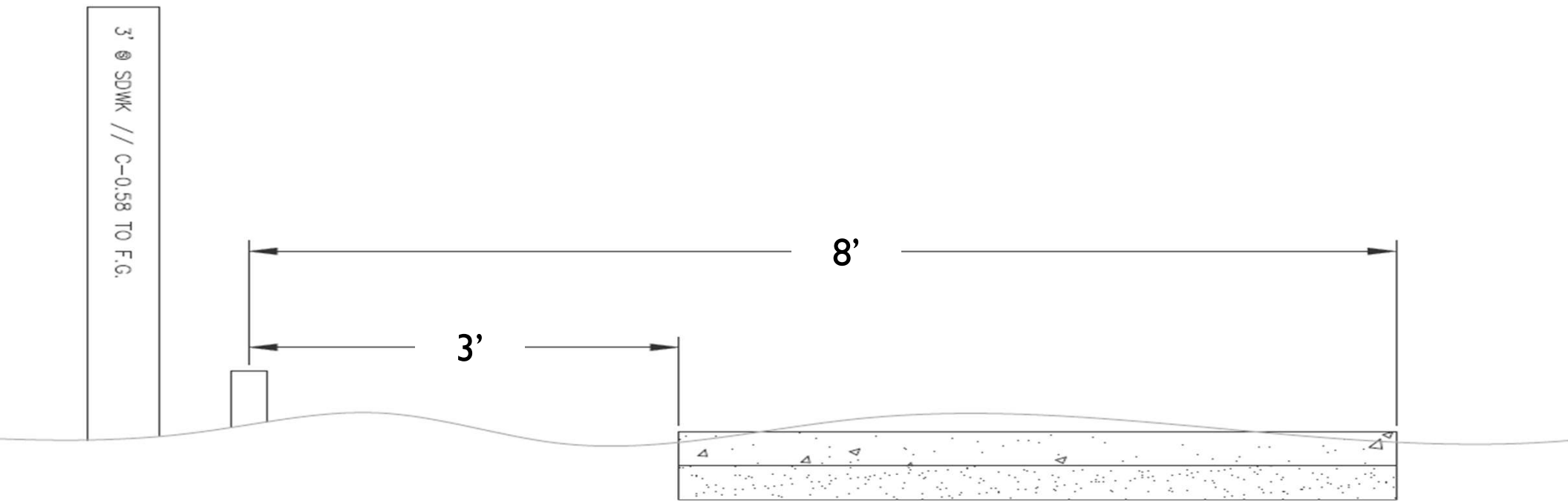
Horizontal Run of 8' & Vertical Rise of 8'

$$8 / 8 = 1:1$$

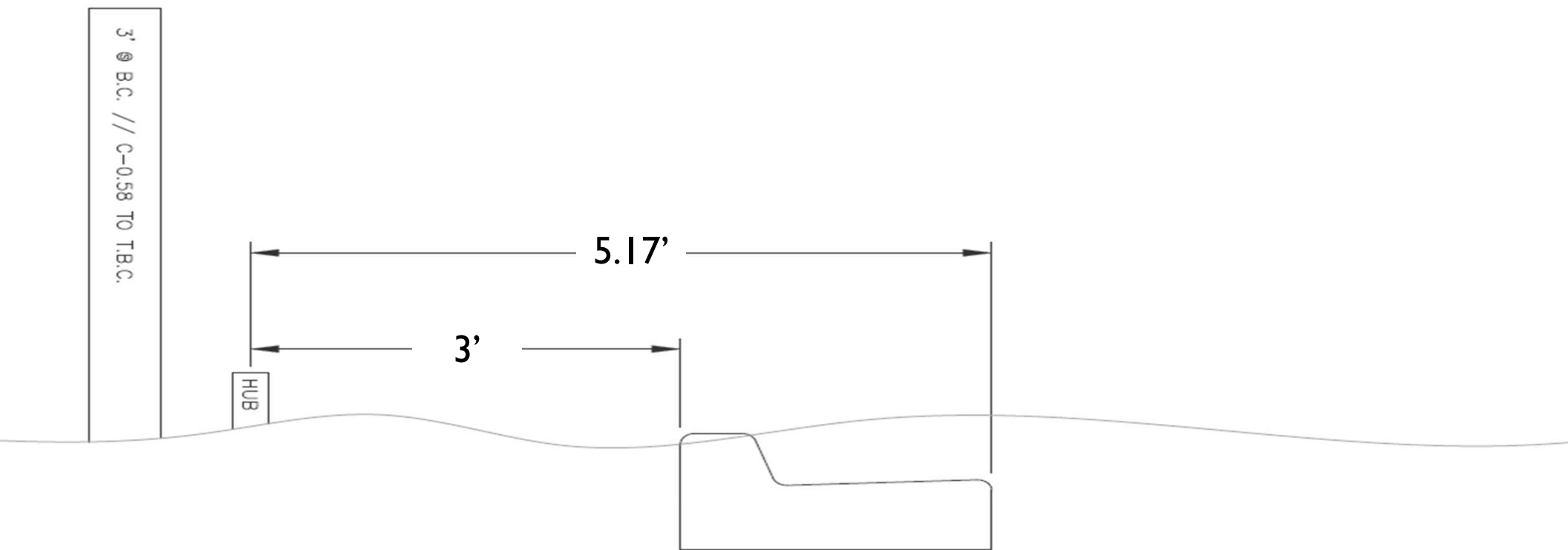
CONSTRUCTION STAKING - DETAILS



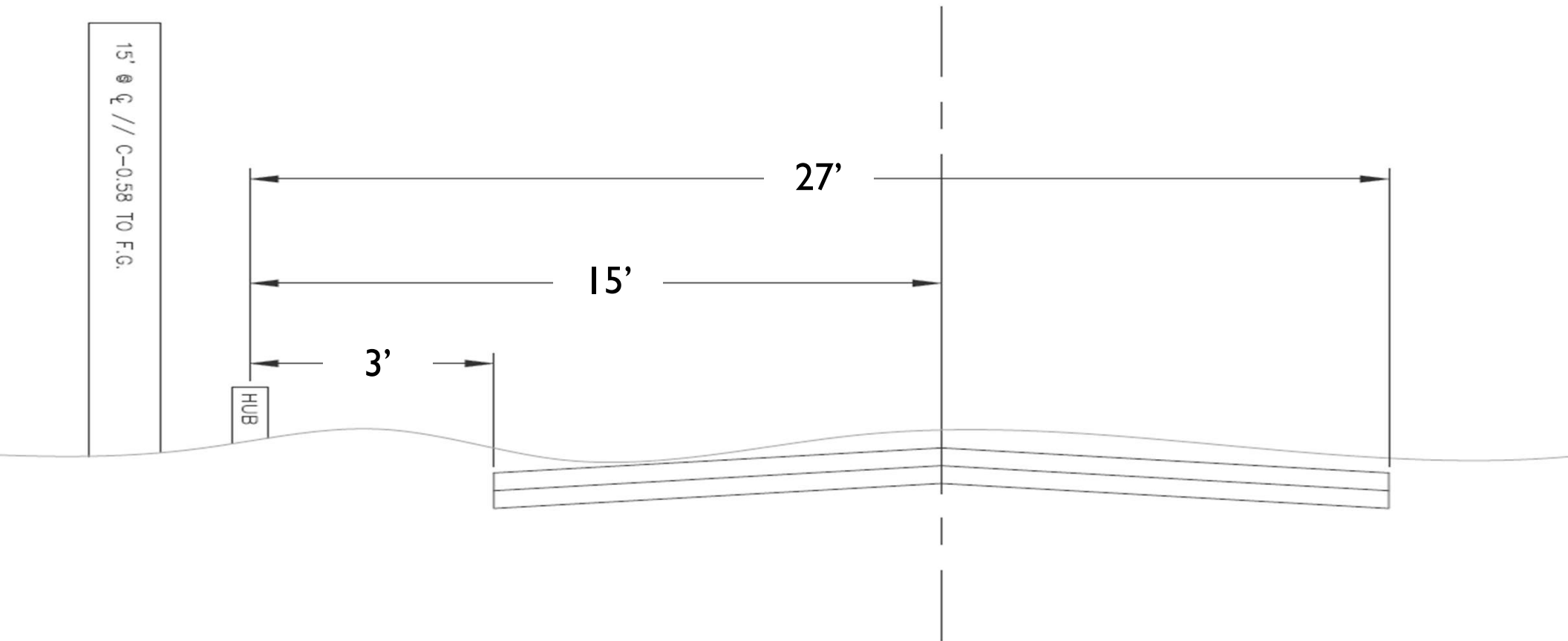
CONSTRUCTION STAKING - SIDEWALK

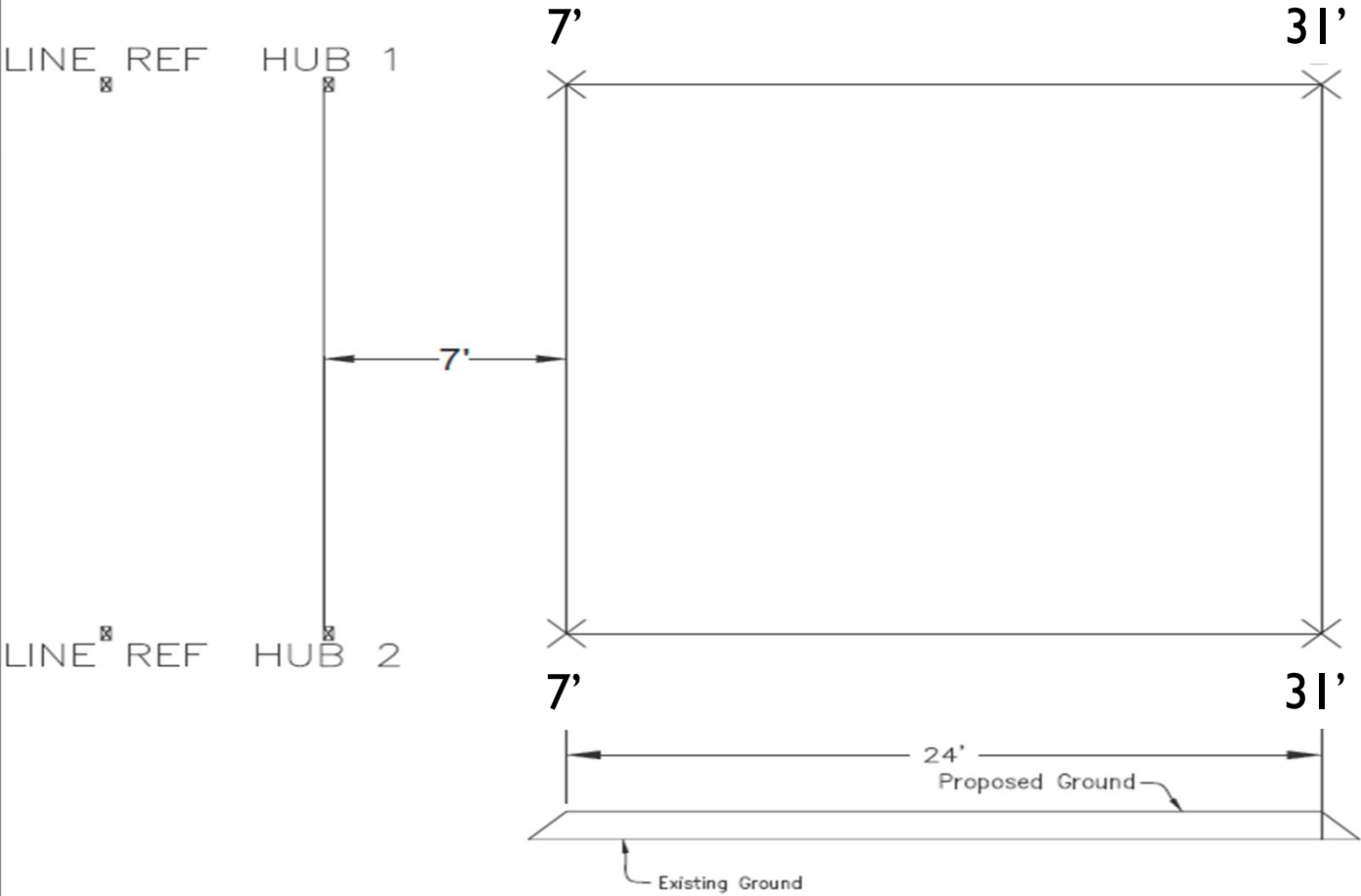


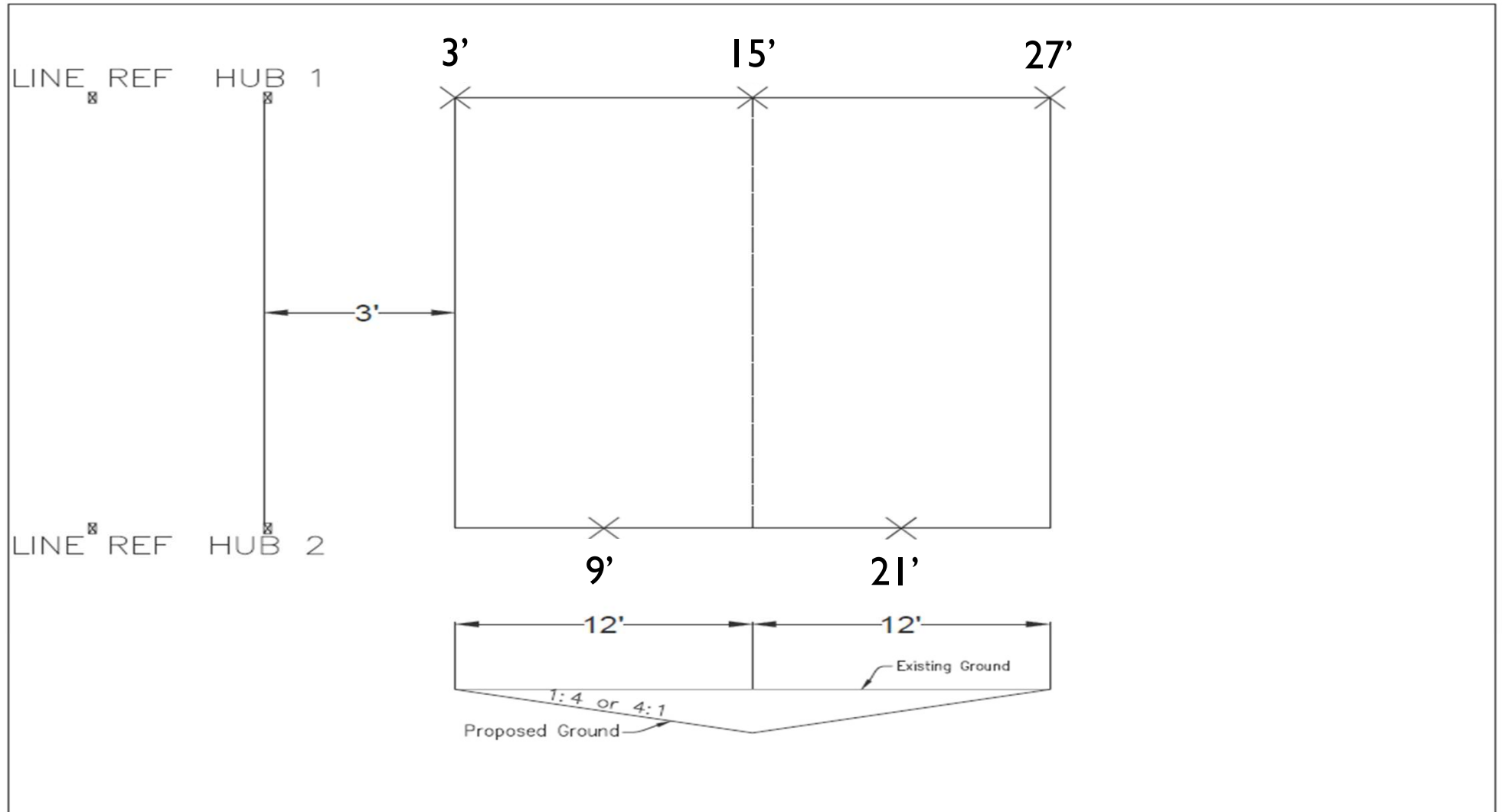
CONSTRUCTION STAKING - CURB & GUTTER

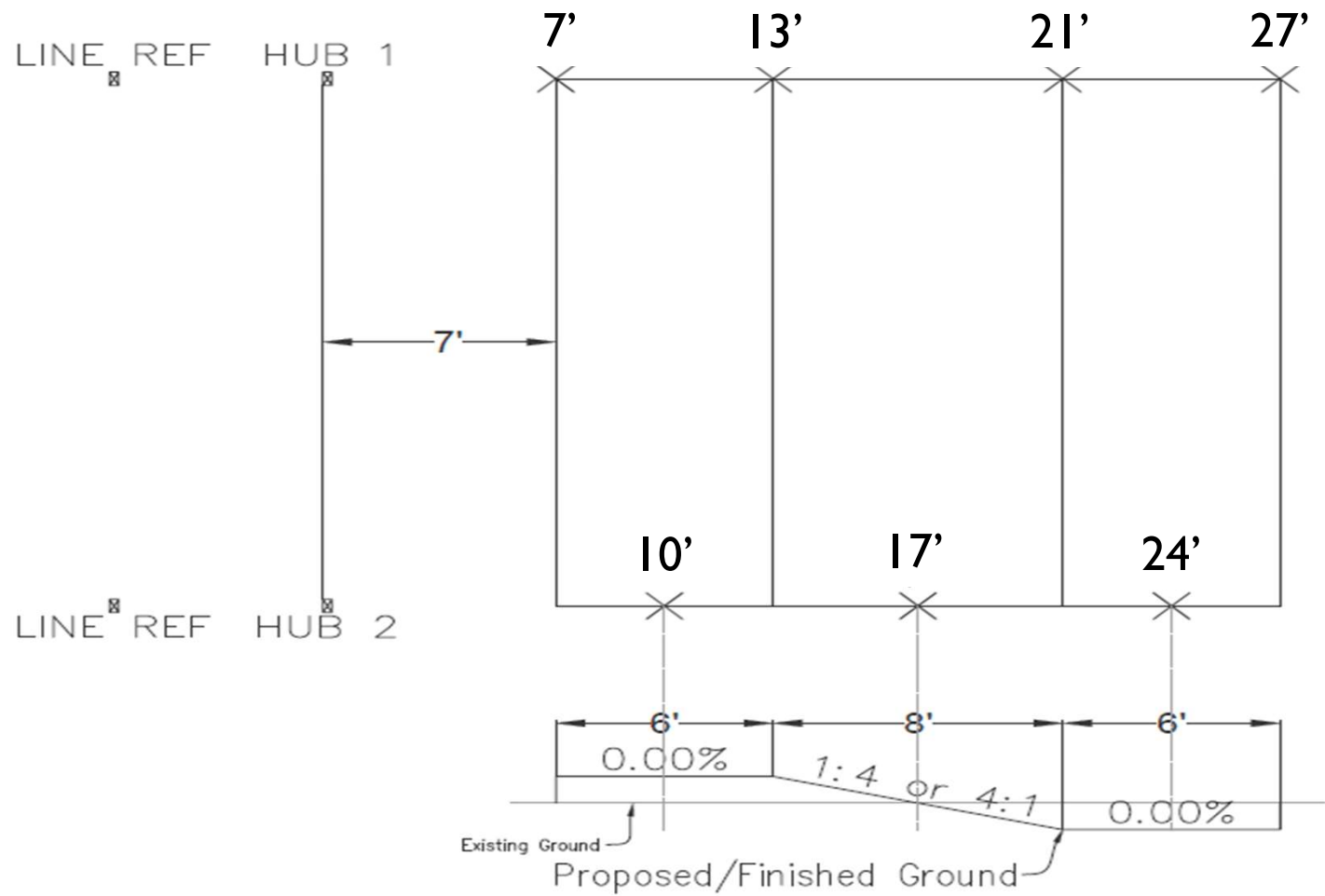


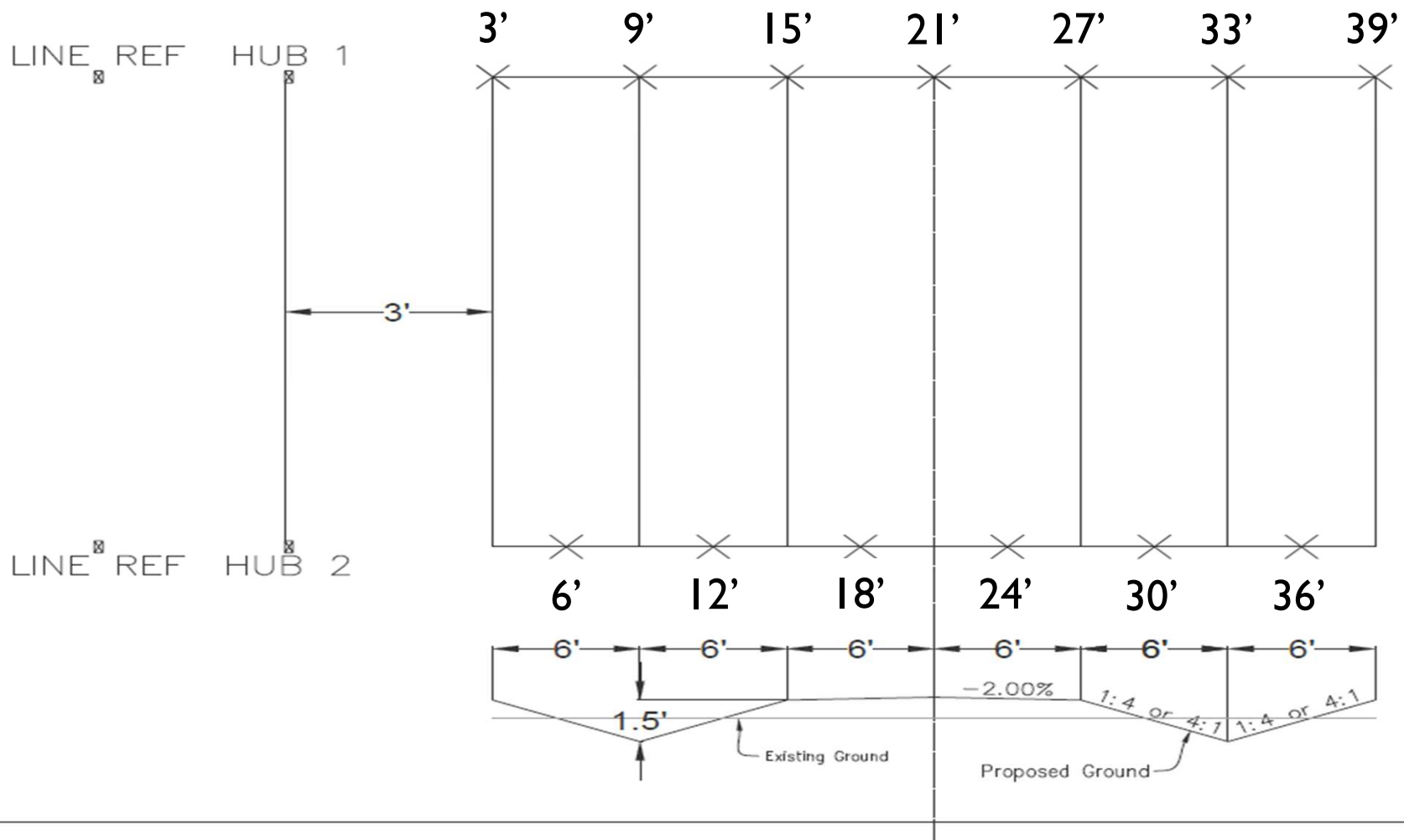
CONSTRUCTION STAKING - ROADWAY SECTION





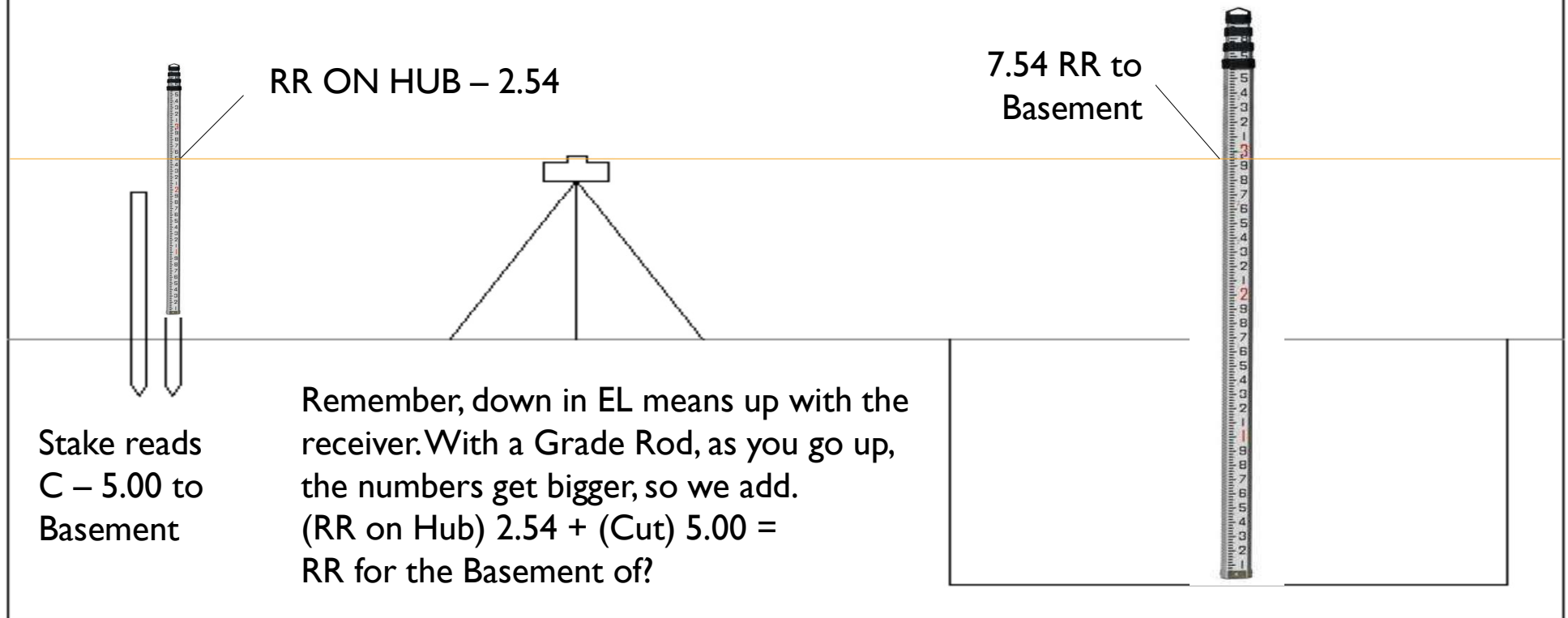






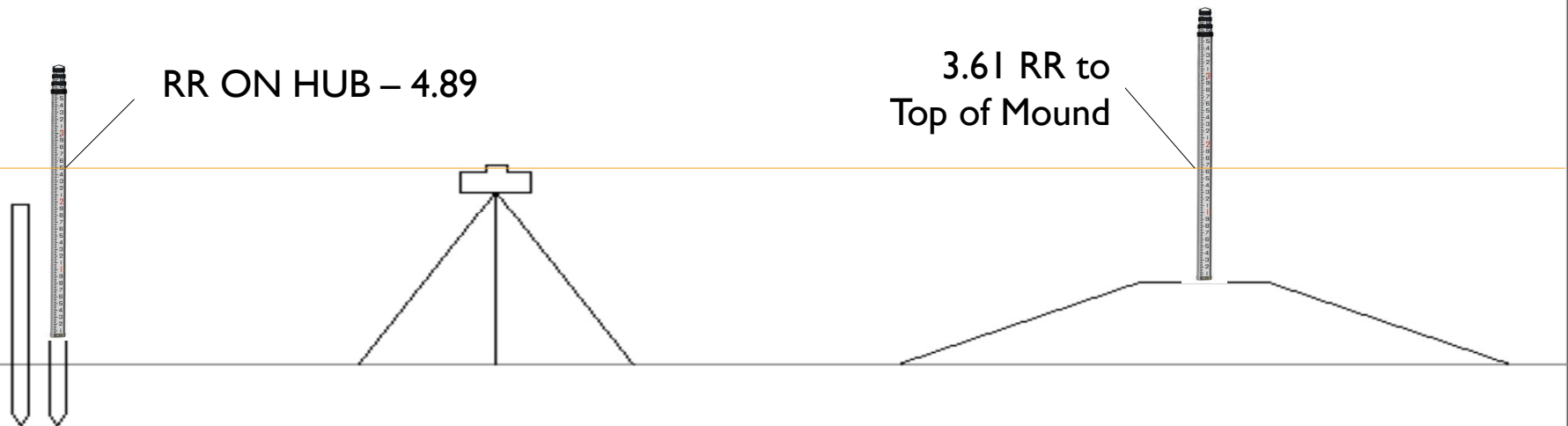
CONSTRUCTION STAKING – GRADE ROD

What is your Rod Reading (RR) to excavate this Basement?



CONSTRUCTION STAKING – GRADE ROD

What is your Rod Reading (RR) to Top of Mound?



Stake reads
F – 1.28 to
Top of Mound

Remember, up in EL means down with the receiver. With a Grade Rod, as you go down, the numbers get smaller, so we subtract.
 $(RR \text{ on Hub}) 4.89 - (\text{Fill}) 1.28 =$
RR to Top of Mound of?

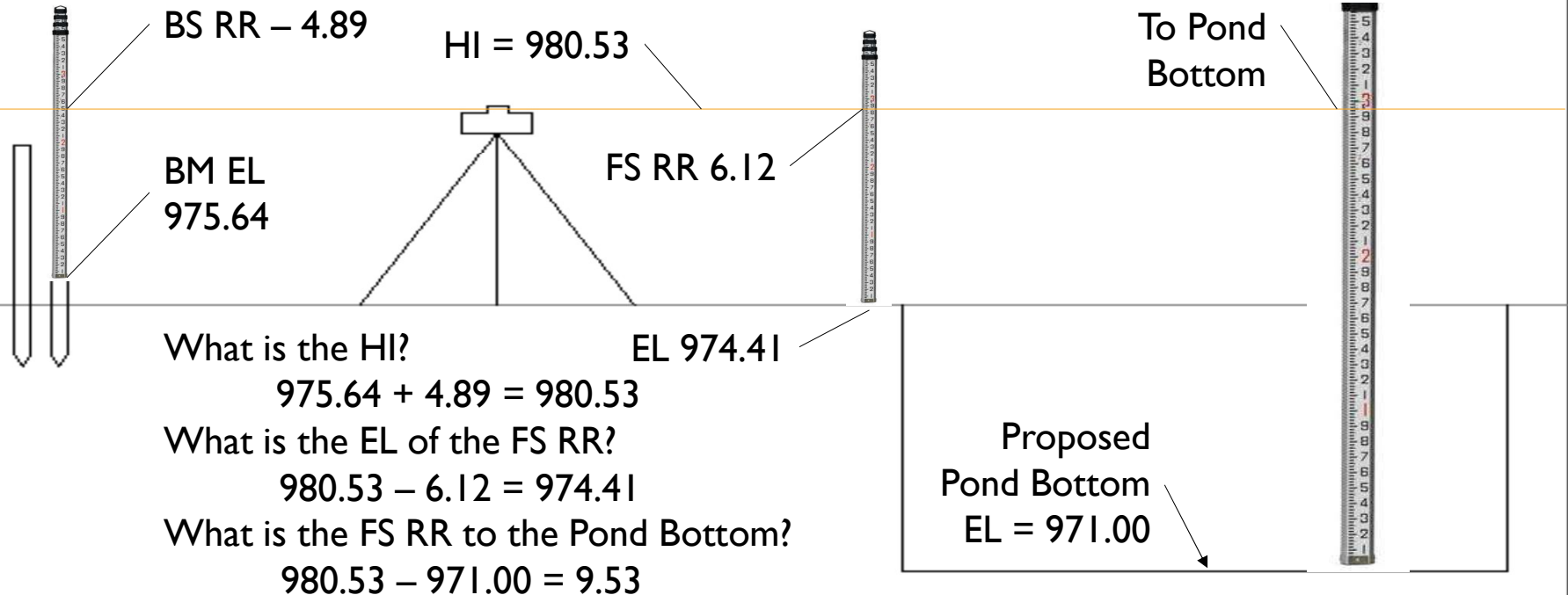
CONSTRUCTION STAKING USING BM – GRADE ROD

Equations

Benchmark (BM) + Backsight (BS) = Height/Elevation of Instrument (HI)

HI – Foresight (FS) = Elevation (EL)

HI – Proposed EL = FS RR



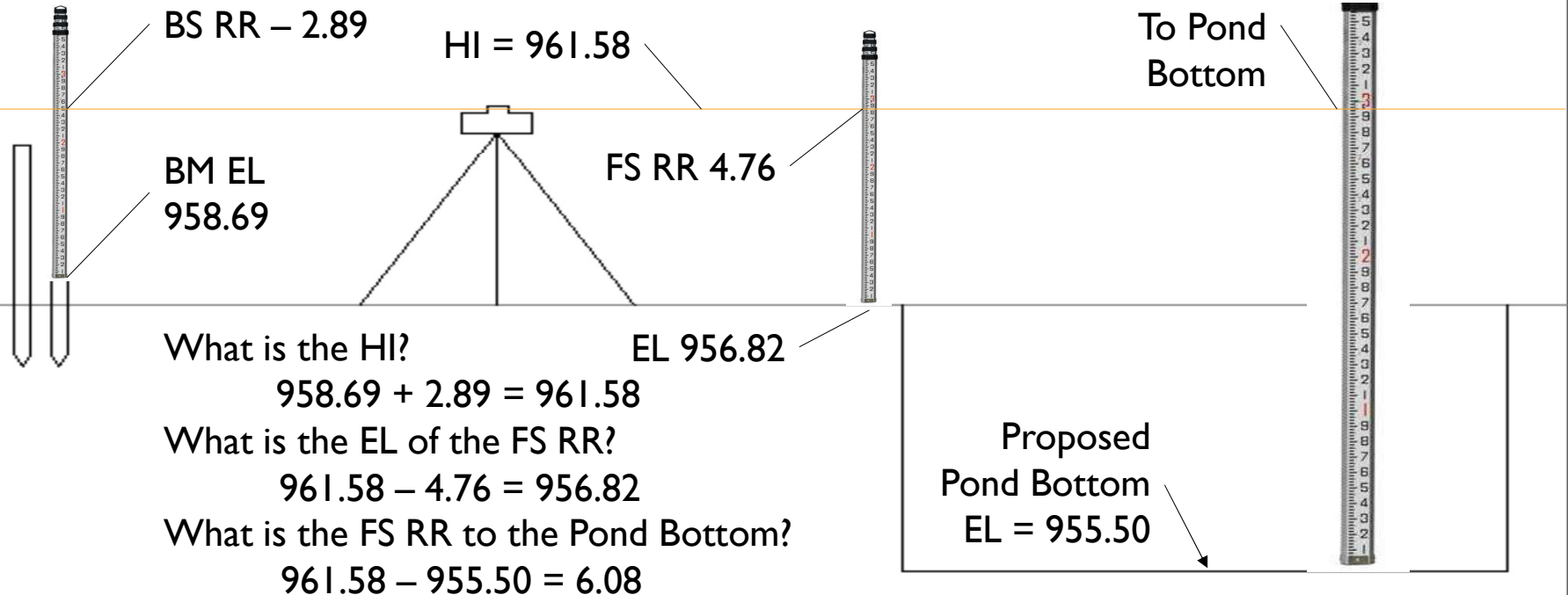
CONSTRUCTION STAKING USING BM – GRADE ROD

Equations

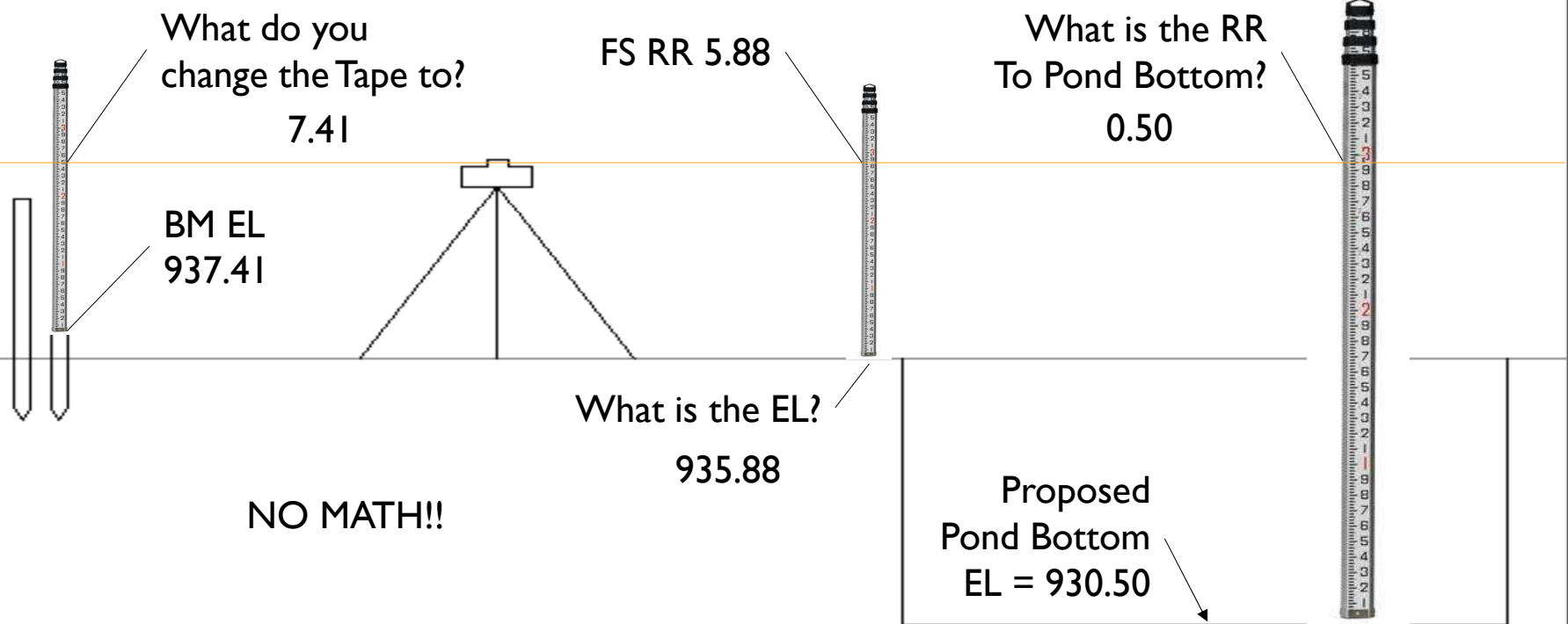
Benchmark (BM) + Backsight (BS) = Height/Elevation of Instrument (HI)

HI – Foresight (FS) = Elevation (EL)

HI – Proposed EL = FS RR

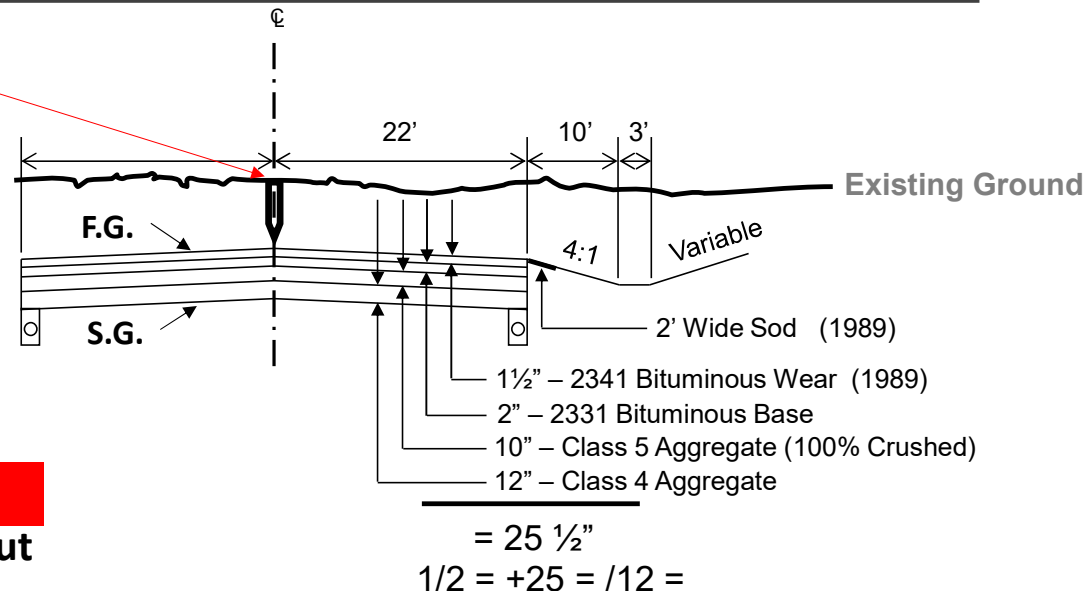


CONSTRUCTION STAKING USING BM – LENKER ROD



STAKE READING WITH SECTION USING 4' LEVEL AND TAPE

**Cut 2.00 to
Finished Grade
From Top of Hub**



Formula

Section + Cut = Total Cut

Section - Fill = (-) is Fill & (+) is Cut

Can we figure out the Cut to SG @ Centerline?

Yes, we can! How?

Add up all the Sections, converting to Decimal Feet and properly rounded = 2.13'

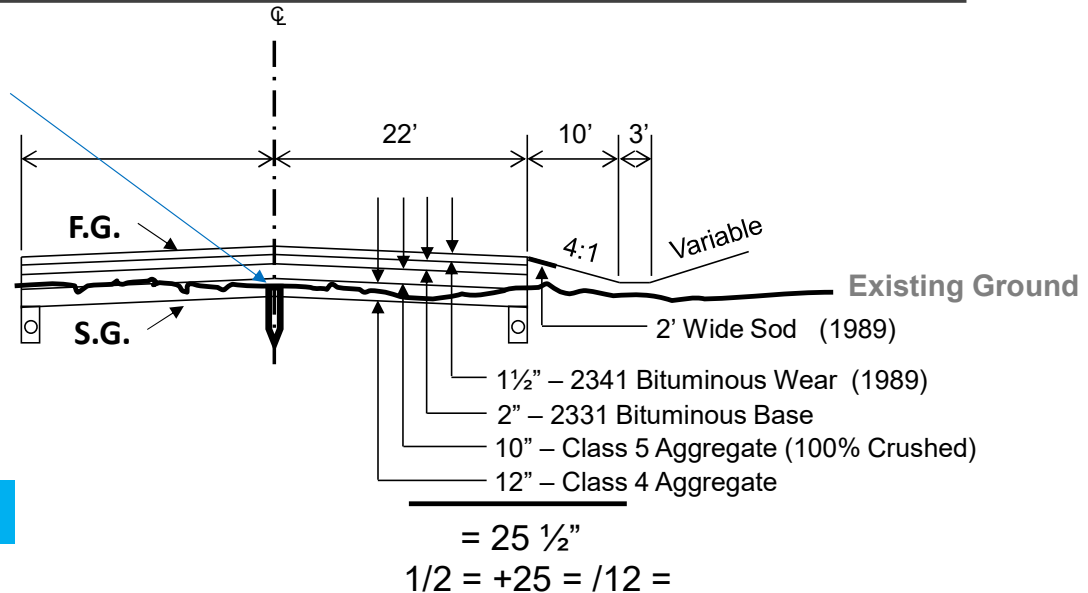
We know it's a Cut of 2.00' to FG @ Centerline and the formula says we add the Cut

Section Converted = 2.13' + Cut of 2.00' = 4.13' Total Cut

From the Top of the Hub, it's a C - 4.13' to S.G. @ Centerline

STAKE READING WITH SECTION USING 4' LEVEL AND TAPE

Fill 2.00 to
Finished Grade
From Top of Hub



Can we figure out the Cut to SG @ Centerline?

Yes, we can! How?

Add up all the Sections, converting to Decimal Feet and properly rounded = 2.13'
We know it's a Fill of 2.00' to FG @ Centerline and the formula says we subtract the Fill
Section Converted = 2.13' - Fill of 2.00' = 0.13' is a positive number
From the Top of the Hub, it's a C - 0.13' to S.G. @ Centerline

SECTION EXERCISE – SIDEWALK USING 4' LEVEL AND TAPE

Concrete Sidewalk Section

4" – Concrete
4" – Sand Cushion

F.G.

S.G.

Add up all thicknesses. Convert inches to decimal feet, properly rounded. Answer in the space provided.

Formula

Section + Cut = Total Cut

Section - Fill = (-) is Fill & (+) is Cut

Total inches of all section thicknesses = 8" Inches

Converted to Decimal Feet = 0.67'

C - 1 ₀₀

$$0.67 + 1.00 = 1.67'$$

Cut 1.67' or Fill _____

C - 0 ₀₀

$$0.67 + 0.00 = 0.67'$$

Cut 0.67' or Fill _____

F - 0 ₅₀

$$0.67 - 0.50 = 0.17'$$

Cut 0.17' or Fill _____

F - 1 ₀₀

$$0.67 - 1.00 = -0.33'$$

Cut _____ or Fill 0.33'

SECTION EXERCISE – BUILDING SLAB USING 4' LEVEL AND TAPE

Concrete Building Slab Section

6" – Concrete	F.G.
6" – Sand Cushion	S.G.

Add up all thicknesses. Convert inches to decimal feet, properly rounded. Answer in the space provided.

Formula

Section + Cut = Total Cut

Section - Fill = (-) is Fill & (+) is Cut

Total inches of all section thicknesses = 12" Inches

Converted to Decimal Feet = 1.00'

C - 1
00

$$1.00 + 1.00 = 2.00'$$

Cut 2.00' or Fill _____

C - 0
00

$$1.00 + 0.00 = 1.00'$$

Cut 1.00' or Fill _____

F - 0
75

$$1.00 - 0.75 = 0.25'$$

Cut 0.25' or Fill _____

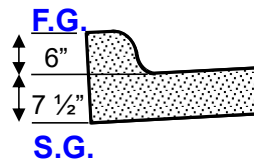
F - 2
00

$$1.00 - 2.00 = -1.00'$$

Cut _____ or Fill 1.00'

SECTION EXERCISE – B618 CURB & GUTTER USING 4' LEVEL AND TAPE

Concrete Curb Section – B618 Curb & Gutter



Add up all thicknesses. Convert inches to decimal feet, properly rounded. Answer in the space provided.

Formula

Section + Cut = Total Cut

Section - Fill = (-) is Fill & (+) is Cut

Total inches of all section thicknesses = 13 1/2" Inches

Converted to Decimal Feet = 1.13'

C - 1 00

$$1.13 + 1.00 = 2.13'$$

Cut 2.13' or Fill _____

C - 0 50

$$1.13 + 0.50 = 1.63'$$

Cut 1.63' or Fill _____

F - 1 00

$$1.13 - 1.00 = 0.13'$$

Cut 0.13' or Fill _____

F - 2 00

$$1.13 - 2.00 = -0.87'$$

Cut _____ or Fill 0.87'

SECTION EXERCISE – ROADWAY USING 4' LEVEL AND TAPE

Blacktop Road Section

F.G.

1 ½" - 2341 Bituminous Wear Course
2" - 2331 Bituminous Base Course
10" - Class 5 Aggregate
12" - Class 4 Aggregate

S.G.

Add up all thicknesses. Convert inches to decimal feet, properly rounded. Answer in the space provided.

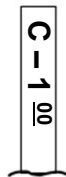
Formula

Section + Cut = Total Cut

Section - Fill = (-) is Fill & (+) is Cut

Total inches of all section thicknesses = 25 ½" Inches

Converted to Decimal Feet = 2.13'



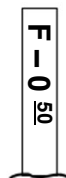
$$2.13 + 1.00 = 3.13'$$

Cut 3.13' or Fill _____



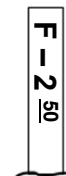
$$2.13 + 0.00 = 2.13'$$

Cut 2.13' or Fill _____



$$2.13 - 0.50 = 1.63'$$

Cut 1.63' or Fill _____



$$2.13 - 2.50 = -0.37'$$

Cut _____ or Fill 0.37'

Stake Reading with Section - Grade Rod

Stake #	Stake Info	Section Thickness	ROD READING ON HUB (RR)	RR+CUT RR-FILL = FG RR	FG RR + Section = SG RR	SG RR - GROUND RR =
						(-) = Fill (+) = Cut
EXAMPLE	F-1.56 TO FG	4" CONCRETE 4" SAND	5.06	(5.06 - 1.56) 3.50	(3.50 + 0.67) 4.17	(4.17 - 5.25) F-1.08 SG
1	C - 0.16 TO FG	4" CONCRETE 4" SAND	7.12	(7.12 + 0.16) FG RR = 7.28	(7.28 + 0.67) SG RR = 7.95	(7.95 - 7.37) C - 0.58
2	F - 1.56 TO FG	4" CONCRETE 4" SAND	6.22	(6.22 - 1.56) FG RR = 4.66	(4.66 + 0.67) SG RR = 5.33	(5.33 - 6.42) F - 1.09
3	C - 0.34 TO FG	4" CONCRETE 4" SAND	4.19	(4.19 + 0.34) FG RR = 4.53	(4.53 + 0.67) SG RR = 5.20	(5.20 - 4.39) C - 0.81
4	F - 1.08 TO FG	4" CONCRETE 4" SAND	10.22	(10.22 - 1.08) FG RR = 9.14	(9.14 + 0.67) SG RR = 9.81	(9.81 - 10.52) F - 0.71
5	C - 0.67 TO FG	6" CONCRETE 6" SAND	2.17	(2.17 + 0.67) FG RR = 2.84	(2.84 + 1.00) SG RR = 3.84	(3.84 - 2.42) C - 1.42
6	F - 0.96 TO FG	6" CONCRETE 6" SAND	3.02	(3.02 - 0.96) FG RR = 2.06	(2.06 + 1.00) SG RR = 3.06	(3.06 - 3.52) F - 0.46
7	C - 1.43 TO FG	6" CONCRETE 6" SAND	8.12	(8.12 + 1.43) FG RR = 9.55	(9.55 + 1.00) SG RR = 10.55	(10.55 - 8.37) C - 2.18
8	F - 0.56 TO FG	6" CONCRETE 6" SAND	9.13	(9.13 - 0.56) FG RR = 8.57	(8.57 + 1.00) SG RR = 9.57	(9.57 - 9.28) C - 0.29
9	C - 1.21 TO FG	CURB & GUTTER 13 ½" SECTION	6.27	(6.27 + 1.21) FG RR = 7.48	(7.48 + 1.13) SG RR = 8.61	(8.61 - 6.53) C - 2.08
10	F - 0.85 TO FG	CURB & GUTTER 13 ½" SECTION	5.74	(5.74 - 0.85) FG RR = 4.89	(4.89 + 1.13) SG RR = 6.02	(6.02 - 6.00) C - 0.02
11	C - 0.01 TO FG	CURB & GUTTER 13 ½" SECTION	9.24	(9.24 + 0.01) FG RR = 9.25	(9.25 + 1.13) SG RR = 10.38	(10.38 - 9.43) C - 0.95
12	F - 2.02 TO FG	CURB & GUTTER 13 ½" SECTION	6.22	(6.22 - 2.02) FG RR = 4.20	(4.20 + 1.13) SG RR = 5.33	(5.33 - 6.52) F - 1.19
13	C - 0.85 TO FG	ROADWAY 25 ½" SECTION	5.74	(5.74 + 0.85) FG RR = 6.59	(6.59 + 2.13) SG RR = 8.72	(8.72 - 6.00) C - 2.72
14	F - 1.11 TO FG	ROADWAY 25 ½" SECTION	3.52	(3.52 - 1.11) FG RR = 2.41	(2.41 + 2.13) SG RR = 4.54	(4.54 - 3.79) C - 0.75
15	C - 2.44 TO FG	ROADWAY 25 ½" SECTION	6.82	(6.82 + 2.44) FG RR = 9.26	(9.26 + 2.13) SG RR = 11.39	(11.39 - 7.08) C - 4.31
16	F - 0.24 TO FG	ROADWAY 25 ½" SECTION	4.74	(4.74 - 0.24) FG RR = 4.50	(4.50 + 2.13) SG RR = 6.63	(6.63 - 4.98) C - 1.65

Stake Reading with Section - Lenker Rod

Stake #	Stake Info	Section Thickness	ROD READING ON HUB (RR)	RR - CUT RR + FILL = FG RR	FG RR - Section = SG RR	GROUND RR - SG RR = (-) = Fill (+) = Cut
EXAMPLE	F-1.56 TO FG	4" CONCRETE 4" SAND	5.06	(5.06 + 1.56) 6.62	(6.62 - 0.67) 5.95	(4.87 - 5.95) F-1.08 SG
1	C - 0.16 TO FG	4" CONCRETE 4" SAND	6.75	(6.75 - 0.16) FG RR = 6.59	(6.59 - 0.67) SG RR = 5.92	(6.50 - 5.92) C - 0.58
2	F - 1.56 TO FG	4" CONCRETE 4" SAND	4.28	(4.28 + 1.56) FG RR = 5.84	(5.84 - 0.67) SG RR = 5.17	(4.03 - 5.17) F - 1.14
3	C - 0.34 TO FG	4" CONCRETE 4" SAND	3.12	(3.12 - 0.34) FG RR = 2.78	(2.78 - 0.67) SG RR = 2.11	(2.87 - 2.11) C - 0.76
4	F - 1.08 TO FG	4" CONCRETE 4" SAND	10.10	(10.10 + 1.08) FG RR = 11.18	(11.18 - 0.67) SG RR = 10.51	(9.85 - 10.51) F - 0.66
5	C - 0.67 TO FG	6" CONCRETE 6" SAND	7.18	(7.18 - 0.67) FG RR = 6.51	(6.51 - 1.00) SG RR = 5.51	(6.93 - 5.51) C - 1.42
6	F - 0.96 TO FG	6" CONCRETE 6" SAND	5.44	(5.44 + 0.96) FG RR = 6.40	(6.40 - 1.00) SG RR = 5.40	(5.19 - 5.40) F - 0.21
7	C - 1.43 TO FG	6" CONCRETE 6" SAND	6.13	(6.13 - 1.43) FG RR = 4.70	(4.70 - 1.00) SG RR = 3.70	(5.88 - 3.70) C - 2.18
8	F - 0.56 TO FG	6" CONCRETE 6" SAND	7.88	(7.88 + 0.56) FG RR = 8.44	(8.44 - 1.00) SG RR = 7.44	(7.63 - 7.44) C - 0.19
9	C - 1.21 TO FG	CURB & GUTTER 13 ½" SECTION	6.97	(6.97 - 1.21) FG RR = 5.76	(5.76 - 1.13) SG RR = 4.63	(6.72 - 4.63) C - 2.09
10	F - 0.85 TO FG	CURB & GUTTER 13 ½" SECTION	12.12	(12.12 + 0.85) FG RR = 12.97	(12.97 - 1.13) SG RR = 11.84	(11.87 - 11.84) C - 0.03
11	C - 0.01 TO FG	CURB & GUTTER 13 ½" SECTION	2.60	(2.60 - 0.01) FG RR = 2.59	(2.59 - 1.13) SG RR = 1.46	(2.35 - 1.46) C - 0.89
12	F - 2.02 TO FG	CURB & GUTTER 13 ½" SECTION	4.13	(4.13 + 2.02) FG RR = 6.15	(6.15 - 1.13) SG RR = 5.02	(3.88 - 5.02) F - 1.14
13	C - 0.85 TO FG	ROADWAY 25 ½" SECTION	5.67	(5.67 - 0.85) FG RR = 4.82	(4.82 - 2.13) SG RR = 2.69	(5.42 - 2.69) C - 2.73
14	F - 1.11 TO FG	ROADWAY 25 ½" SECTION	7.44	(7.44 + 1.11) FG RR = 8.55	(8.55 - 2.13) SG RR = 6.42	(7.19 - 6.42) C - 0.77
15	C - 2.44 TO FG	ROADWAY 25 ½" SECTION	9.13	(9.13 - 2.44) FG RR = 6.69	(6.69 - 2.13) SG RR = 4.56	(8.88 - 4.56) C - 4.32
16	F - 0.24 TO FG	ROADWAY 25 ½" SECTION	8.42	(8.42 + 0.24) FG RR = 8.66	(8.66 - 2.13) SG RR = 6.53	(8.17 - 6.53) C - 1.64

Stake Reading with Section - Grade Rod

Stake #	Stake Info	Section Thickness	ROD READING ON HUB (RR)	RR+CUT RR-FILL = FG RR	FG RR + Section = SG RR	SG RR - GROUND RR =
						(-) = Fill (+) = Cut
EXAMPLE	F-1.56 TO FG	4" CONCRETE 4" SAND	5.06	(5.06 - 1.56) 3.50	(3.50 + 0.67) 4.17	(4.17 - 5.25) F-1.08 SG
1	C - 0.16 TO FG	4" CONCRETE 4" SAND	4.58	(4.58 + 0.16) 4.74	(4.74 + 0.67) 5.41	(5.41 - 4.88) C - 0.53
2	F - 1.56 TO FG	4" CONCRETE 4" SAND	7.69	(7.69 - 1.56) 6.13	(6.13 + 0.67) 6.80	(6.80 - 7.99) F - 1.19
3	C - 0.34 TO FG	4" CONCRETE 4" SAND	3.25	(3.25 + 0.34) 3.59	(3.59 + 0.67) 4.26	(4.26 - 3.55) C - 0.71
4	F - 1.08 TO FG	4" CONCRETE 4" SAND	9.54	(9.54 - 1.08) 8.46	(8.46 + 0.67) 9.13	(9.13 - 9.84) F - 0.71
5	C - 0.67 TO FG	6" CONCRETE 6" SAND	4.22	(4.22 + 0.67) 4.89	(4.89 + 1.00) 5.89	(5.89 - 4.52) C - 1.37
6	F - 0.96 TO FG	6" CONCRETE 6" SAND	6.98	(6.98 - 0.96) 6.02	(6.02 + 1.00) 7.02	(7.02 - 7.28) F - 0.26
7	C - 1.43 TO FG	6" CONCRETE 6" SAND	8.58	(8.58 + 1.43) 10.01	(10.01 + 1.00) 11.01	(11.01 - 8.88) C - 2.13
8	F - 0.56 TO FG	6" CONCRETE 6" SAND	15.54	(15.54 - 0.56) 14.98	(14.98 + 1.00) 15.98	(15.98 - 15.84) C - 0.14
9	C - 1.21 TO FG	CURB & GUTTER 13 ½" SECTION	5.24	(5.24 + 1.21) 6.45	(6.45 + 1.13) 7.58	(7.58 - 5.54) C - 2.04
10	F - 0.85 TO FG	CURB & GUTTER 13 ½" SECTION	6.85	(6.85 - 0.85) 6.00	(6.00 + 1.13) 7.13	(7.13 - 7.15) F - 0.02
11	C - 0.01 TO FG	CURB & GUTTER 13 ½" SECTION	5.69	(5.69 + 0.01) 5.70	(5.70 + 1.13) 6.83	(6.83 - 5.99) C - 0.84
12	F - 2.02 TO FG	CURB & GUTTER 13 ½" SECTION	12.69	(12.69 - 2.02) 10.67	(10.67 + 1.13) 11.80	(11.80 - 12.99) F - 1.19
13	C - 0.85 TO FG	ROADWAY 25 ½" SECTION	10.12	(10.12 + 0.85) 10.97	(10.97 + 2.13) 13.10	(13.10 - 10.42) C - 2.68
14	F - 1.11 TO FG	ROADWAY 25 ½" SECTION	3.52	(3.52 - 1.11) 2.41	(2.41 + 2.13) 4.54	(4.54 - 3.82) C - 0.72
15	C - 2.44 TO FG	ROADWAY 25 ½" SECTION	7.26	(7.26 + 2.44) 9.70	(9.70 + 2.13) 11.83	(11.83 - 7.56) C - 4.27
16	F - 0.24 TO FG	ROADWAY 25 ½" SECTION	8.22	(8.22 - 0.24) 7.98	(7.98 + 2.13) 10.11	(10.11 - 8.52) C - 1.59

Stake Reading with Section - Lenker Rod

Stake #	Stake Info	Section Thickness	ROD READING ON HUB (RR)	RR - CUT RR + FILL = FG RR	FG RR - Section = SG RR	GROUND RR - SG RR = (-) = Fill (+) = Cut
EXAMPLE	F-1.56 TO FG	4" CONCRETE 4" SAND	5.06	(5.06 + 1.56) 6.62	(6.62 - 0.67) 5.95	(4.87 - 5.95) F-1.08 SG
1	C - 0.16 TO FG	4" CONCRETE 4" SAND	4.52	(4.52 - 0.16) 4.36	(4.36 - 0.67) 3.69	(4.22 - 3.69) C - 0.53
2	F - 1.56 TO FG	4" CONCRETE 4" SAND	3.54	(3.54 + 1.56) 5.10	(5.10 - 0.67) 4.43	(3.24 - 4.43) F - 1.19
3	C - 0.34 TO FG	4" CONCRETE 4" SAND	6.89	(6.89 - 0.34) 6.55	(6.55 - 0.67) 5.88	(6.59 - 5.88) C - 0.71
4	F - 1.08 TO FG	4" CONCRETE 4" SAND	5.12	(5.12 + 1.08) 6.20	(6.20 - 0.67) 5.53	(4.82 - 5.53) F - 0.71
5	C - 0.67 TO FG	6" CONCRETE 6" SAND	4.86	(4.86 - 0.67) 4.19	(4.19 - 1.00) 3.19	(4.56 - 3.19) C - 1.37
6	F - 0.96 TO FG	6" CONCRETE 6" SAND	6.33	(6.33 + 0.96) 7.29	(7.29 - 1.00) 6.29	(6.03 - 6.29) F - 0.26
7	C - 1.43 TO FG	6" CONCRETE 6" SAND	5.63	(5.63 - 1.43) 4.20	(4.20 - 1.00) 3.20	(5.33 - 3.20) C - 2.13
8	F - 0.56 TO FG	6" CONCRETE 6" SAND	3.96	(3.96 + 0.56) 4.52	(4.52 - 1.00) 3.52	(3.66 - 3.52) C - 0.14
9	C - 1.21 TO FG	CURB & GUTTER 13 ½" SECTION	4.85	(4.85 - 1.21) 3.64	(3.64 - 1.13) 2.51	(4.55 - 2.51) C - 2.04
10	F - 0.85 TO FG	CURB & GUTTER 13 ½" SECTION	3.77	(3.77 + 0.85) 4.62	(4.62 - 1.13) 3.49	(3.47 - 3.49) F - 0.02
11	C - 0.01 TO FG	CURB & GUTTER 13 ½" SECTION	6.32	(6.32 - 0.01) 6.31	(6.31 - 1.13) 5.18	(6.02 - 5.18) C - 0.84
12	F - 2.02 TO FG	CURB & GUTTER 13 ½" SECTION	5.89	(5.89 + 2.02) 7.91	(7.91 - 1.13) 6.78	(5.59 - 6.78) F - 1.19
13	C - 0.85 TO FG	ROADWAY 25 ½" SECTION	4.63	(4.63 - 0.85) 3.78	(3.78 - 2.13) 1.65	(4.33 - 1.65) C - 2.68
14	F - 1.11 TO FG	ROADWAY 25 ½" SECTION	3.75	(3.75 + 1.11) 4.86	(4.86 - 2.13) 2.73	(3.45 - 2.73) C - 0.72
15	C - 2.44 TO FG	ROADWAY 25 ½" SECTION	6.12	(6.12 - 2.44) 3.68	(3.68 - 2.13) 1.55	(5.82 - 1.55) C - 4.27
16	F - 0.24 TO FG	ROADWAY 25 ½" SECTION	5.41	(5.41 + 0.24) 5.65	(5.65 - 2.13) 3.52	(5.11 - 3.52) C - 1.59

SECTION 5

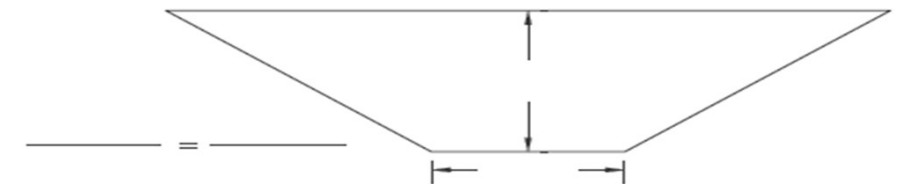
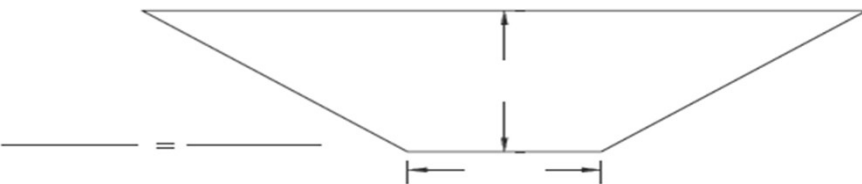
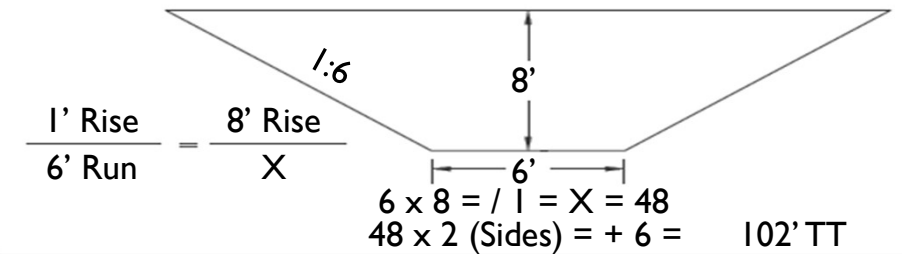
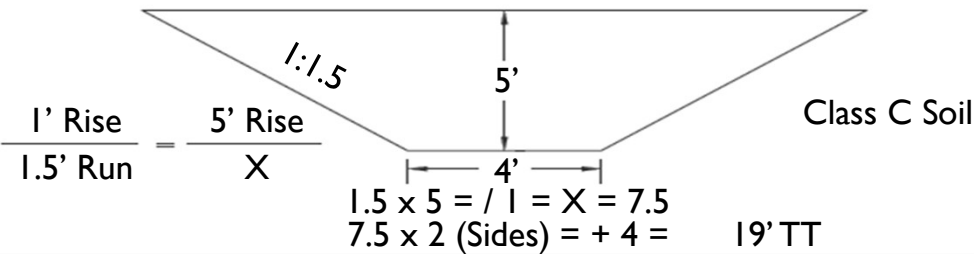
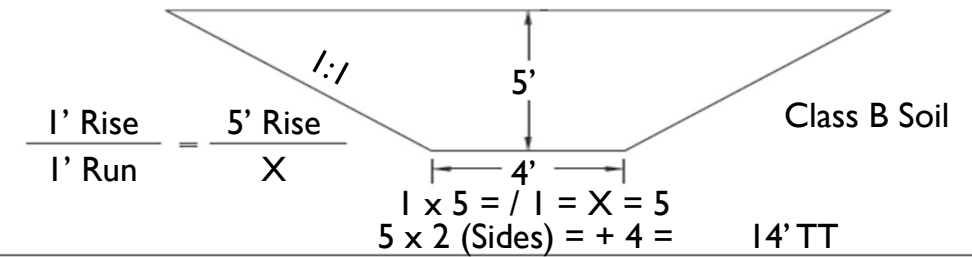
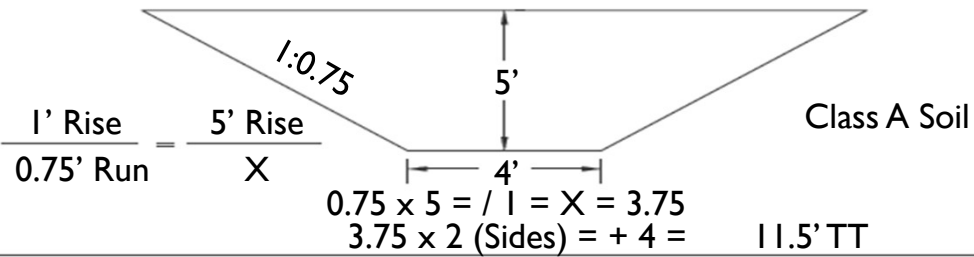
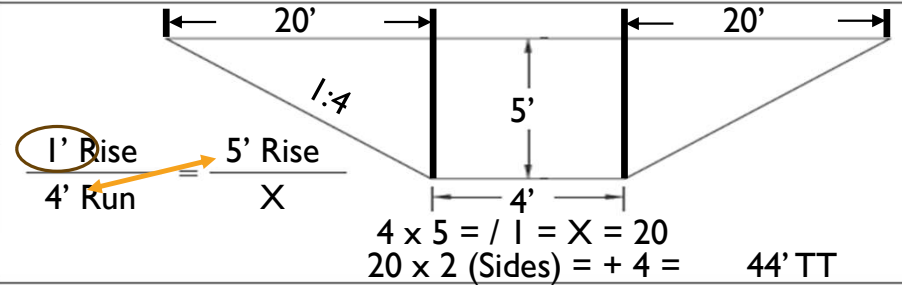
Pacing & Proration



Total Trench Exercise

$$\begin{aligned} \text{SOLVING FOR RISE} &= \frac{1' \text{ (RISE)}}{4' \text{ (RUN)}} = \frac{X \text{ (RISE)}}{14' \text{ (RUN)}} \\ &= 14 \times 1 = 14 \div 4 = X = 3.5' \end{aligned}$$

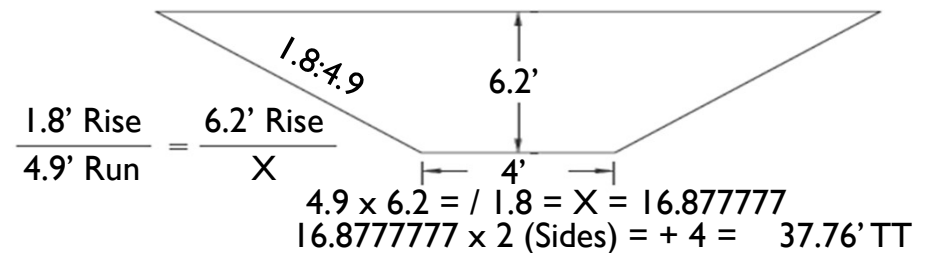
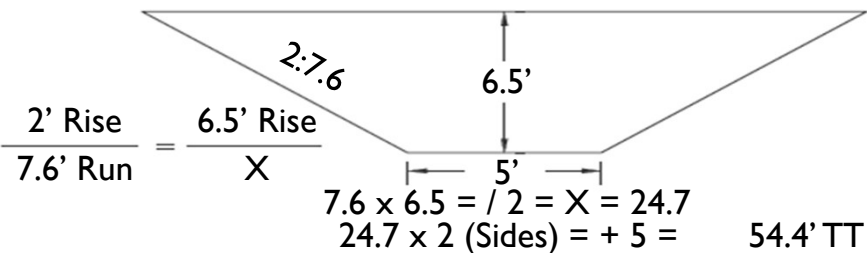
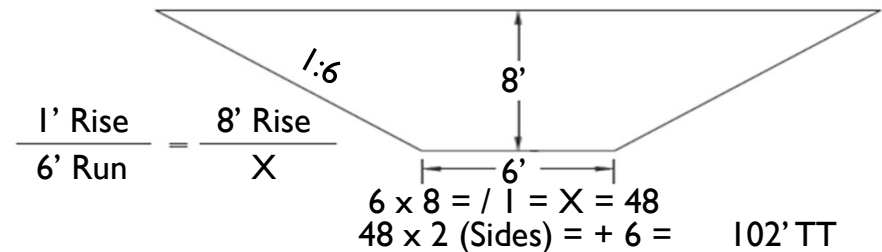
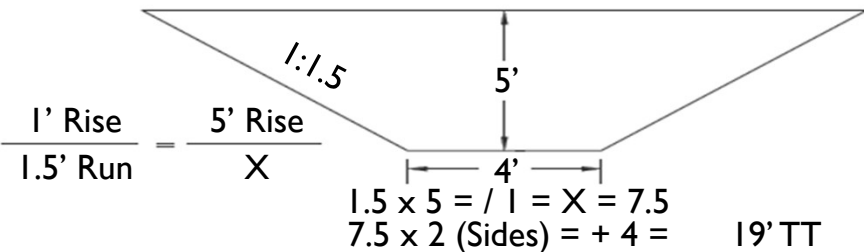
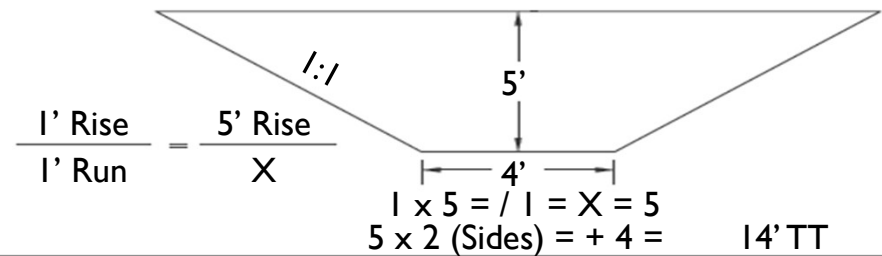
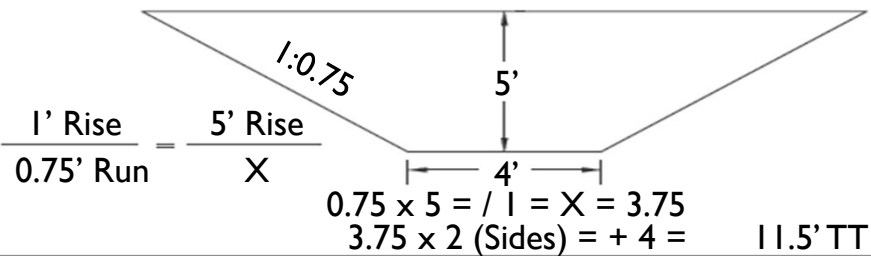
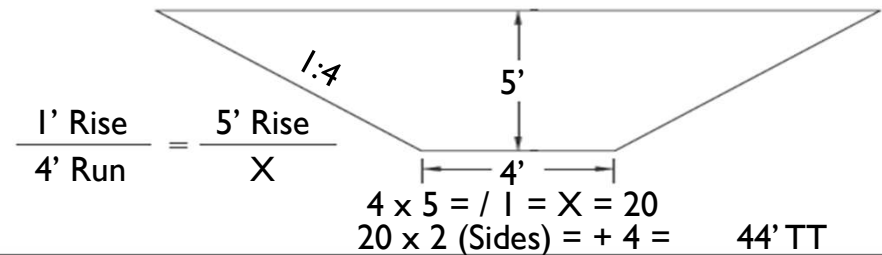
$$\begin{aligned} \text{SOLVING FOR RUN} &= \frac{1' \text{ (RISE)}}{4' \text{ (RUN)}} = \frac{5' \text{ (RISE)}}{X \text{ (RUN)}} \\ &= 5 \times 4 = 20 \div 1 = X = 20' \end{aligned}$$



Total Trench Exercise

$$\begin{aligned} \text{SOLVING FOR RISE} &= \frac{1' \text{ (RISE)}}{4' \text{ (RUN)}} = \frac{X \text{ (RISE)}}{14' \text{ (RUN)}} \\ &= 14 \times 1 = 14 \div 4 = X = 3.5' \end{aligned}$$

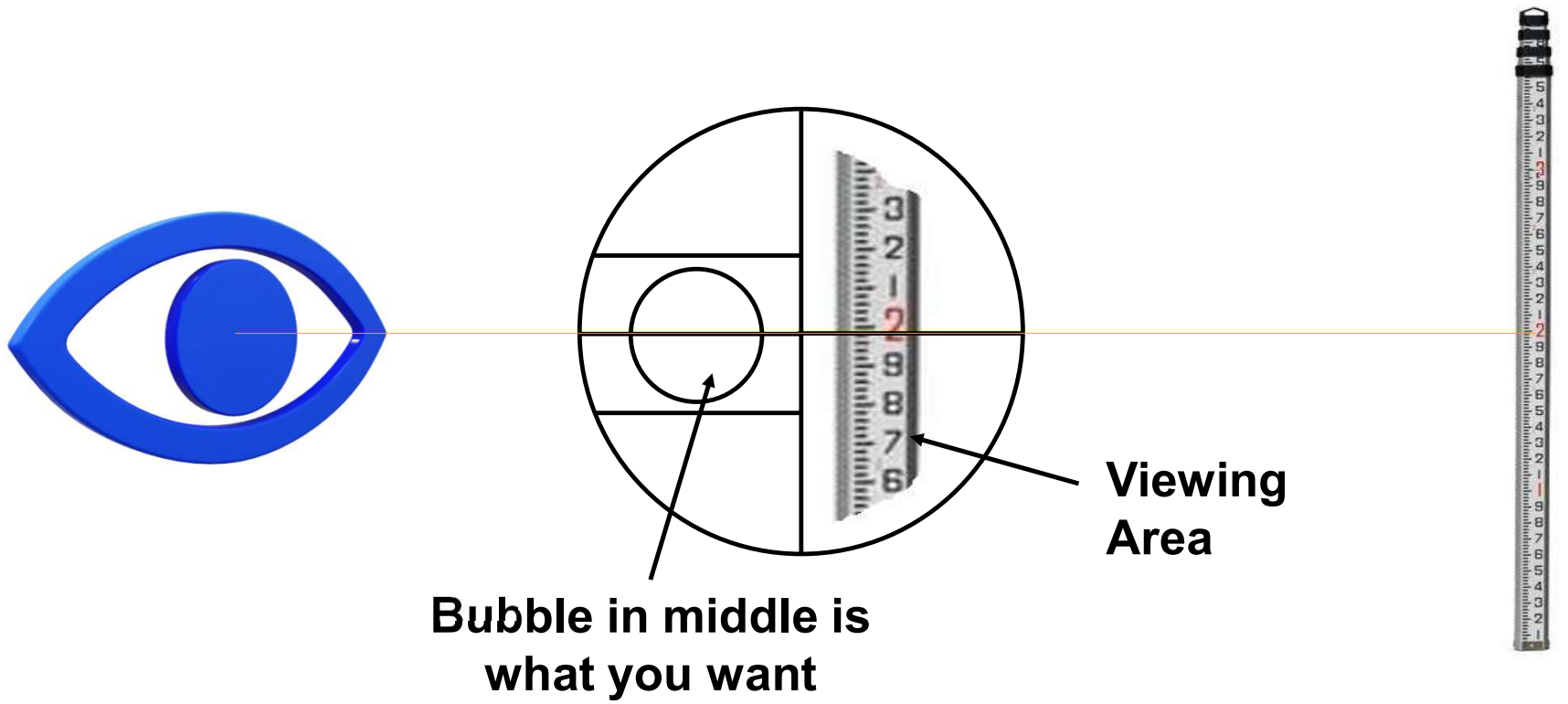
$$\begin{aligned} \text{SOLVING FOR RUN} &= \frac{1' \text{ (RISE)}}{4' \text{ (RUN)}} = \frac{5' \text{ (RISE)}}{X \text{ (RUN)}} \\ &= 5 \times 4 = 20 \div 1 = X = 20' \end{aligned}$$



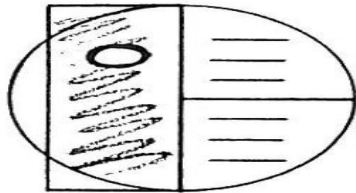


SECTION 6

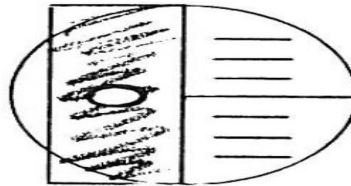
Eye Levels



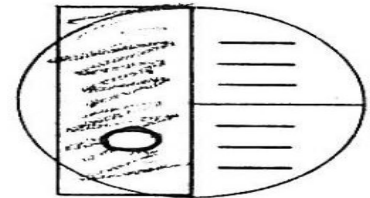
EYE LEVELS – WHAT TO LOOK FOR



LINE OF SIGHT
TOO HIGH



LINE OF SIGHT
IS LEVEL



LINE OF SIGHT
TOO LOW

Eye Level Use Poem

If your lye is high
then look to the sky.
(Fill)

If your lye is low
then down you must go.
(Cut)



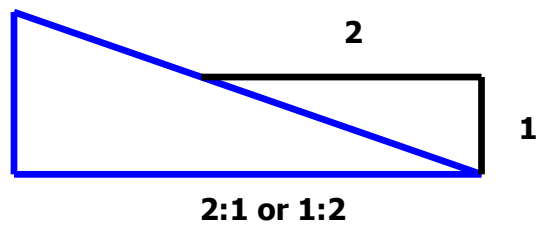
1980 called.....

They want their Eye
Level back

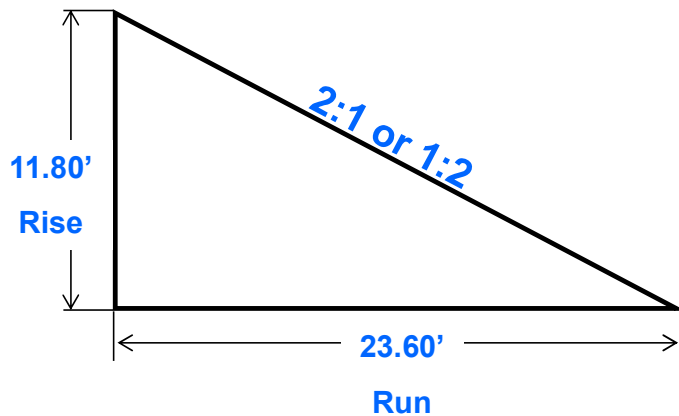


SECTION 7

Slope Ratio



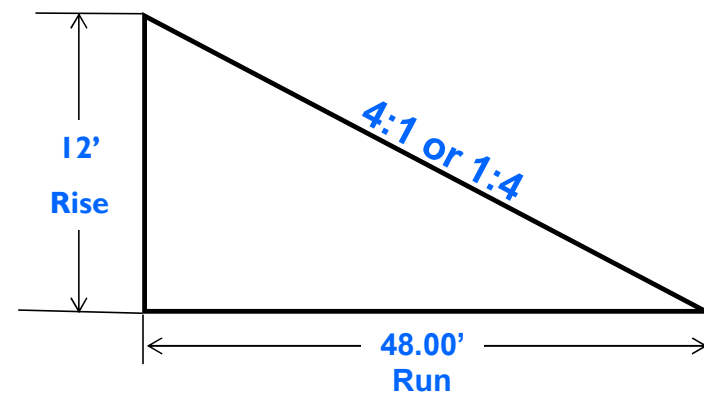
DETERMINING SLOPE RATIOS



How is slope ratio arrived at?

The formula is:

$$\frac{23.60' \text{ Run}}{11.80' \text{ Rise}} = \text{Slope Ratio } 2:1$$

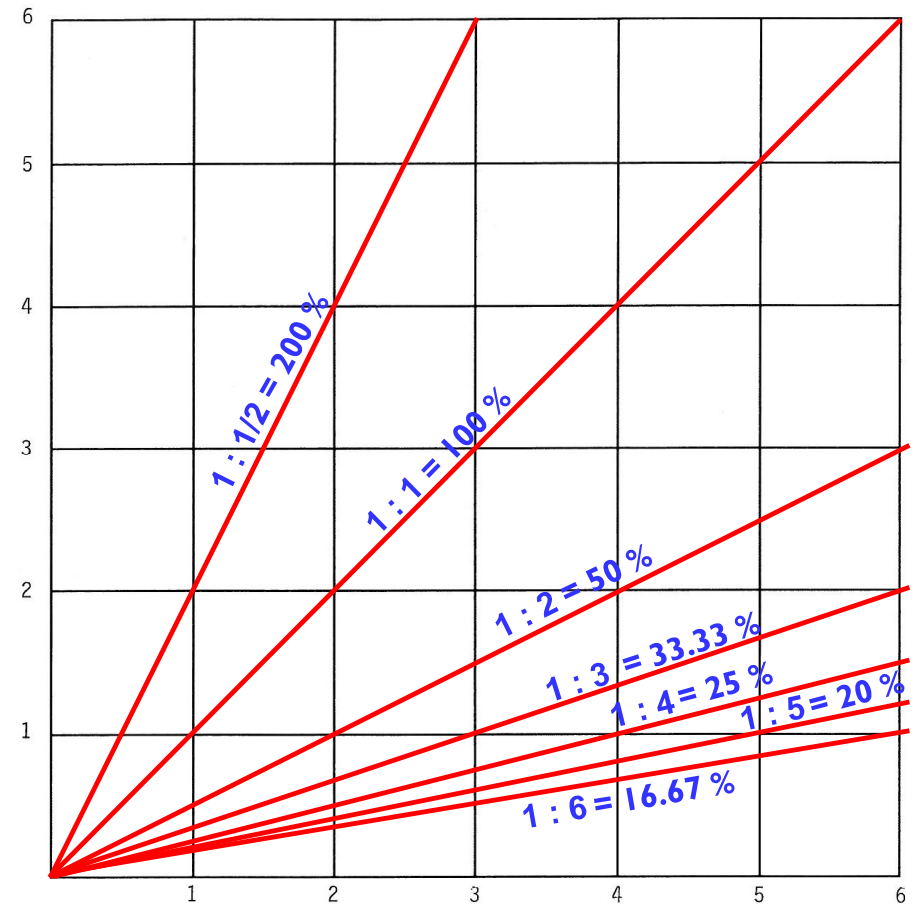


What is this slope ratio?

$$\frac{48 \text{ Run}}{12 \text{ Rise}} = \text{Slope Ratio } 4:1$$

COMMON SLOPE RATIOS AND PERCENTAGES

Slope Ratio	Vertical	Horizontal
1:1	1	1
1:2	1	2
1:3	1	3
1:4	1	4
1:5	1	5

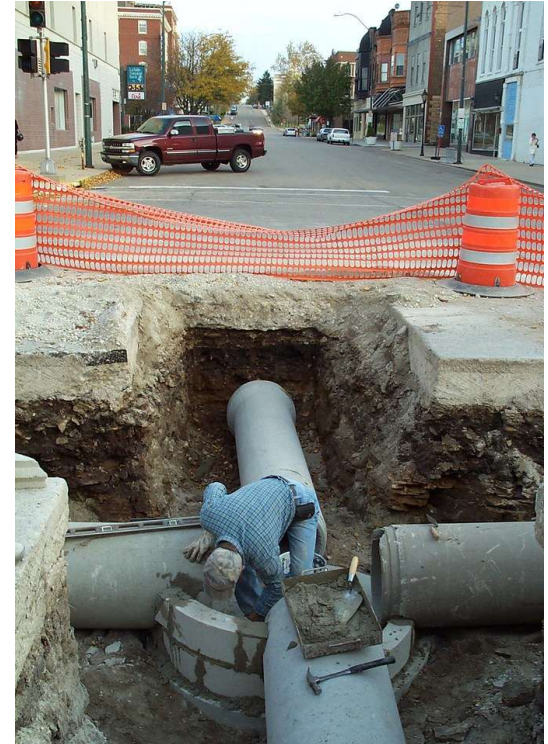


SECTION 8

Percentages

PERCENTAGE APPLICATIONS

What applications do we use
percentage for?
Roadways and pipes



CALCULATING PERCENTAGES



Formula

$$\frac{\text{Rise}}{\text{Run}} = \text{FT/FT} \times 100 = \%$$

$$2,552 \text{ Miles} \times 5,280 \text{ (Ft./Mile)} = 13,474,560 \text{ Ft.}$$

$$\frac{\text{Rise}}{1475 \text{ Ft.}} \div \frac{\text{Run}}{13,474,560 \text{ Ft.}} = 0.0001094 \text{ FT/FT}$$

NEVER ROUND

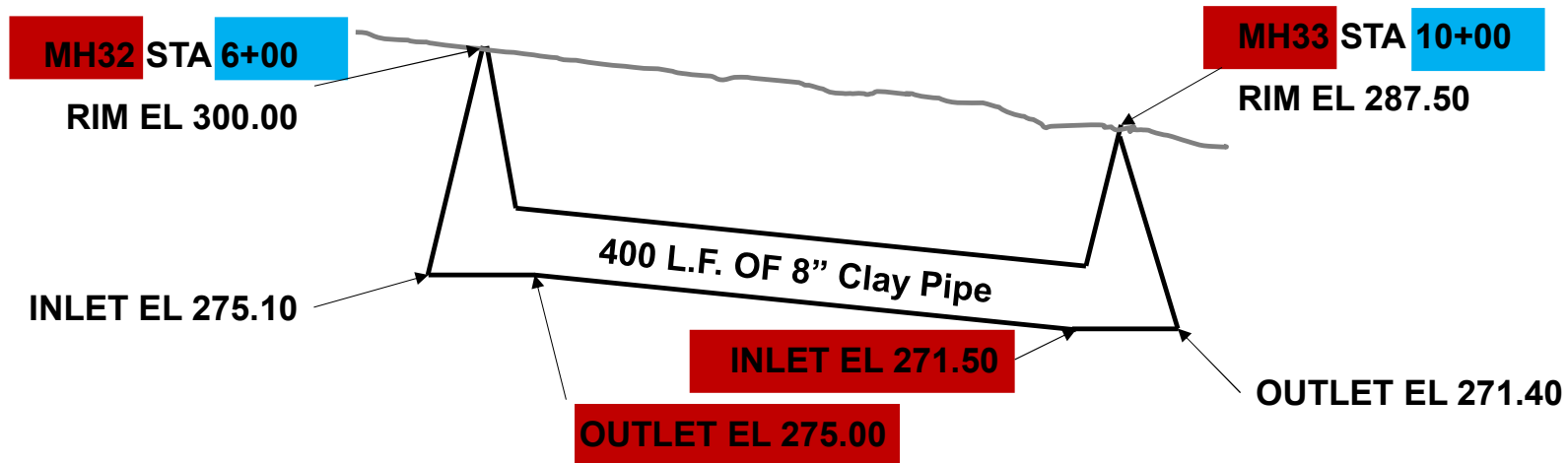
$0.0001094 \text{ FT/FT} \times 100 = \% = 0.01 \%$
WHEN CONVERTED TO A PERCENTAGE,
WE CAN THEN PROPERLY ROUND

COMMON SENSE PERCENTAGES

Percent	Rise/Fall	Distance
1%	1'	100'
2%	2'	100'
3%	3'	100'
4%	4'	100'
5%	5'	100'

Percent	Rise/Fall	Distance
6%	6'	100'
7%	7'	100'
8%	8'	100'
9%	9'	100'
10%	10'	100'

DETERMINING FT/FT (GOLD)



$$\frac{\text{3.50' Rise}}{\text{400' Run}} = \text{FT/FT } 0.00875'$$

Outlet Elevation @ MH32 Station 6+00 = 275.00'

Inlet Elevation @ MH33 Station 10+00 = 271.50'
400' 3.50'

DETERMINE INVERT ELEVATIONS

<u>Station #</u>	<u>Distance</u>	<u>X</u>	<u>FT/FT</u>	<u>=</u>	<u>Rise or Fall</u>	<u>+</u>	<u>Elevation</u>
10+00							271.50
9+50	50.00		0.00875		0.4375		271.94
9+00	100.00		0.00875		0.875		272.38
8+50	150.00		0.00875		1.3125		272.81
8+00	200.00		0.00875		1.75		273.25
7+50	250.00		0.00875		2.1875		273.69
7+00	300.00		0.00875		2.625		274.13
6+50	350.00		0.00875		3.0625		274.56
6+00	400.00		0.00875		3.5		275.00

Tie back to station 10+00 for all.

TIE
OUT!

<u>Station #</u>	<u>Distance</u>	<u>X</u>	<u>FT/FT</u>	<u>=</u>	<u>Rise or Fall</u>	<u>+</u>	<u>Elevation</u>
10+00							271.50
9+56	44.00		0.00875		0.385		271.89
9+21	79.00		0.00875		0.69125		272.19
8+90	110.00		0.00875		0.9625		272.46
8+36	164.00		0.00875		1.435		272.94
7+65	235.00		0.00875		2.05625		273.56
7+32	268.00		0.00875		2.345		273.85
6+85	315.00		0.00875		2.75625		274.26
6+00	400.00		0.00875		3.5		275.00

TIE
OUT!

DETERMINING PERCENTAGES

- Determining or double-checking plan percentages
- Formula – “Gold”en Rules
- Rise / Run = Ft/Ft
- $Ft/Ft \times 100 = \text{Percent } \%$
- Round off to the nearest hundredth of a percent
- Example: You have a 3' rise and 250' run, what % is this?
- $3 / 250 = 0.012$
- $0.012 \times 100 = \%$
- 1.20%
- Let's do some more practice

MH 32
RIM EL = 980.56
INV IN = 972.52
INV OUT = 972.42

WHAT PERCENT IS THIS PIPE RUN?

$$972.42 - 970.12 = \text{Rise} = 2.30'$$

$$2.30 / 400 = \text{FT/FT} = 0.00575$$

$$0.00575 \times 100 = \% = 0.58\%$$

Positive or Negative 0.58%?

Depends which way its dug

MH 31
RIM EL = 979.56
INV IN = 970.12
INV OUT = 970.02

400 LF OF 18" RCP @ 0.58%

CONVERTING PERCENTAGES INTO “GOLD”

- Formula to convert
- $\% / 100 = \text{Gold} = \text{Ft}/\text{Ft}$ (never round off)
- Once you know how much rise or fall you have in 1 foot horizontally, you can now determine the rise or fall for any horizontal distance along the slope.
- Example: +2% slope for 256'
- $2 / 100 = 0.02$
- $0.02 \times 256 =$
- 5.12' of Rise in 256' of Run
- Why is it a “Rise” of 5.12'?



MH 32
RIM EL = 980.56
INV IN =
INV OUT = 973.64

WHAT IS THE INVERT OUT OF MH 32?

$$0.88 / 100 = \text{FT/FT} = 0.0088$$

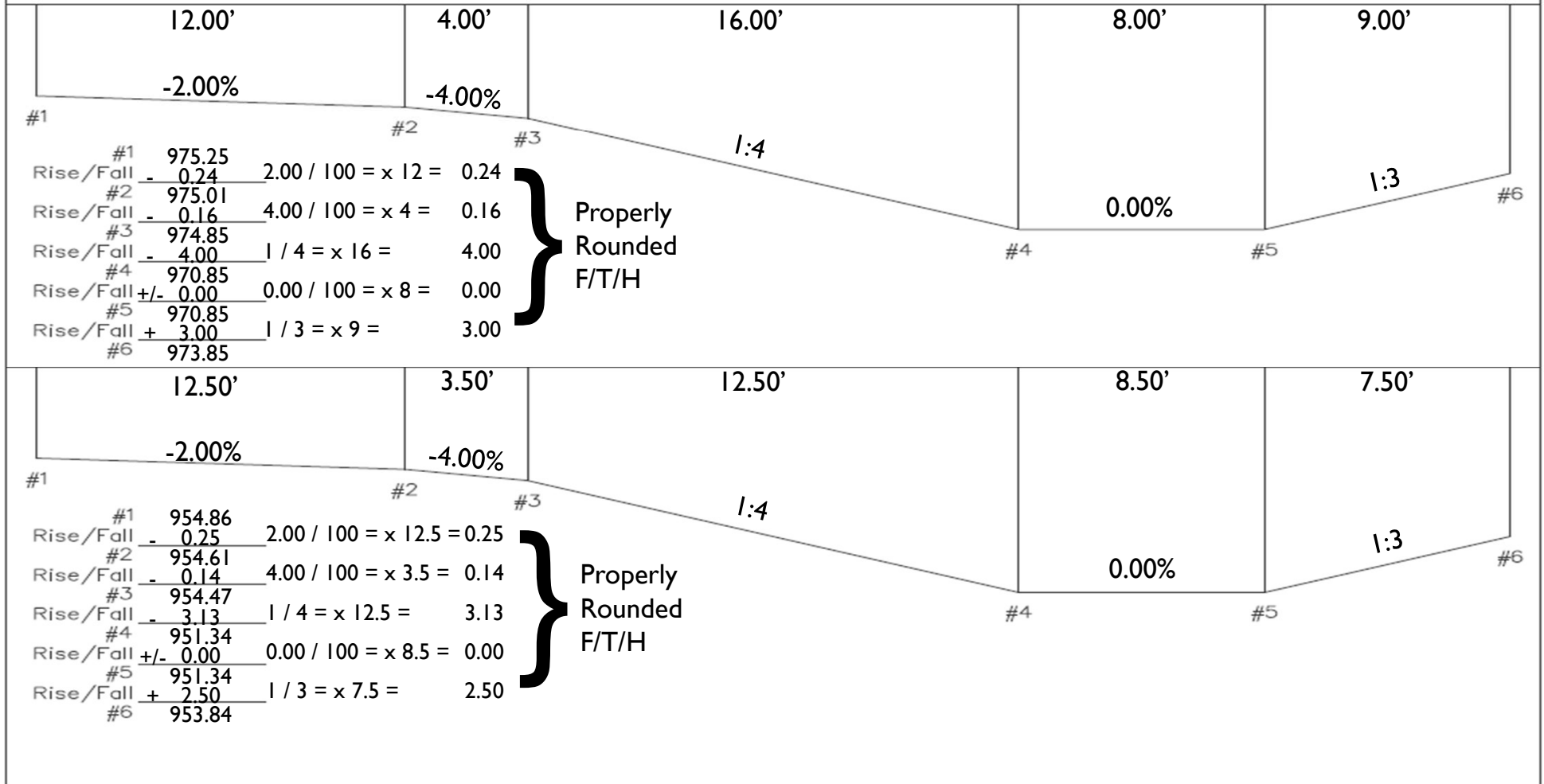
$$0.0088 \times 400 = \text{Rise} = 3.52$$

$$3.52 + 970.12 = 973.64$$

MH 31
RIM EL = 979.56
INV IN = 970.12
INV OUT = 970.02

400 LF OF 18" RCP @ 0.88 %

TYPICAL SECTION EXERCISES



TYPICAL SECTION EXERCISES

Exercise 1 Data:

Point	Width	Slope	Elevation	Calculation
#1	12.50'	-2.50%	864.89	
#2	3.50'	-3.50%	864.58	$2.50 / 100 = x \ 12.5 = 0.31$
#3	12.50'	1:5	864.46	$3.50 / 100 = x \ 3.5 = 0.12$
#4	7.50'	0.00%	861.96	$1 / 5 = x \ 12.5 = 2.50$
#5	7.50'	1:7	861.96	$0.00 / 100 = x \ 7.5 = 0.00$
#6			863.03	$1 / 7 = x \ 7.5 = 1.07$

Exercise 2 Data:

Point	Width	Slope	Elevation	Calculation
#1	11.75'	-2.12%	981.22	
#2	4.25'	-3.83%	980.97	$2.12 / 100 = x \ 11.75 = 0.25$
#3	15.36'	1:4.5	980.81	$3.83 / 100 = x \ 4.25 = 0.16$
#4	8.42'	0.00%	977.40	$1 / 4.5 = x \ 15.36 = 3.41$
#5	13.85'	1:3.8	977.40	$0.00 / 100 = x \ 8.42 = 0.00$
#6			981.04	$1 / 3.8 = x \ 13.85 = 3.64$

#1

12.50'

3.50'

12.50'

7.50'

7.50'

#2

#3

1:5

1:7

#6

#1	864.89		
Rise/Fall	- 0.31	2.50 / 100 = x	12.5 = 0.31
#2	864.58		
Rise/Fall	- 0.12	3.50 / 100 = x	3.5 = 0.12
#3	864.46		
Rise/Fall	- 2.50	1 / 5 = x	12.5 = 2.50
#4	861.96		
Rise/Fall	+/- 0.00	0.00 / 100 = x	7.5 = 0.00
#5	861.96		
Rise/Fall	+ 1.07	1 / 7 = x	7.5 = 1.07
#6	863.03		

#1	864.89 - 1.50 =	863.39
#2	864.58 - 1.50 =	863.08
#3	864.46 - 1.50 =	862.96
#4	861.96 - 0.50 =	861.46
#5	861.96 - 0.50 =	861.46
#6	863.03 - 0.50 =	862.53

#4

#5

11.75'

4.25'

15.36'

8.42'

13.85'

#2

#3

1:4.5

1:3.8

#6

#1

-2.12%

-3.83%

FG CL EL @ STA15+50

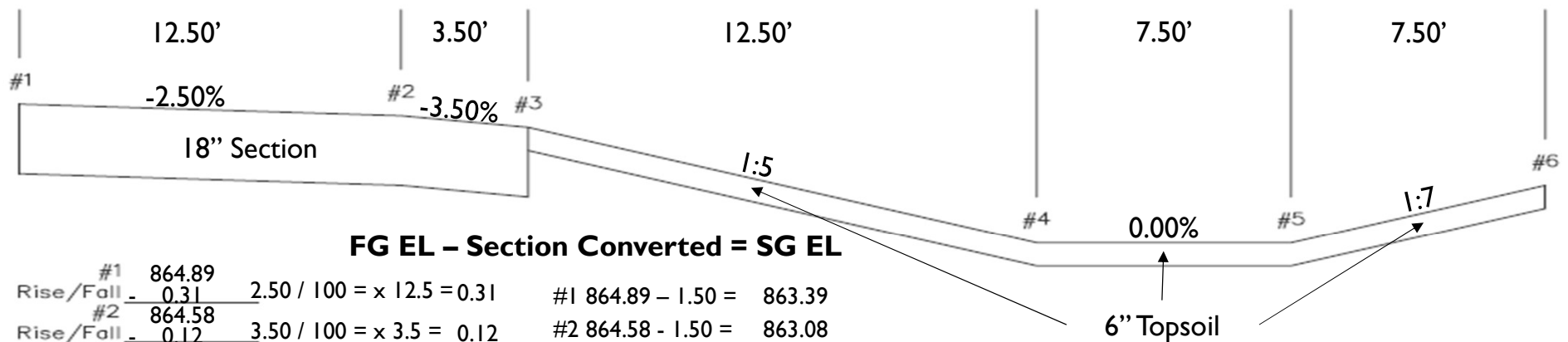
#1	981.22		
Rise/Fall	- 0.25	2.12 / 100 = x	11.75 = 0.25
#2	980.97		
Rise/Fall	- 0.16	3.83 / 100 = x	4.25 = 0.16
#3	980.81		
Rise/Fall	- 3.41	1 / 4.5 = x	15.36 = 3.41
#4	977.40		
Rise/Fall	+/- 0.00	0.00 / 100 = x	8.42 = 0.00
#5	977.40		
Rise/Fall	+ 3.64	1 / 3.8 = x	13.85 = 3.64
#6	981.04		

$$\begin{array}{lcl} \#1 & 981.22 - 2.17 = & 979.05 \\ \#2 & 980.97 - 2.17 = & 978.80 \\ \#3 & 980.81 - 2.17 = & 978.64 \\ \#4 & 977.40 - 0.33 = & 977.07 \\ \#5 & 977.40 - 0.33 = & 977.07 \\ \#6 & 981.04 - 0.33 = & 980.71 \end{array}$$

#4

#5

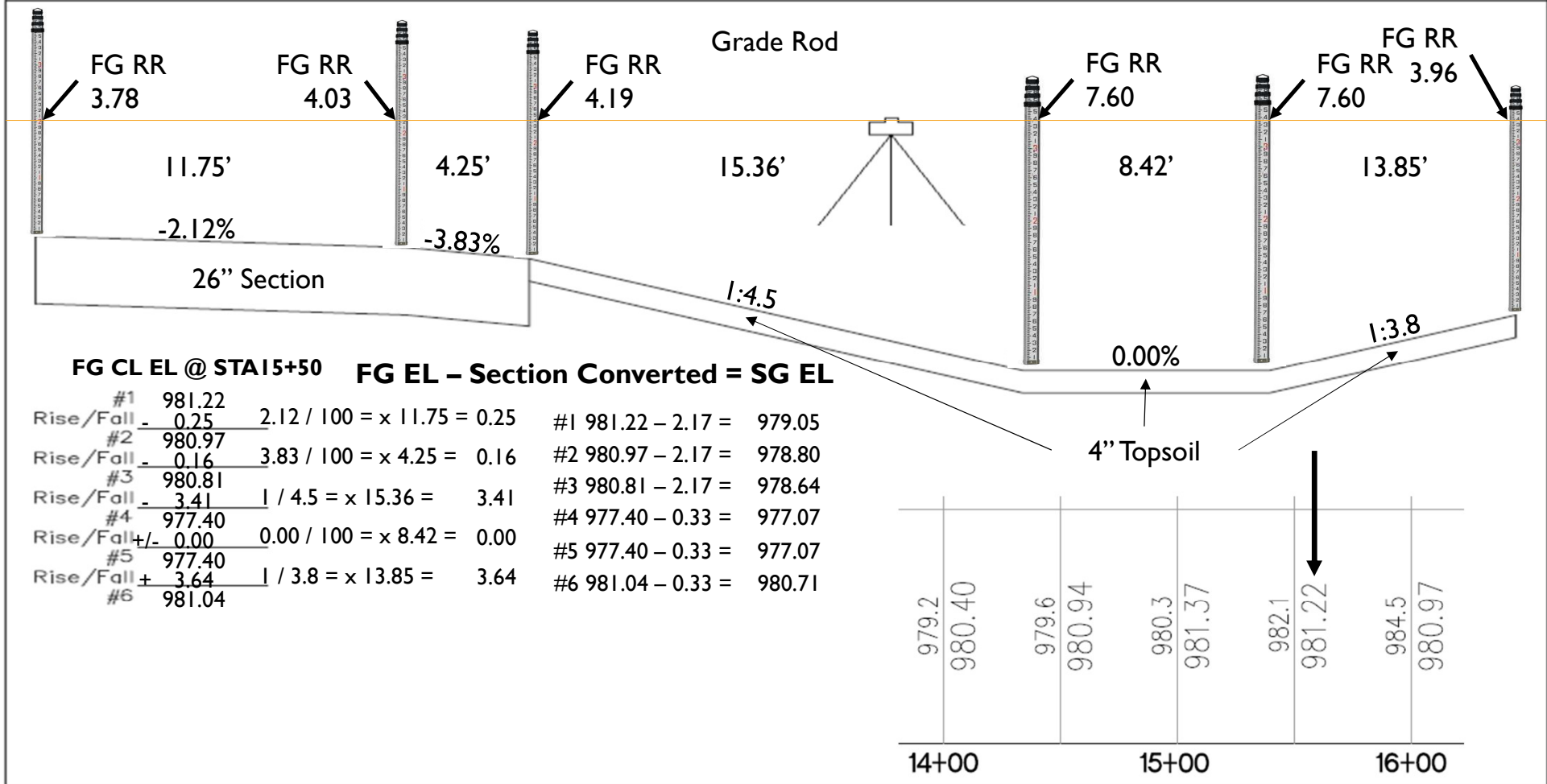
TYPICAL SECTION EXERCISES



FG EL – Section Converted = SG EL

#1	864.89			#1	864.89 - 1.50 =	863.39
Rise/Fall -	0.31	2.50 / 100 = x 12.5 =	0.31	#2	864.58 - 1.50 =	863.08
#2	864.58			Rise/Fall -	0.12	3.50 / 100 = x 3.5 = 0.12
Rise/Fall -	0.12			#3	864.46	
#3	864.46			Rise/Fall -	2.50	1 / 5 = x 12.5 = 2.50
Rise/Fall -	2.50			#4	861.96	
#4	861.96			Rise/Fall +/-	0.00	0.00 / 100 = x 7.5 = 0.00
Rise/Fall +/-	0.00			#5	861.96	
#5	861.96			Rise/Fall +	1.07	1 / 7 = x 7.5 = 1.07
Rise/Fall +	1.07			#6	863.03	
#6	863.03					

TYPICAL SECTION EXERCISES



TYPICAL SECTION EXERCISES

12.00'		4.00'	16.00'		8.00'	9.00'
-2.00%		-4.00%			0.00%	
#1		#2	#3		#4	#5
#1	933.96			1:4		
Rise/Fall	+ 0.24	2.00 / 100 = x 12 =	0.24			
#2	933.72					
Rise/Fall	+ 0.16	4.00 / 100 = x 4 =	0.16			
#3	933.56					
Rise/Fall	+ 4.00	1 / 4 = x 16 =	4.00			
#4	929.56					
Rise/Fall	+/- 0.00	0.00 / 100 = x 8 =	0.00			
#5	929.56					
Rise/Fall	- 3.00	1 / 3 = x 9 =	3.00			
#6	932.56					
12.50'		3.50'	12.50'		8.50'	7.50'
-2.00%		-4.00%			0.00%	
#1		#2	#3		#4	#5
#1	954.86			1:4		
Rise/Fall	- 0.25	2.00 / 100 = x 12.5 =	0.25			
#2	954.61					
Rise/Fall	- 0.14	4.00 / 100 = x 3.5 =	0.14			
#3	954.47					
Rise/Fall	- 3.13	1 / 4 = x 12.5 =	3.13			
#4	951.34					
Rise/Fall	+/- 0.00	0.00 / 100 = x 8.5 =	0.00			
#5	951.34					
Rise/Fall	+ 2.50	1 / 3 = x 7.5 =	2.50			
#6	953.84					



SECTION 9

Basic Quantities

CALCULATING SQUARE FEET (SQ FT)

Square Feet or Area

- Two-Dimensional
- Feet x Feet = SQ FT
 - Must convert inches to decimal feet
- Use it to find the square foot of your house
- One square foot is nothing more than a square that is 1 foot wide by 1 foot long.



CALCULATING SQ FT

Formula – FT x FT =

Let's do the first one together...

- $80 \times 10 =$
- 800 SQ FT

Let's do the next one together...

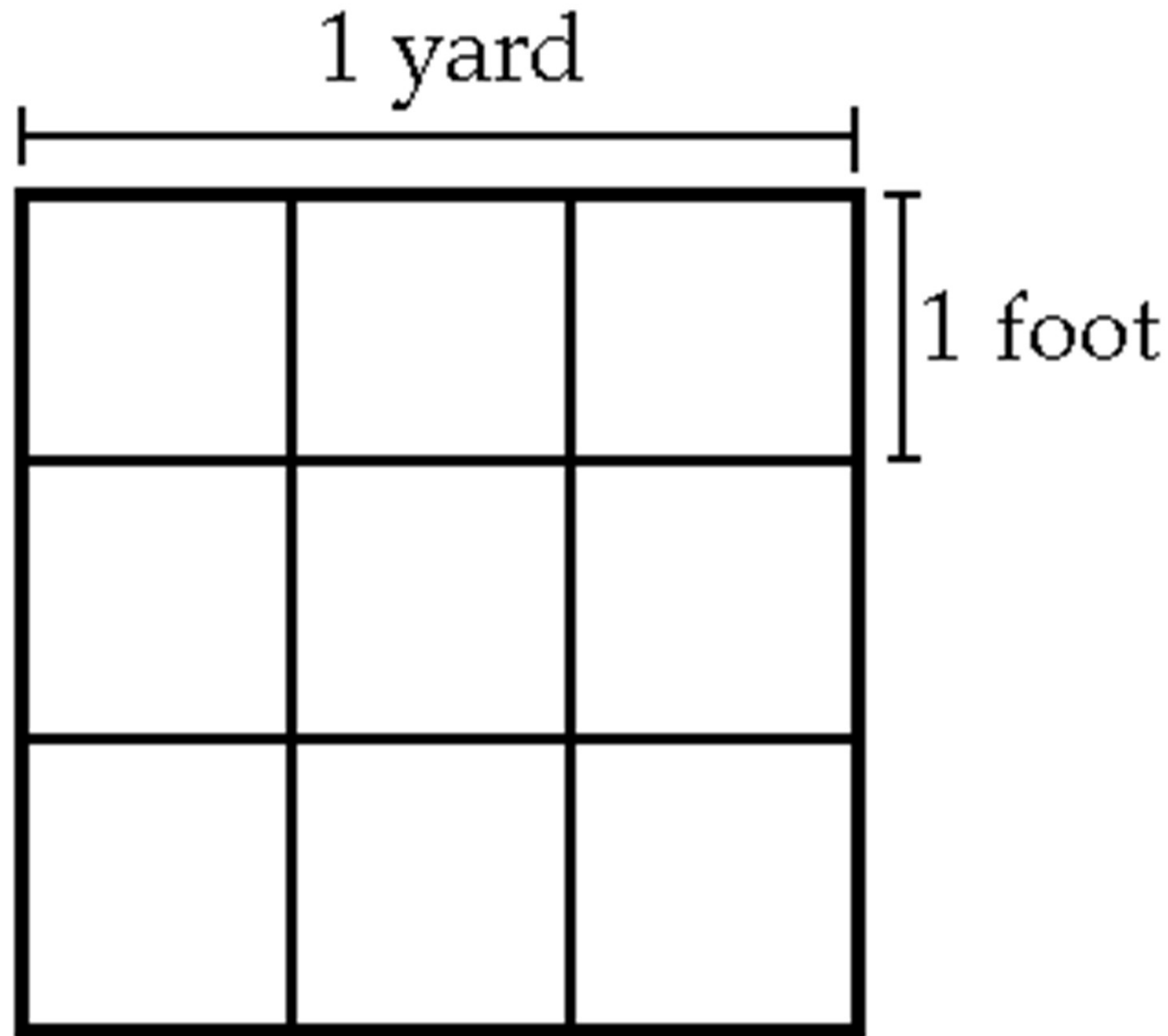
- Must convert inches to decimal feet
- $16 / 12 = \times 42 =$
- 55.999
- Looking at the 3rd digit after the decimal, 5 or higher we round up and 4 and lower, we keep it the same
- 56.00 SQ FT

FT x FT =	SQ FT
80' x 10'	800.00
42' x 16"	56.00
75' x 12'	900.00
64' x 16"	85.33
112' x 13"	121.33
52' x 32'	1664.00
18" x 16"	2.00
86' x 8"	57.33
42' x 20"	70.00
32' x 120"	320.00
48' x 22"	88.00
75' x 22'	1650.00
84' x 10"	70.00

CALCULATING SQUARE YARDS (SQ YD)

**Once we determine Sq Ft,
it can then be converted to
Sq Yds**

- Very few pay items are in Sq Ft
- Most pay items are in Sq Yds
- Must multiply Feet x Feet, converting inches first.
- $\text{Feet} \times \text{Feet} = / 9 = \text{Sq Yds}$



CALCULATING SQ YDS

Formula – $FT \times FT = / 9 =$

Let's do the first one together...

- $80 \times 10 = / 9 =$
- 88.89 SQ YDS

Let's do the next one together...

- Must convert inches to decimal feet
- $16 / 12 = \times 42 = / 9 =$
- 6.222
- Looking at the 3rd digit after the decimal, 5 or higher we round up and 4 and lower, we keep it the same
- 6.22 SQ YDS

FT x FT = / 9 =	SQ YDS
80' x 10'	88.89
42' x 16"	6.22
75' x 12'	100.00
64' x 16"	9.48
112' x 13"	13.48
52' x 32'	184.89
18" x 16"	0.22
86' x 8"	6.37
42' x 20"	7.78
32' x 120"	35.56
48' x 22"	9.78
75' x 22'	183.33
84' x 10"	7.78

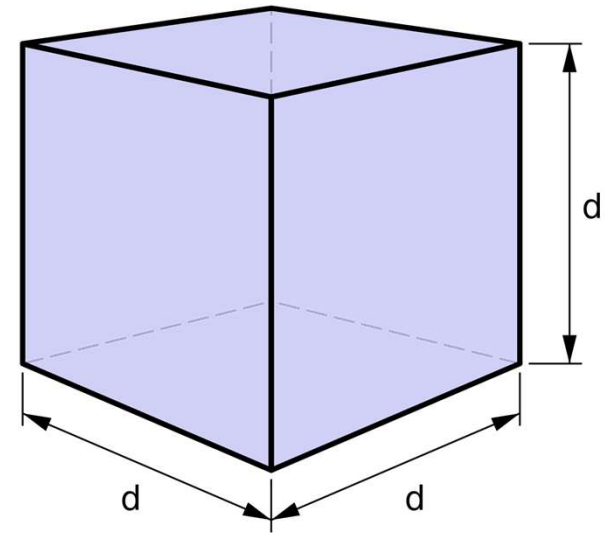
CALCULATING CUBIC FEET (CU FT)

Onto cubic feet and Three-Dimensional Volumes...

- A cubic foot is 3-D
- A cubic foot is 1 foot high by 1 foot long by 1 foot deep

Multiply Feet x Feet x Feet = CU FT

- Must convert inches to decimal feet
- Not feet times inches or feet times yards



CALCULATING CU FT

Formula – FT x FT x FT=

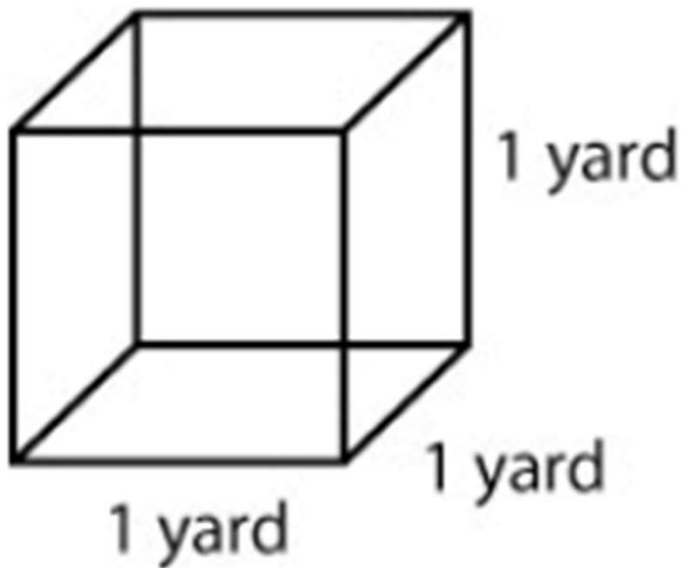
Let's do the first one together...

- $80 \times 10 \times 8 =$
- 6400.00 CU FT

Let's do the next one together...

- Must convert inches to decimal feet
- $10 / 12 = \times 150 \times 24 =$
- 2999.999
- Looking at the 3rd digit after the decimal, 5 or higher we round up and 4 and lower, we keep it the same
- 3000.00 CU FT

FT x FT x FT =	CU FT
80' x 10' x 8'	6400.00
150' x 24' x 10"	3000.00
75' x 12' x 6'	5400.00
64' x 16' x 16"	1365.33
112' x 13' x 20'	29120.00
52' x 32' x 10"	1386.67
18' x 16' x 14"	336.00
86' x 8' x 20"	1146.67
42' x 20' x 13"	910.00
32' x 120' x 5"	1600.00
48' x 22' x 32"	2816.00
75' x 22' x 12'	19800.00
84' x 10' x 16'	13440.00



CALCULATING CUBIC YARDS (CU YDS)

Now to convert cubic feet to cubic yards...

- Cubic yards are how most of earth quantities are measured and paid for.
- A cubic yard is 3 foot by 3 foot by 3 foot.
- There are 27 cubic feet in one cubic yard ($3 \times 3 \times 3 = 27$)
- Find Cubic Feet and then $/ 27 =$ Cubic Yards (Cu Yds)

CALCULATING CU YDS

Formula – FT x FT x FT = / 27 =

Let's do the first one together...

- $80 \times 10 \times 8 = / 27 =$
- 237.04 CUYDS

Let's do the next one together...

- Must convert inches to decimal feet
- $10 / 12 = \times 150 \times 24 = / 27 =$
- 111.111
- Looking at the 3rd digit after the decimal, 5 or higher we round up and 4 and lower, we keep it the same
- 111.11 CUYDS

FT x FT x FT = / 27 =	CU YDS
80' x 10' x 8'	237.04
150' x 24' x 10"	111.11
75' x 12' x 6'	200.00
64' x 16' x 16"	50.57
112' x 13' x 20'	1078.52
52' x 32' x 10"	51.36
18' x 16' x 14"	12.44
86' x 8' x 20"	42.47
42' x 20' x 13"	33.70
32' x 120' x 5"	59.26
48' x 22' x 32"	104.30
75' x 22' x 12'	733.33
84' x 10' x 16'	497.78

BASIC QUANTITY EXERCISE

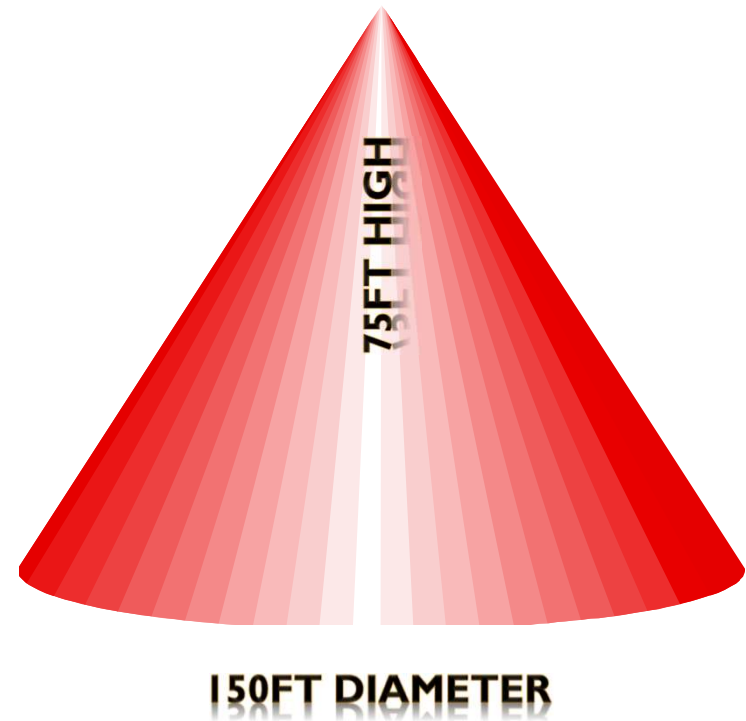
- 1- 44' x 26' = 127.11 Sq Yds
- 2- 112' x 12' x 20" = 82.96 Cu Yds
- 3- 36' x 22" = 66.00 Sq Ft
- 4- 41' x 15' = 615.00 Sq Ft
- 5- 120' x 12" x 26" = 260.00 Cu Ft
- 6- 51' x 8' x 6' = 2448.00 Cu Ft
- 7- 52' x 20" = 9.63 Sq Yds
- 8- 35' x 12' = 46.67 Sq Yds
- 9- 154' x 32" = 45.63 Sq Yds
- 10- 85' x 22" = 155.83 Sq Ft
- 11- 48' x 20" = 80.00 Sq Ft
- 12- 33' x 56" = 17.11 Sq Yds

- 13- 48" x 32" = 1.19 Sq Yds
- 14- 83' x 42" = 290.50 Sq Ft
- 15- 140' x 64' x 64" = 1769.88 Cu Yds
- 16- 140' x 64' x 64" = 47786.67 Cu Ft
- 17- 72' x 56' x 10' = 1493.33 Cu Yds
- 18- 44' x 22" = 8.96 Sq Yds
- 19- 24" x 16" = 2.67 Sq Ft
- 20- 24' x 32' x 10' = 7680.00 Cu Ft
- 21- 60" x 72" x 48" = 120.00 Cu Ft
- 22- 60' x 72' x 48' = 7680.00 Cu Yds
- 23- 6 3/4" x 15 1/4" = 0.71 Sq Ft
- 24- 27 cu. Ft. = 1.00 Cu Yds

BASIC QUANTITIES - PILE

Volume of a crusher pile

- This pile is shaped like a cone.
- The formula for a cone is:
 - $(1/3) \times \pi \times \text{radius}^2 \times \text{height}$
 - Radius is half the diameter $150 / 2 = 75$
 - $(75 \times 75) = \times 75 = 421,875$
 - $421,875 \times 3.14 = 1,324,687.50$
 - $1,324,687.50 / 3 = 441,562.50 \text{ Cu Ft}$
 - $441,562.50 / 27 = 16,354.17 \text{ Cu Yds}$



GALLONS OF WATER PER INCH OF RAINFALL

**How many gallons of water fall on one acre
of land that receives 1" of rain?**

- An acre of land is 66' x 660'
- Convert inches first – $1 / 12 = \times 66 \times 660 = 3630.00 \text{ Cu Ft}$
- There are 7.481 gallons of water in a cubic foot –
 $\times 7.481 = 27,156.03 \text{ gallons/acre}$
- There are 640 acres/section of land –
 $\times 640 = 17,379,859.19 \text{ gallons/section}$
- There are 36 sections/township –
 $\times 36 = 625,674,930.95 \text{ gallons/township}$



SECTION 10

Level Looping

To Level Loop you start by:

Setting up the instrument 250' max away from the benchmark. Next have the rod man "Rod" the rod on the Benchmark (BM), this is known as the Back Sight (BS)

The Height of Instrument (HI) is determined by taking a BS rod reading on a known BM or elevation.

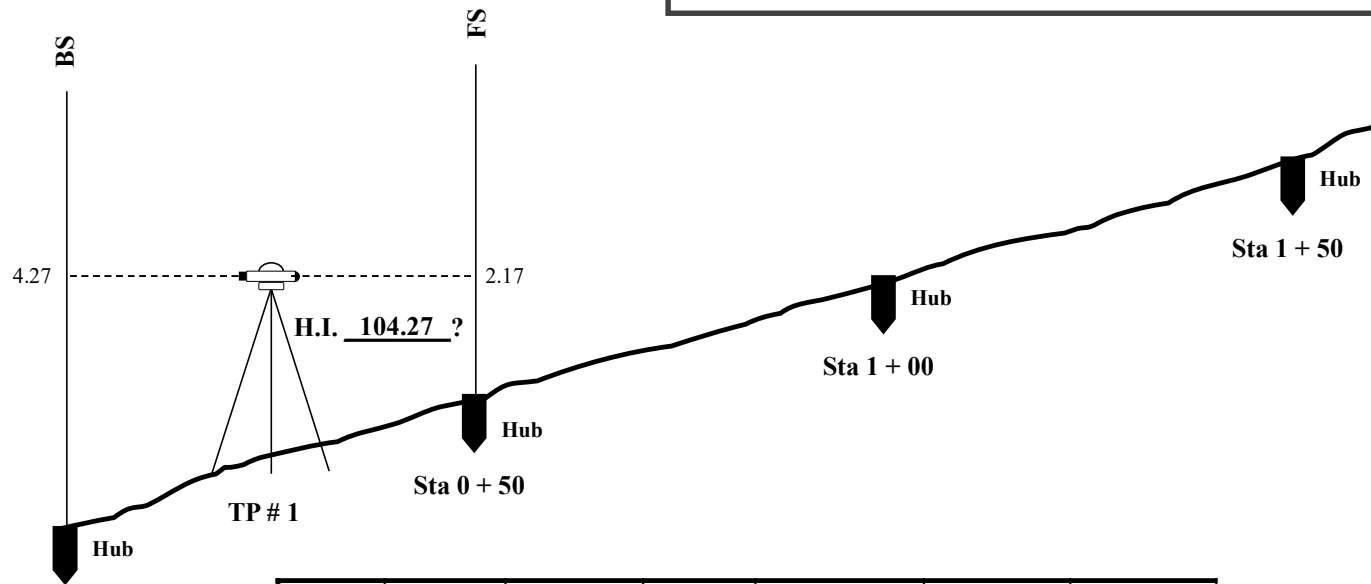
The BS rod reading is added (+) to the BM Elevation to determine the HI.

Once the HI is established, any other Foresight (FS) or Turn Point (TP) rod reading is subtracted from the HI to establish an objects Elevations.

Then continue looping until you come back to the original BM (Around the World) or once you establish an Elevation on the unknown, loop back to the original BM and close within tolerance.

Let's do some practice examples...

ESTABLISHING AN ELEVATION



BM
El 100.00
Sta 0 + 00

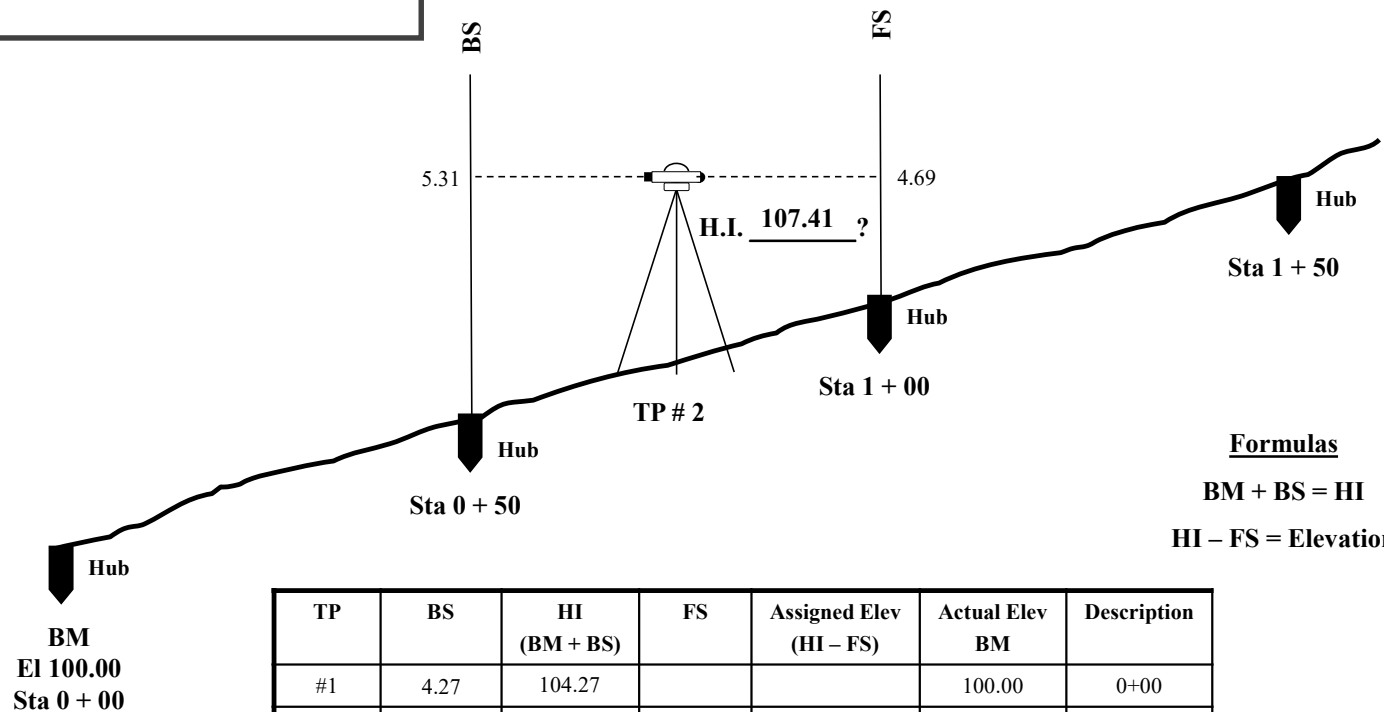
Formulas

$$\text{BM} + \text{BS} = \text{HI}$$

$$\text{HI} - \text{FS} = \text{Elevation}$$

TP	BS	HI (BM + BS)	FS	Assigned Elev (HI - FS)	Actual Elev BM	Description
#1	4.27	104.27			100.00	0+00
#2			2.17	102.10		0+50
#3						1+00
						1+50

ESTABLISHING AN ELEVATION



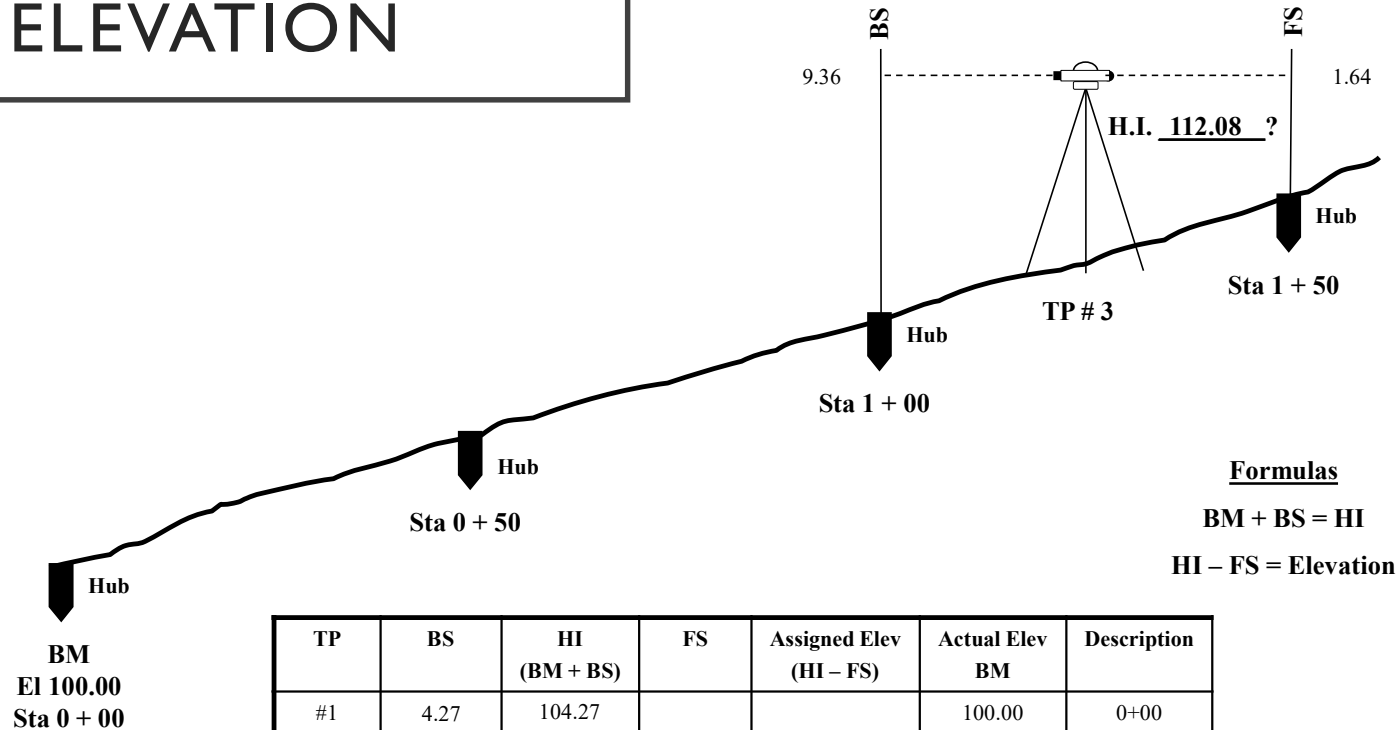
Formulas

$$BM + BS = HI$$

$$HI - FS = \text{Elevation}$$

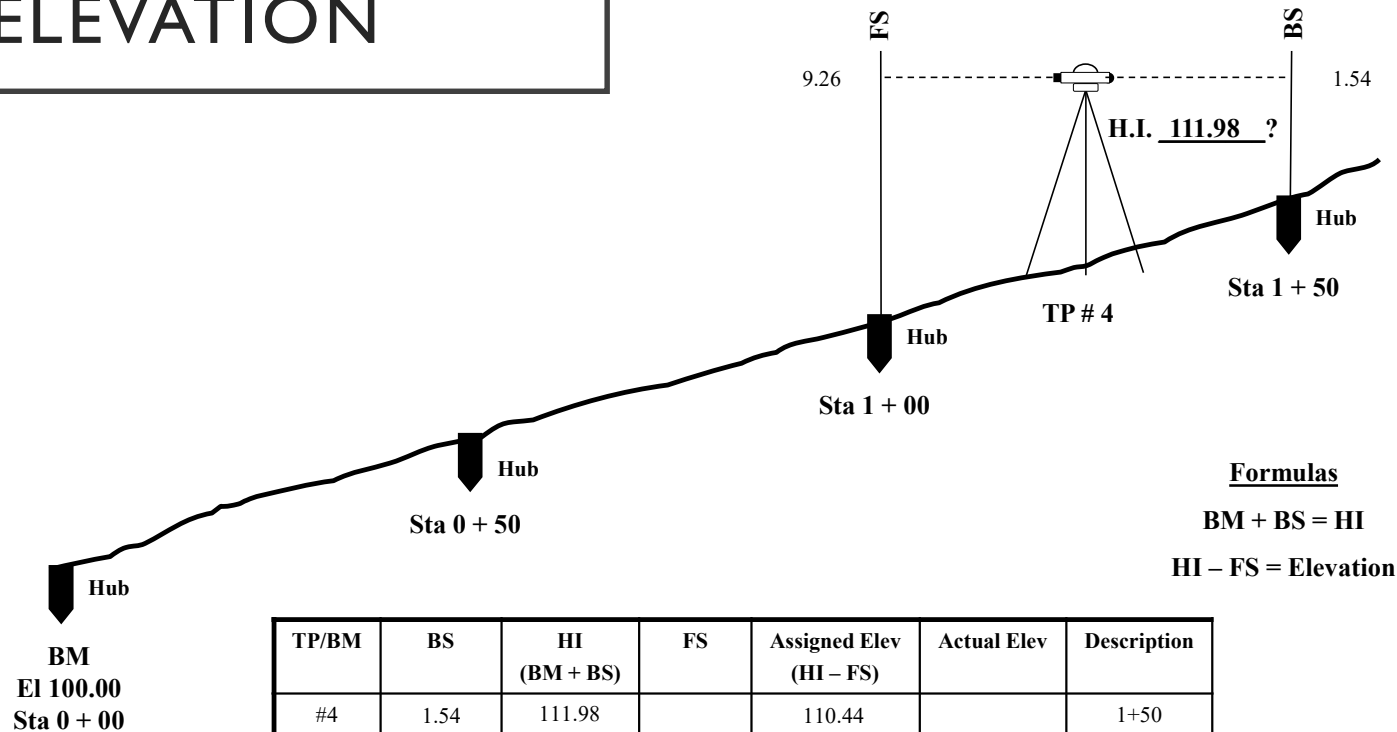
TP	BS	HI (BM + BS)	FS	Assigned Elev (HI - FS)	Actual Elev BM	Description
#1	4.27	104.27			100.00	0+00
#2	5.31	107.41	2.17	102.10		0+50
#3			4.69	102.72		1+00
						1+50

ESTABLISHING AN ELEVATION



Difference in Hub elevations between Sta 0 + 00 & Sta 1 + 50 10.44 ?

CONFIRMING THE ELEVATION



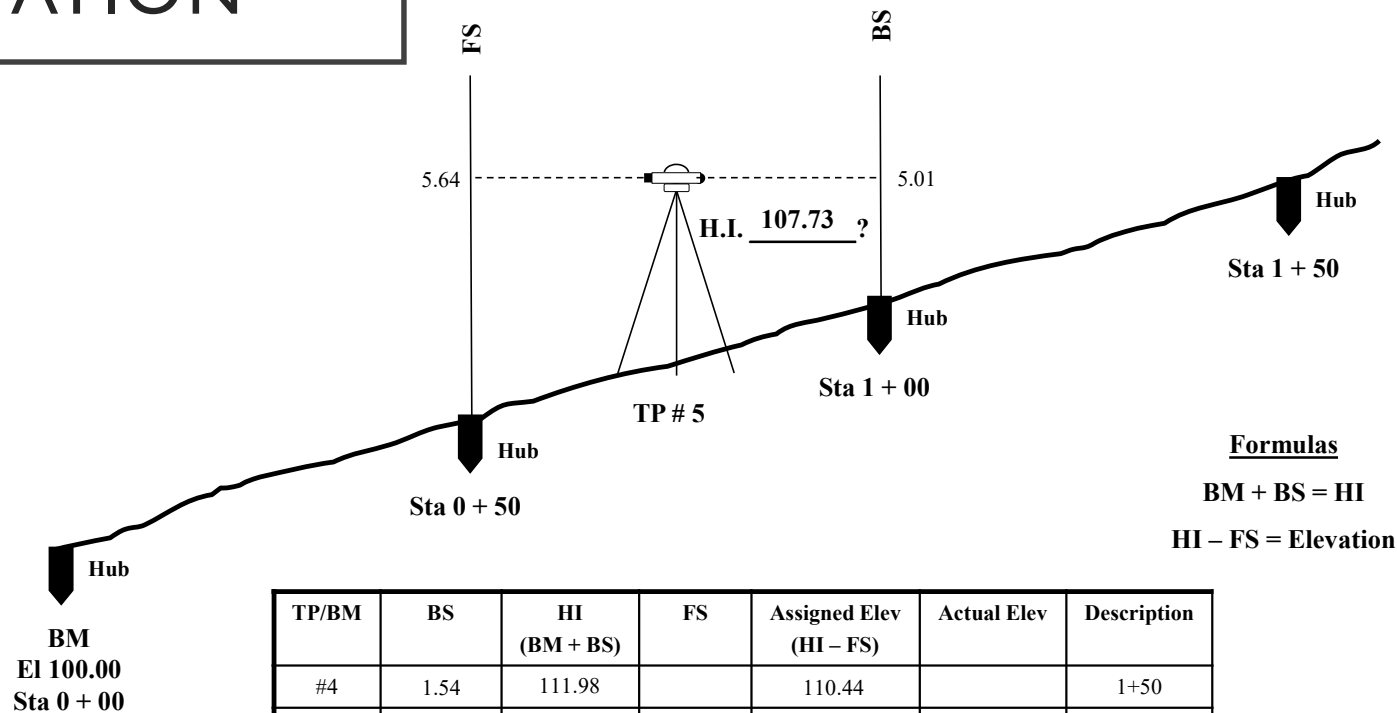
Formulas

$$\text{BM} + \text{BS} = \text{HI}$$

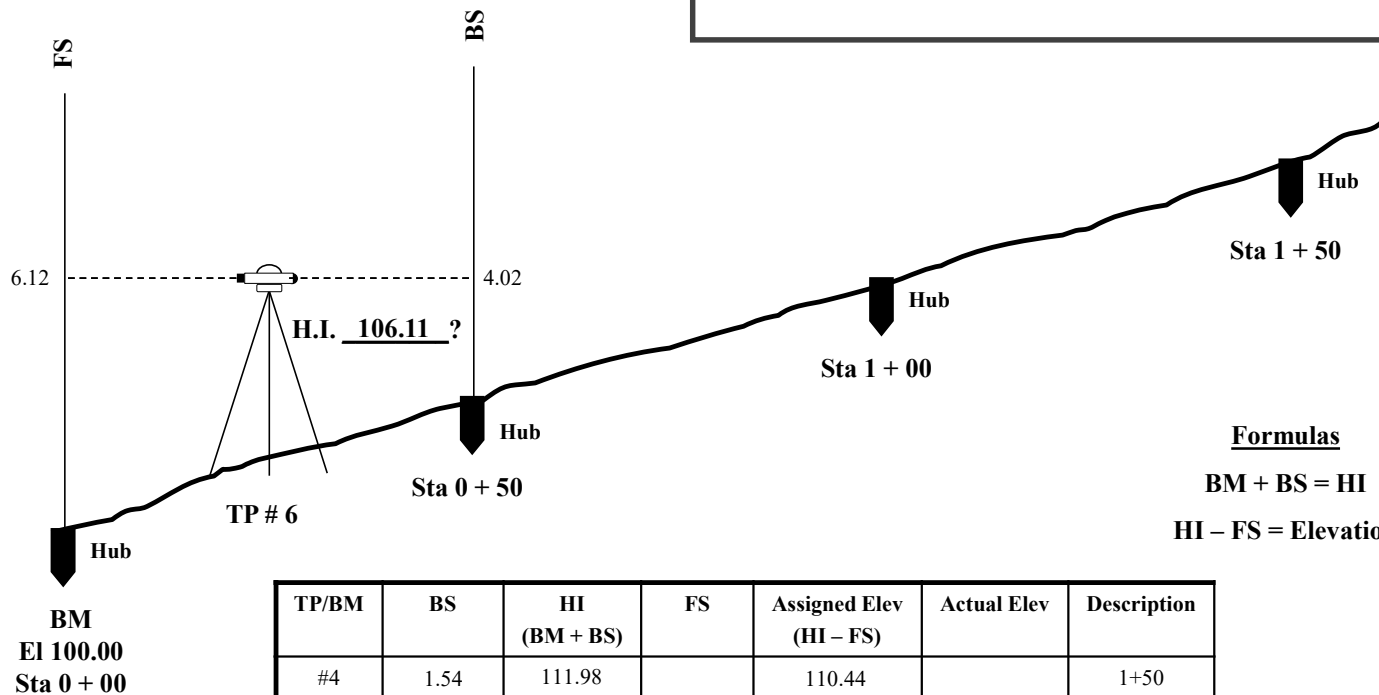
$$\text{HI} - \text{FS} = \text{Elevation}$$

TP/BM	BS	HI (BM + BS)	FS	Assigned Elev (HI - FS)	Actual Elev	Description
#4	1.54	111.98		110.44		1+50
#5			9.26	102.72		1+00
#6						0+50
					100.00	0+00

CONFIRMING THE ELEVATION



CONFIRMING THE ELEVATION



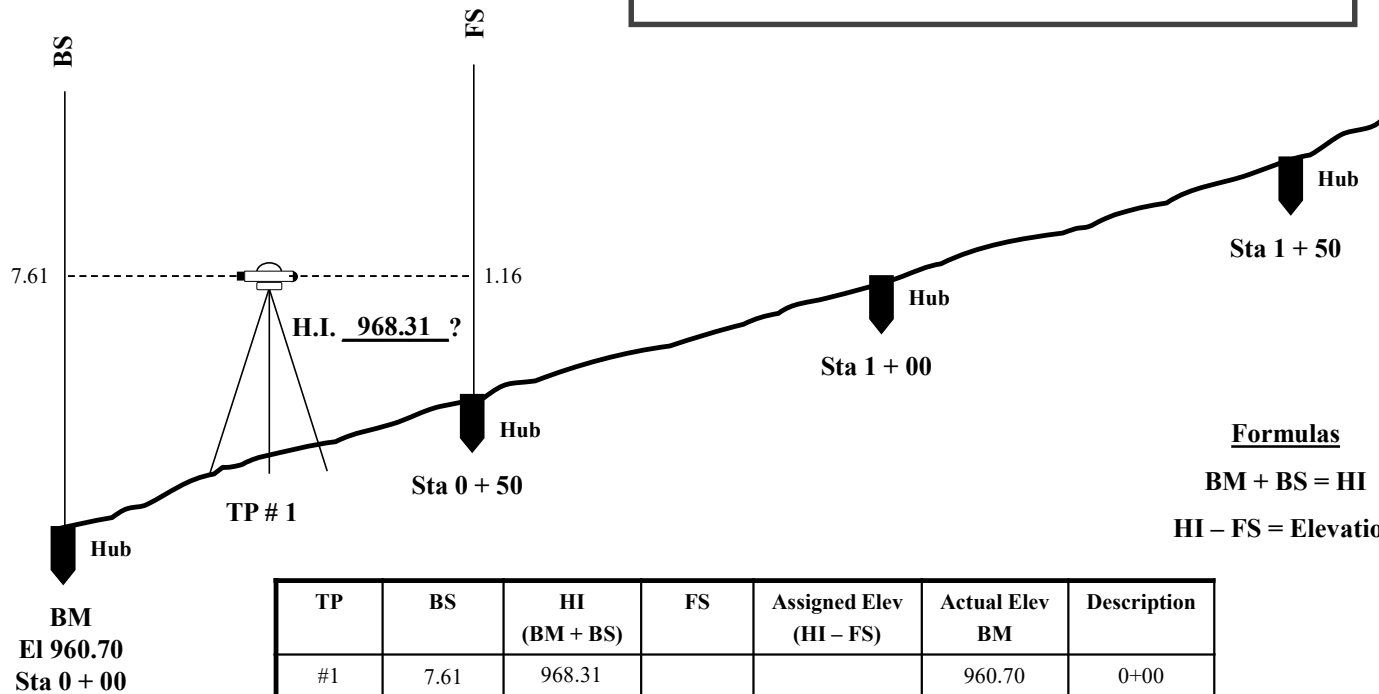
Formulas

$$\text{BM} + \text{BS} = \text{HI}$$

$$\text{HI} - \text{FS} = \text{Elevation}$$

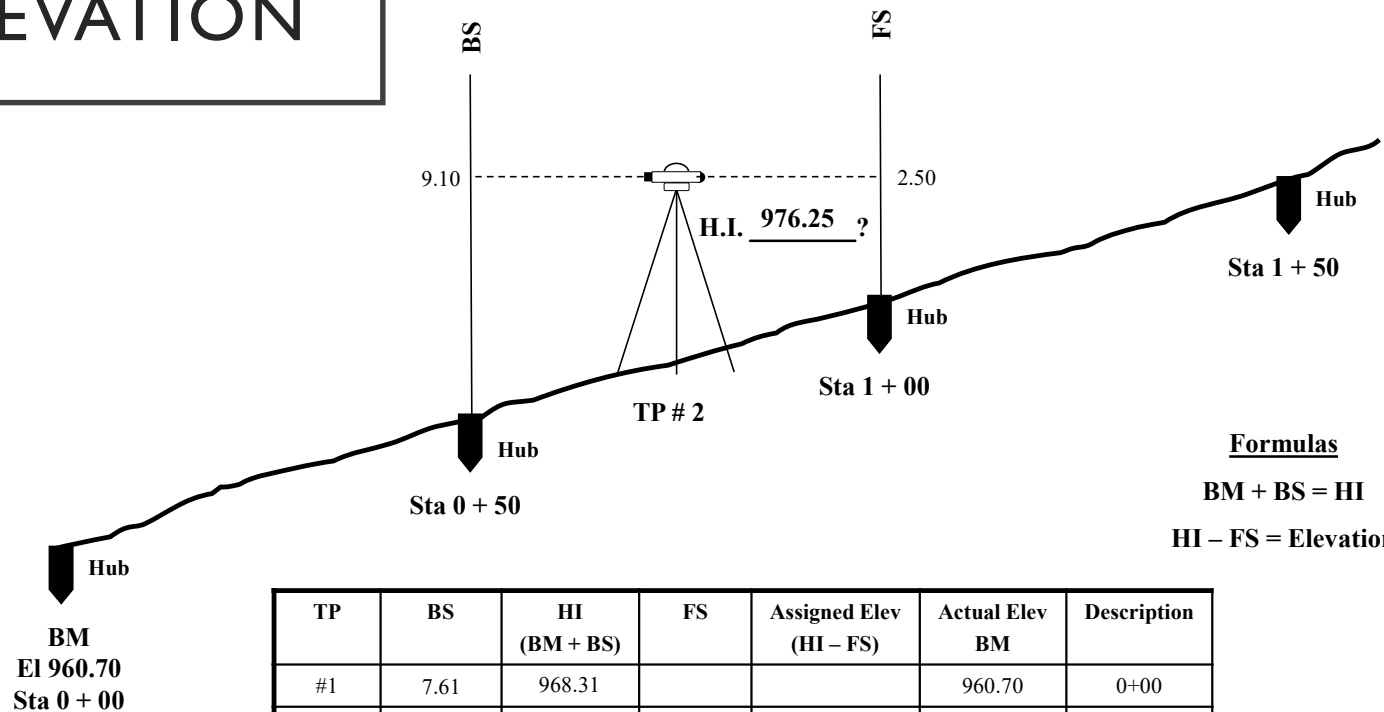
Does this close within Tolerance? Yes

ESTABLISHING AN ELEVATION



TP	BS	HI (BM + BS)	FS	Assigned Elev (HI - FS)	Actual Elev BM	Description
#1	7.61	968.31			960.70	0+00
#2			1.16	967.15		0+50
#3						1+00
						1+50

ESTABLISHING AN ELEVATION

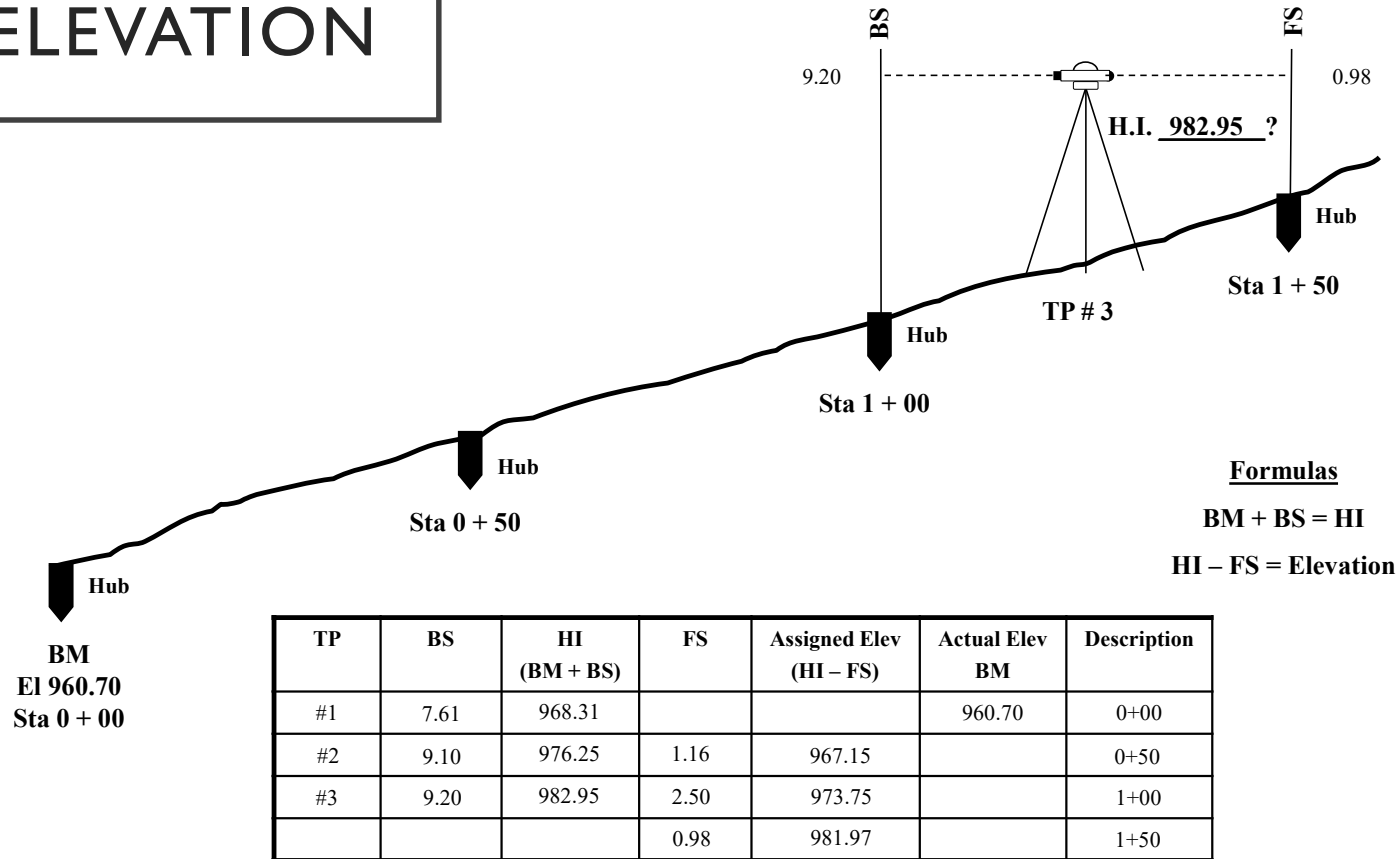


Formulas

$$\text{BM} + \text{BS} = \text{HI}$$

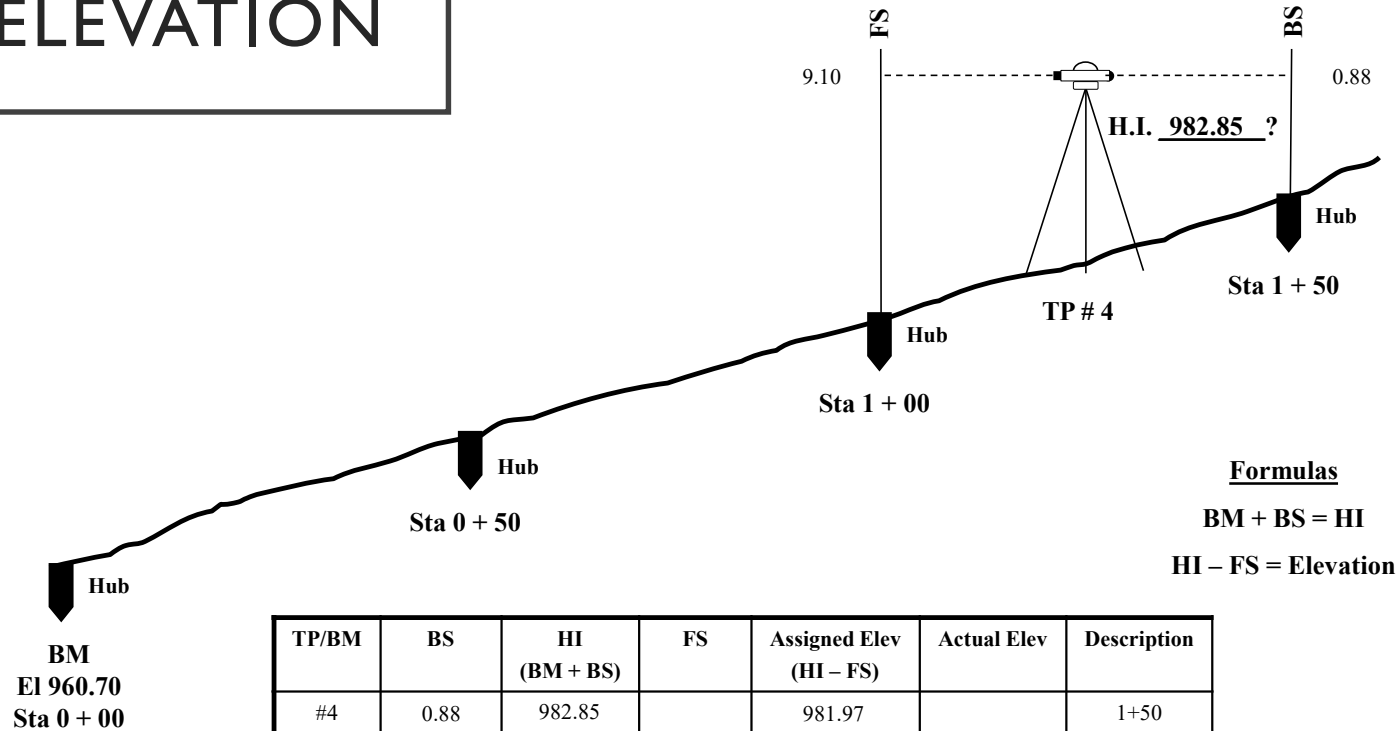
$$\text{HI} - \text{FS} = \text{Elevation}$$

ESTABLISHING AN ELEVATION



Difference in Hub elevations between Sta 0 + 00 & Sta 1 + 50 21.27 ?

CONFIRMING THE ELEVATION



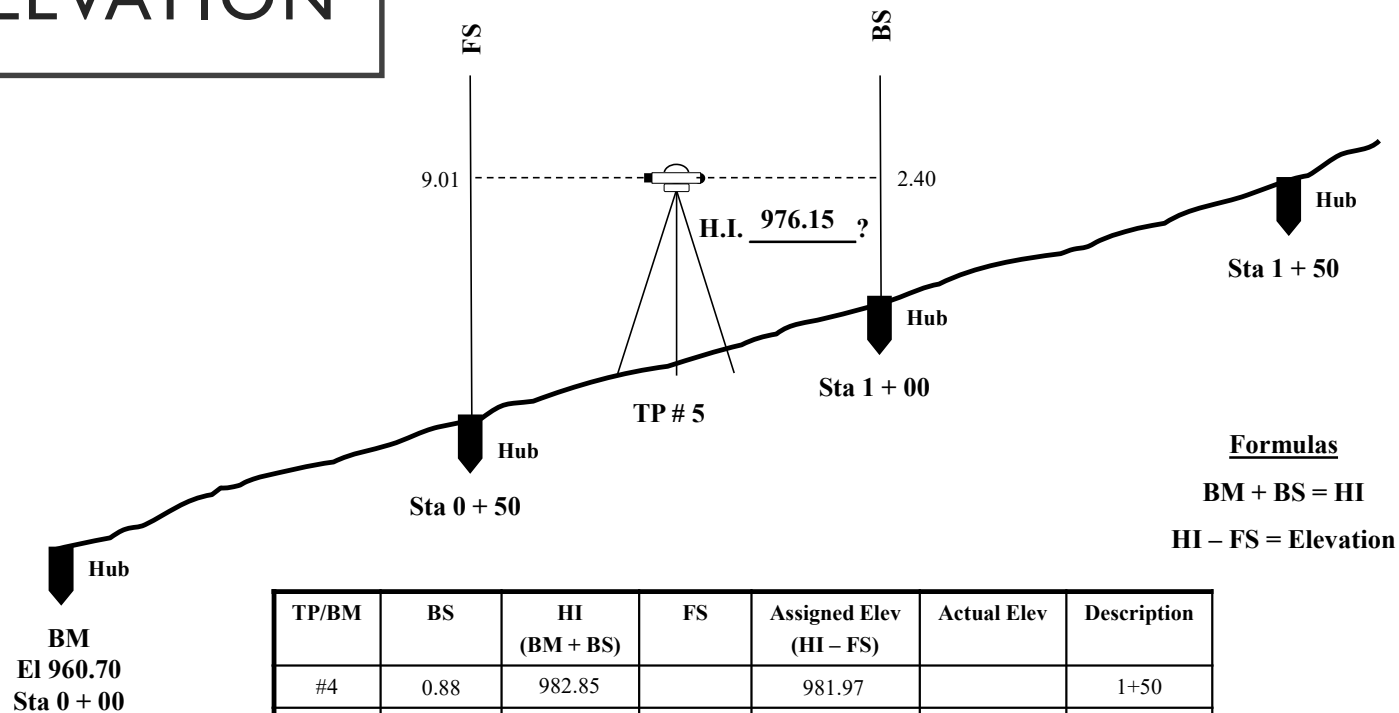
Formulas

$$\text{BM} + \text{BS} = \text{HI}$$

$$\text{HI} - \text{FS} = \text{Elevation}$$

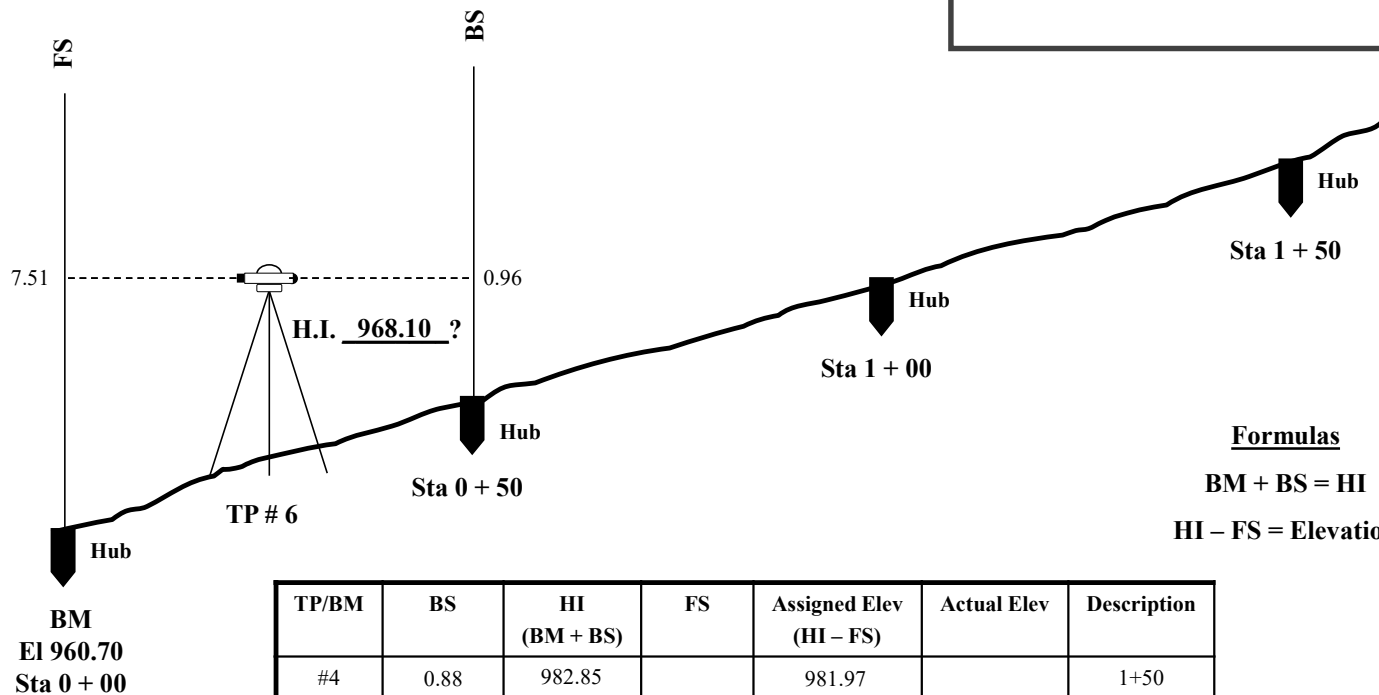
TP/BM	BS	HI (BM + BS)	FS	Assigned Elev (HI - FS)	Actual Elev	Description
#4	0.88	982.85		981.97		1+50
#5			9.10	973.75		1+00
#6						0+50
					960.70	0+00

CONFIRMING THE ELEVATION



TP/BM	BS	HI (BM + BS)	FS	Assigned Elev (HI - FS)	Actual Elev	Description
#4	0.88	982.85		981.97		1+50
#5	2.40	976.15	9.10	973.75		1+00
#6			9.01	967.14		0+50
					960.70	0+00

CONFIRMING THE ELEVATION



TP/BM	BS	HI (BM + BS)	FS	Assigned Elev (HI - FS)	Actual Elev	Description
#4	0.88	982.85		981.97		1+50
#5	2.40	976.15	9.10	973.75		1+00
#6	0.96	968.10	9.01	967.14		0+50
			7.51	960.59	960.70	0+00

Does this close within Tolerance? No

LEVEL LOOPING WITH AUTO LEVELS

Level looping is taking an elevation from a known elevation to determine an elevation of an unknown object. To do so properly, you should loop from the known to an unknown, bump the instrument and loop back to the original known elevation within tolerance. Tolerances vary and are determined by how many feet apart the loop was and how close you closed.

When looping long distances, you want to maximize the distance but no further than 250.00 from Instrument to each shot. This is where pacing comes in handy.

Some things to know before we begin...

- 1 – Setting up the Tripod or the Legs
- 2 – Leveling the instrument
- 3 – Reading a Grade Rod through the Auto Level.
- 4 – Rodding a Rod
- 5 – Common Hand signals from Instrument Person.
- 6 – Putting Equipment away Properly

Straight Grade - 2 Elev/RR & Dist - Grade Rod

BM	BS RR	HI	FS RR	Elevation	Distance		
980.32	3.24	983.56					
			LP RR – 9.87	973.69	132.50		
			HP RR – 6.54	977.02			
	Highest RR – Lowest RR =		(9.87 – 6.54) = 3.33'		3.33 / 132.50 = FT/FT = 0.02513 FT/FT		
		Want it staked in 4 Equal Segments		132.50 / 4 = 33.125'			
DIST	X	FT/FT	=	RISE	LP RR – RISE = FG RR	SECTION–4"BIT+8"CL–5 FG RR+SECTION=SG RR	
33.125		0.02513		0.83	9.87 – 0.83	9.04	9.04 + 1.00 = 10.04
66.25		0.02513		1.66	9.87 – 1.66	8.21	8.21 + 1.00 = 9.21
99.375		0.02513		2.50	9.87 – 2.50	7.37	7.37 + 1.00 = 8.37
132.50		0.02513		3.33	9.87 – 3.33	6.54	6.54 + 1.00 = 7.54

BM	BS RR	HI	FS RR	Elevation	Distance		
975.72	4.06	979.78					
			LP RR – 8.75	971.03	196.44		
			HP RR – 6.24	973.54			
	Highest RR – Lowest RR =		(8.75 - 6.24) = 2.51		2.51 / 196.44 = FT/FT = 0.0127774		
		Want it staked in 4 Equal Segments		196.44 / 4 = D = 49.11			
DIST (D)	X	FT/FT	=	RISE	LP RR – RISE = FG RR	SECTION–4"BIT+8"CL–5 FG RR+SECTION=SG RR	
(DX1) 49.11		0.0127774		0.63	8.75 – 0.63	8.12	8.12 + 1.00 = 9.12
(DX2) 98.22		0.0127774		1.25	8.75 – 1.25	7.50	7.50 + 1.00 = 8.50
(DX3) 147.33		0.0127774		1.88	8.75 – 1.88	6.87	6.87 + 1.00 = 7.87
(DX4) 196.44		0.0127774		2.51	8.75 – 2.51	6.24	6.24 + 1.00 = 7.24

TRY SOME RANDOM DISTANCES

62.22		0.0127774		0.80	8.75 – 0.80	7.95	7.95 + 1.00 = 8.95
107.10		0.0127774		1.37	8.75 – 1.37	7.38	7.38 + 1.00 = 8.38
118.59		0.0127774		1.52	8.75 – 1.52	7.23	7.23 + 1.00 = 8.23
132.07		0.0127774		1.69	8.75 – 1.69	7.06	7.06 + 1.00 = 8.06

Straight Grade - 2 Elev/RR & Dist - Lenker Rod

BM	BS RR	HI	FS RR	Elevation	Distance
980.32		0.32			
			LP RR - 3.69	973.69	
			HP RR - 7.02	977.02	132.50
	Highest RR - Lowest RR =		(7.02 - 3.69) = 3.33'		
		Want it staked in 4 Equal Segments		3.33 / 132.50 = FT/FT = 0.02513 FT/FT	
				132.50 / 4 = 33.125'	
DIST	X	FT/FT	=	RISE	LP RR + RISE = FG RR
33.125		0.02513		0.83	3.69 + 0.83 = 4.52
66.25		0.02513		1.66	3.69 + 1.66 = 5.35
99.375		0.02513		2.50	3.69 + 2.50 = 6.19
132.50		0.02513		3.33	3.69 + 3.33 = 7.02
					SECTION-4"BIT+8"CL-5 FG RR-SECTION=SG RR
					4.52 - 1.00 = 3.52
					5.35 - 1.00 = 4.35
					6.19 - 1.00 = 5.19
					7.02 - 1.00 = 6.02

BM	BS RR	HI	FS RR	Elevation	Distance
952.22		2.22			
			LP RR - 4.47	954.47	
			HP RR - 6.40	956.40	176.00
	Highest RR - Lowest RR =		(6.40 - 4.47) = 1.93		
		Want it staked in 4 Equal Segments		1.93 / 176.00 = FT/FT = 0.0109659	
				176.00 / 4 = D = 44.00	
DIST (D)	X	FT/FT	=	RISE	LP RR + RISE = FG RR
(DX1) 44.00		0.0109659		0.48	4.47 + 0.48 = 4.95
(DX2) 88.00		0.0109659		0.96	4.47 + 0.96 = 5.43
(DX3) 132.00		0.0109659		1.45	4.47 + 1.45 = 5.92
(DX4) 176.00		0.0109659		1.93	4.47 + 1.93 = 6.40
					SECTION-4"BIT+8"CL-5 FG RR-SECTION=SG RR
					4.95 - 1.00 = 3.95
					5.43 - 1.00 = 4.43
					5.92 - 1.00 = 4.92
					6.40 - 1.00 = 5.40

TRY SOME RANDOM DISTANCES					
20.27		0.0109659		0.22	4.47 + 0.22 = 4.69
57.64		0.0109659		0.63	4.47 + 0.63 = 5.10
97.01		0.0109659		1.06	4.47 + 1.06 = 5.53
162.72		0.0109659		1.78	4.47 + 1.78 = 6.25
					6.25 - 1.00 = 5.25

Straight Grade - 1 Elev/RR, Dist & Rise/Fall - Grade Rod

BM	BS RR	HI	FS RR	Elevation	Distance	+ % = Rise - % = Fall	
980.32	3.24	983.56					
			RR - 9.87	973.69	20.00	+2.00%	
		Want Rise/Fall in FT/FT		+2.00% / 100 = FT/FT = +0.02			
		Want it staked in 4 Equal Segments		20.00 / 4 = D = 5.00			
DIST (D)	X	FT/FT	=	+ = Rise - = Fall	RR - Rise RR + Fall	= FG RR SECTION-4"BIT+8"CL-5 FG RR+SECTION=SG RR	
(DX1) 5.00		0.02		0.10	9.87 - 0.10	9.77	9.77 + 1.00 = 10.77
(DX2) 10.00		0.02		0.20	9.87 - 0.20	9.67	9.67 + 1.00 = 10.67
(DX3) 15.00		0.02		0.30	9.87 - 0.30	9.57	9.57 + 1.00 = 10.57
(DX4) 20.00		0.02		0.40	9.87 - 0.40	9.47	9.47 + 1.00 = 10.47

BM	BS RR	HI	FS RR	Elevation	Distance	Rise (+) Fall (-)	
980.32	4.77	985.09					
			8.72	976.37	20.00	-2.00%	
		Want Rise/Fall in FT/FT		-2.00% / 100 = FT/FT = -0.02			
		Want it staked in 4 Equal Segments		20.00 / 4 = D = 5.00			
DIST (D)	X	FT/FT	=	+ = Rise - = Fall	RR - Rise RR + Fall	= FG RR SECTION-4"BIT+8"CL-5 FG RR+SECTION=SG RR	
(DX1) 5.00		-0.02		-0.10	8.72 + 0.10	8.82	8.82 + 1.00 = 9.82
(DX2) 10.00		-0.02		-0.20	8.72 + 0.20	8.92	8.92 + 1.00 = 9.92
(DX3) 15.00		-0.02		-0.30	8.72 + 0.30	9.02	9.02 + 1.00 = 10.02
(DX4) 20.00		-0.02		-0.40	8.72 + 0.40	9.12	9.12 + 1.00 = 10.12

TRY SOME RANDOM DISTANCES							
3.33		-0.02		-0.07	8.72 + 0.07	8.79	8.79 + 1.00 = 9.79
6.66		-0.02		-0.13	8.72 + 0.13	8.85	8.85 + 1.00 = 9.85
12.27		-0.02		-0.25	8.72 + 0.25	8.97	8.97 + 1.00 = 9.97
17.52		-0.02		-0.35	8.72 + 0.35	9.07	9.07 + 1.00 = 10.07

Straight Grade - 1 Elev/RR, Dist & Rise/Fall - Lenker Rod

BM	BS RR	HI	FS RR	Elevation	Distance	+ % = Rise - % = Fall
980.32		0.32				
			RR - 3.69	973.69	20.00	+2.00%
		Want Rise/Fall in FT/FT		+2.00% / 100 = FT/FT = +0.02		
		Want it staked in 4 Equal Segments		20.00 / 4 = D = 5.00		
DIST (D)	X	FT/FT	=	+ = Rise - = Fall	RR + Rise RR - Fall	= FG RR SECTION-4"BIT+8"CL-5 FG RR-SECTION=SG RR
(DX1) 5.00		0.02		0.10	3.69 + 0.10	3.79 3.79 - 1.00 = 2.79
(DX2) 10.00		0.02		0.20	3.69 + 0.20	3.89 3.89 - 1.00 = 2.89
(DX3) 15.00		0.02		0.30	3.69 + 0.30	3.99 3.99 - 1.00 = 2.99
(DX4) 20.00		0.02		0.40	3.69 + 0.40	4.09 4.09 - 1.00 = 3.09

BM	BS RR	HI	FS RR	Elevation	Distance	Rise (+) Fall (-)
980.32		0.32				
			9.00	979.00	40.00	+2.00%
		Want Rise/Fall in FT/FT		+2.00% / 100 = FT/FT = +0.02		
		Want it staked in 4 Equal Segments		40.00 / 4 = D = 10.00		
DIST (D)	X	FT/FT	=	+ = Rise - = Fall	RR + Rise RR - Fall	= FG RR SECTION-4"BIT+8"CL-5 FG RR-SECTION=SG RR
(DX1) 10.00		+0.02		+0.20	9.00 + 0.20	9.20 9.20 - 1.00 = 8.20
(DX2) 20.00		+0.02		+0.40	9.00 + 0.40	9.40 9.40 - 1.00 = 8.40
(DX3) 30.00		+0.02		+0.60	9.00 + 0.60	9.60 9.60 - 1.00 = 8.60
(DX4) 40.00		+0.02		+0.80	9.00 + 0.80	9.80 9.80 - 1.00 = 8.80

TRY SOME RANDOM DISTANCES						
12.50		+0.02		+0.25	9.00 + 0.25	9.25 9.25 - 1.00 = 8.25
26.62		+0.02		+0.53	9.00 + 0.53	9.53 9.53 - 1.00 = 8.53
30.77		+0.02		+0.62	9.00 + 0.62	9.62 9.62 - 1.00 = 8.62
38.21		+0.02		+0.76	9.00 + 0.76	9.76 9.76 - 1.00 = 8.76