Developed by the ABCs of Construction National Workplace Literacy Project, these seven workbooks are designed to enhance the basic skills of pipefitters. Reading and Solving Basic Pipefitting Problems #1 defines and uses eight basic terms pipefitters need to know, reviews steps a pipefitter must take to identify and solve a simple pipefitting problem, and includes simple problems to find "take out" and welder's gaps. Reading and Solving Basic Pipefitting Problems #2 reviews seven basic terms pipefitters need to know, uses each term while solving 45 pipefitting problems, introduces a five-step method to solve pipefitting problems, and provides practice exercises. Practicing Problem Solving for Pipefitters uses pipes velcroed onto a wall to practice real pipefitting problems, using the five-step method. Exercises are designed to help the worker transfer the method to handling a real-world pipefitting problem. Basic Vocabulary for Pipefitters depicts and explains 11 terms and has a fill-in-the-blanks exercise. Basic Trig for Pipefitters explains right angles, teaches the worker how to "see" one in pipe elbows, reviews what the sides of a triangle are called, practices how to see them in a pipe elbow, shows the worker how to use a trigonometry chart to find tangents, and includes practice exercises. Reading and Solving Pipefitter Take Out Problems shows what a "take out" is, provides exercises on finding one, shows how to read "The Pipefitters Blue Book" to find tangents, and provides practice exercises. Reading and Solving Basic Pipefitting Problems #3 introduces four steps to solve simple offset problems when the elbows are not 45 or 90 degrees and provides simple offset examples and problems. (YLB)
Pipefitter Workbooks
Reading & Solving Basic Pipefitting Problems # 1
These instructional materials were made possible through a National Workplace Literacy Grant funded through the U.S. Department of Education from November 1, 1992, to December 31, 1993, at the training center of the Pelican Chapter of Associated Builders and Contractors in Baton Rouge, Louisiana. The public/private partnership involved in the project included the East Baton Rouge Parish Schools Adult and Continuing Education Department and the Greater Baton Rouge Chamber of Commerce. The contents do not necessarily represent the policy of the Department of Education, and you should not assume endorsement by the Federal Government.

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Instructor Information for the Pipefitter Series

Seven workbooks have been designed to enhance the basic skills of pipefitters at the Technical Development Center. A brief description of each workbook follows:

1. **Reading and Solving Basic Pipefitting Problems # 1**
   Defines and uses eight basic terms pipefitters need to know. Reviews steps a Pipefitter must take to identify and solve a simple 90 pipefitting problem. Includes simple problems to find "take out" and welder's gaps.

2. **Reading and Solving Basic Pipefitting Problems # 2**
   Reviews seven basic terms pipefitters need to know: "center line," "cut length," "face to face," "offset," "run," "take out," and "welder's gap." Uses each of these terms while solving 45 pipefitting problems. Introduces a five step method to solve pipefitting problems. Provides exercises to practice this five step method.

3. **Practicing Problem Solving for Pipefitters**
   Uses the pipes velcroed onto the movable wall in the TDC room to practice real pipefitter problems. Workers use the five step method introduced in Reading and Solving Basic Pipefitting Problems # 2 to find the "cut length" of the connecting pipe between pipes located on the movable wall. Exercises are designed to help the worker transfer the five step method to "handling" a physically real pipefitting problem.

4. **Basic Vocabulary for Pipefitters**
   Depicts and explains eleven terms pipefitters need to know. Has an exercise wherein the worker must fill in the blanks using the correct terms.

5. **Basic Trig for Pipefitters**
   Helps the worker to know what is a right triangle and to be able to "see" right triangles in pipe elbows. Reviews what the sides of a triangle are called: "hypotenuse," "adjacent" and "opposite." Practices how to "see" these sides in a pipe elbow. Shows the worker how to use a trigonometry chart to find the tangent of an angle. Includes exercises for to find "take outs" wherein the worker must use a trig chart to find the tangent of an angle.

6. **Reading and Solving Pipefitter Take Out Problems**
   Shows what a "take out" is in 90 and 45 elbows. Provides exercises to find "take outs" in 90 elbows. Reviews how to find a "take out" in a 45 elbow using a trigonometry chart to find the tangent of an angle. Provides practice exercises. Shows how to read The Pipe Fitters Blue Book to find the tangent of an angle then provides practice exercises.

7. **Reading and Solving Basic Pipefitting Problems # 3**
   Introduces four steps to take in order to solve simple offset problems when the elbows are not 45 or 90. Provides simple offset examples and problems.
Connecting Pipes

Connecting pipes together isn’t easy unless you know how to do it correctly. There are terms you need to know before we begin to review the steps you should follow in order to connect two runs of pipes together.

**Terms Pipefitters Should Know**

When you are connecting two pipes that are level with the ground, it is called a **simple offset**. Most pipes in the industrial plants are laid in north/south or east/west directions. In order to find the distance between the two pipes you want to connect, you must find the distance between their **center lines**. A center line goes along the very middle of a pipe. A center line in a pipe is like the point where someone would first place a knife in order to cut out a piece of pie. The distance between the center lines is called an **offset**.

![Diagram of a simple offset]

**Take Outs**

In order to know how long a pipe fitting you need to connect two other pipes, you must first find out how much length the elbows (ells) add to connecting these pipes together. **Take Out** of a pipe fitting is the distance that a fitting extends the center line of a run of pipe past the end of the pipe. It is the length of pipe the elbows add to the pipe offset.

![Diagram of take outs]
In every elbow (ell) you can "see" right triangles. The "legs" of the right triangle are actually the adjacent sides of the right triangle. In an ell they are equal to the radius of the ell and extend to the center lines of the ell.

ex.

Welder's Gaps

When two pieces of pipe need to be welded together there needs to be a space allotted for the welder to make his/her weld. This space is called the gap. It is important that the pipefitter ask the welder how much space should be allotted for gaps. Depending on the size of the pipe, most welders like a 1/8" or 3/32" gap between pipes.

ex.
Steps to Correct Runs of Pipe

A. Identify Problem

Begin by drawing a rough picture of the pipes you need to connect and the pieces you'll need to connect them. Will the elbows you use to connect these pipes use 90° or 45° elbows (ells)?

ex.

B. Find Take Outs

In order to find the length of pipe needed to connect two pipes, we must first identify how much of the offset is taken up by the ells. The center radius of an elbow that will be welded to connect two pipes together is equal to 1½ times the nominal pipe size.\(^2\)

\[
\text{radius of a } 6'' \text{ 90° elbow} = 6'' \times 1\frac{1}{2} = 9''
\]

\(^1\)Ell is the shortened name for elbow.

\(^2\)Nominal pipe size (NPS) is the size we call the pipe, not to be confused with the actual size of the pipe.
Take Out Exercises

1. When using a 90° butt weld ell, if the pipe size is 8", what is the take out? (Remember, the Take Out of a fitting is the distance that a fitting extends the center line of a run of pipe past the end of the pipe.)
   
   ex. Nominal Pipe Size = 8"
   
   Radius of an 8" pipe = 1½ x 8"
   
   If radius = take out
   
   What is take out of a 90° butt weld of an 8" pipe?

2. When using a 90° butt weld ell, if the pipe size is 12", what is the take out?
   
   ex. Nominal Pipe Size = 12"
   
   Radius of an 12" pipe = 1½ x 12"
   
   If radius = take out
   
   What is take out of a 90° butt weld of an 12" pipe?

Please Note: Elbows that are factory made often have different sizes of ells than field cut ones. Be sure to check what is the actual radius of the butt weld ell you are using. If you do not check this, an incorrect radius may make your take out incorrect.

3. In a 90° butt weld ell, what is the take out if you have a factory made 5" pipe?
   
   ex. Nominal Pipe Size = 5"
   
   Radius =
   
   Take Out =

4. In a 90° butt weld ell, what is the take out if you make a 3" pipe?
   
   Ex. Pipe Size = 3"
   
   Radius =
   
   Take Out =

"When you make an elbow it is called a "field cut" elbow."
Take Out Exercises

1. When using a 90° butt weld ell, if the pipe size is 8", what is the take out? (Remember, the Take Out of a fitting is the distance that a fitting extends the center line of a run of pipe past the end of the pipe.)

ex. Nominal Pipe Size = 8"
Radius of an 8" pipe = 1½ x 8" = 12"
If radius = take out
What is take out of a 90° butt weld of an 8" pipe? = 12"

2. When using a 90° butt weld ell, if the pipe size is 12", what is the take out?

ex. Nominal Pipe Size = 12"
Radius of an 12" pipe = 1½ x 12" = 18"
If radius = take out
What is take out of a 90° butt weld of an 12" pipe? = 18"

Please Note: Elbows that are factory made often have different sizes of ells than field cut ones. Be sure to check what is the actual radius of the butt weld ell you are using. If you do not check this, an incorrect radius may make your take out incorrect.

3. In a 90° butt weld ell, what is the take out if you have a factory made 5" pipe?

ex. Nominal Pipe Size = 5"
Radius = 1½ x 5" = 7½"
Take Out = Radius = 7½"

4. In a 90° butt weld ell, what is the take out if you field cut a 3" pipe?

Ex. Pipe Size = 3"
Radius = 1½ x 3" = 4½"
Take Out = Radius = 4½"
C. Find Welder's Gap

1. In connecting the pipe runs in the example below, how many welds would a welder need to make?

2. How much distance does a welder generally need to make a good weld in each welder's gap?

3. How much distance will the welder's gaps add to the length of the offset (distance between the center lines of the two runs of pipe) that are connected with 45° ells?

Answers to Welder's Gap:
1. 4 welds
2. Welds are 1/4" (sometimes welders request 3/32")
3. 2 welds and each weld is 1/4" or $2 \times \frac{1}{4}" = \frac{2}{4}" = \frac{1}{2}"
Practice Problems for 90° Simple Offset

To calculate how long a connecting cut length of pipe is needed to join two pipes in a 90° simple offset, you would subtract the take outs of two 90° elbows, and two welder's gaps from the length of the run. Your answer would be how long the connecting pipe should be.

ex. \[ \text{Cut Length of Pipe} = \text{Offset} - 2 \text{ Take Outs} - 2 \text{ Welder's Gaps} \]

\[ \begin{align*}
5\frac{1}{2}" & - 2(1\frac{1}{2}"") - 2(\frac{1}{8}")) = \text{Cut Length of Pipe} \\
5\frac{1}{2}" & - 3" - \frac{1}{4}" = \text{Cut Length of Pipe} \\
& = 2\frac{1}{4}" \\
\end{align*} \]

Please note: When you are determining the length of an "offset" between two pipes, you figure the run as the distance between the two center lines of the connecting pipes; therefore, your calculations include 2 welder's gaps, not all four the welder must make to complete the job.

Practice 90° Simple Offset Problems

Find the cut length of the 90° offsets. Use a \( \frac{1}{8}" \) for the welder's gaps (and remember there will be two of these) and that the take out for a 90° elbow is 1.5 times the NPS (Nominal Pipe Size, what it is called). Answers to these problems are found in the next section. All the steps to doing these problems are explained here.

1. Offset is 24"
   Pipe size is 6"
   Cut Length of Pipe = ?

\[ \text{Cut Length of Pipe} = 2\text{(Take Outs)} - 2\text{(Welder's Gap)} \]

\[ 2\frac{1}{4}" \]

'The run is the path that the pipe takes to get to the new center line.'
2. Offset is 6'2"
   Pipe size is 2"
   Connecting pipe length is = ?

3. Offset is 7"
   Pipe size is 3"
   Connecting pipe length is = ?

4. Offset is 84/16
   Pipe size is 8"
   Connecting pipe length is = ?

5. Offset is 22/16
   Pipe size is 12"
   Connecting pipe length is = ?
Answers:

1. Offset is 24"
   Pipe size is 6"
   Connecting pipe length = ?

   $24" - 2(\text{Take Outs}) - 2(\text{Welder's Gap}) = \text{Length of Connecting Pipe}$
   
   $24" - 2(6" \times 1\frac{1}{2}) - 2(1\frac{1}{4}"") = \text{Length}$
   
   $24" - 2(9"") - 1\frac{1}{4}" = \text{Length}$
   
   $24" - 18" - 1\frac{1}{4}" = \text{Length}$
   
   $= 5\frac{3}{4}"$

2. Offset is 6'2"
   Pipe size is 2"
   Connecting pipe length is = ?

   $6'2" - 2(2" \times 1\frac{1}{2}) - 2(1\frac{1}{4}"") = \text{Length}$
   
   $6'10" - 2(3"") - 1\frac{1}{4}" = \text{Length}$
   
   $6'10" - 6" - 1\frac{1}{4}" = \text{Length}$
   
   $= 6'3\frac{3}{4}"$

3. Offset is 17"
   Pipe size is 3"
   Connecting pipe length is = ?

   $17" - 2(3" \times 1\frac{1}{2}) - 2(1\frac{1}{4}"") = \text{Length}$
   
   $17" - 2(4\frac{1}{2}"") - 1\frac{1}{4}" = \text{Length}$
   
   $17" - 9" - 1\frac{1}{4}" = \text{Length}$
   
   $= 7\frac{3}{4}"$

4. Offset is 19'11"
   Pipe size is 8"
   Connecting pipe length is = ?

   $19'11" - 2(8" \times 1\frac{1}{2}) - 2(1\frac{1}{4}"") = \text{Length}$
   
   $19'11" - 2(12"") - 1\frac{1}{4}" = \text{Length}$
   
   $19'11" - 24" - 1\frac{1}{4}" = \text{Length}$
   
   $= 17'10\frac{3}{4}"$

5. Offset is 22'4\frac{1}{2}" 
   Pipe size is 12"
   Connecting pipe length is = ?

   $22'4\frac{1}{2}" - 2(12" \times 1\frac{1}{2}) - 2(1\frac{1}{4}"") = \text{Length}$
   
   $22'4\frac{1}{2}" - 2(18"") - 1\frac{1}{4}" = \text{Length}$
   
   $22'4\frac{1}{2}" - 36" - 1\frac{1}{4}" = \text{Length}$
   
   $= 19'4\frac{3}{4}"$

\[522'4\frac{1}{2}" = 19' + 36" + 4\frac{1}{2}" \quad (3' = 36")\]
Reading & Solving
Basic
Pipefitting Problems
# 2

Associated Builders & Contractors, Inc.
EBR Adult & Continuing Education
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Basic Pipefitting # 2

Connecting pipes that are fairly close together may require the use of 45° butt weld elbows. Many electricians would like to use an 45° elbow because it is easier to pull their wires through it than the 90° elbow. In the petrochemical industrial plants, 45° elbows are most often used to connect pipes because liquids or gases can flow more easily through them.

The 45° butt weld elbow is the second most used butt weld (B.W.) elbow.

The most common kind is the 90° elbow (ell).

The words you should know to do the problems that follow are:

- **Run**: The path that a pipe takes to get from one center line to another center line.

- **Offset**: Usually a combination of two ells and a cut length of pipe that moves a line of pipe to a new position.

- **Center Line**: The line that is equal distant from all sides of a pipe that is in the middle of a pipe.

- **Take Out**: The distance that an ell extends the center line of a run of pipe past the end of the pipe.

- **Welder's Gap**: The space between a fitting and the pipe that is filled by welding.
There is another term you need to know when you work with 45° Butt Weld ells.

**Face to face** The distance between the parallel faces of the pipes you are trying to connect.

When you measure the distance between two pipes you'd like to connect, there are five steps you can follow in order to find out how long you should cut the length of the pipe to connect those pipes together.

**Step 1** Measure the distance between the two pipes. This distance is the "face to face" distance between the two pipes to be connected.

a. Measure how far the two pipes are apart. Be sure if you measure the distance from the bottom of one pipe, you measure to the bottom of the other pipe (or the top to the top).
Step 2  Find the "take out" (the distance an ell extends the center line of a run of pipe past the end of a pipe).

a. Identify the size of the pipes you will connect together (is it 3", 6", etc.).

b. Identify if the ells you will use to connect the pipes are field cut or factory made.

c. Use the chart below to find the length of the take out you will use to connect these pipes.

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Take out Field Cut 45's</th>
<th>Take out Factory Made 45's</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>0.625&quot;</td>
<td>0.625&quot;</td>
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<tr>
<td>3/4</td>
<td>0.4660&quot;</td>
<td>0.4375&quot;</td>
</tr>
<tr>
<td>1&quot;</td>
<td>0.6213&quot;</td>
<td>0.875&quot;</td>
</tr>
<tr>
<td>1 1/4&quot;</td>
<td>0.7767&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>1 1/2&quot;</td>
<td>0.9320&quot;</td>
<td>1.125&quot;</td>
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<tr>
<td>2&quot;</td>
<td>1.2426&quot;</td>
<td>1.375&quot;</td>
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<tr>
<td>2 1/2&quot;</td>
<td>1.5533&quot;</td>
<td>1.75&quot;</td>
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<tr>
<td>3&quot;</td>
<td>1.8640&quot;</td>
<td>2&quot;</td>
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<tr>
<td>3 1/2&quot;</td>
<td>2.1746&quot;</td>
<td>2.25&quot;</td>
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<td>4&quot;</td>
<td>2.4853&quot;</td>
<td>2.5&quot;</td>
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<td>24&quot;</td>
<td>14.9117&quot;</td>
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Step 3  Find the Offset

a. From the length of the "face to face" distance, subtract 2 take outs.

![Diagram of face to face and take out](image-url)
Step 4

Find the Run (the path from one center line to another center line).

a. The Csc 45° = 1.4142
b. Multiply the Csc 45° (or 1.4142) x the Offset = Run

Step 5

Find the cut length of pipe to connect the pipes.

a. Use the formula:

\[ \text{Run} - 2 \text{ Take Outs} - 2 \text{ Welder's Gaps} = \text{Cut Length} \]

Example 1

Step 1

Measure the "face to face" distance between the two pipes to be connected.

a. Measure from the bottom of one pipe to the bottom of the second pipe (or the top to the top). The face to face is 31.5".

---

[Diagram of the steps and measurements]
Step 2  Find the "take out" (the distance an ell extends the center line of a run of pipe past the end of a pipe).

a. The size of the pipe is 6".

b. The ells are factory made.

c. The take out for a 6" factory made ell is 3.75".

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<td>14.9117&quot;</td>
<td>15&quot;</td>
</tr>
</tbody>
</table>

Step 3  Find the Offset

a. From the length of the "face to face" distance, subtract 2 take outs.

\[
\text{Face to Face} - 2 \text{ Take Outs} = \text{Offset}
\]

\[
31.5" - 2(3.75") = \text{Offset}
\]

\[
31.5" - 7.5" = \text{Offset}
\]

\[
24" = \text{Offset}
\]
Step 4  
**Find the Run** (the path from one center line to another center line).

a. The Csc 45° = 1.4142

b. Multiply the Csc 45° (or 1.4142) x the Offset = Run

\[ 1.4142 \times 24'' = 33.94'' \]

---

**Step 5**  
Find the cut length of pipe to connect the pipes.

a. Use the formula:

\[ \text{Run} - 2 \text{ Take Outs} - 2 \text{ Welder's Gaps} = \text{Cut Length} \]

- \[ 33.94'' - 2(3.75'') = 26.19'' \]
- \[ 33.94'' - 7.5'' = 26.19'' \]

* Use \( \frac{1}{8}'' \) for the Welder's Gap
Example 2  The distance between two 4" pipes that you want to connect is 28" using 45° 4" ells. How long will the cut length of your connecting pipe be?

Step 1  The "face to face" distance between the two pipes is 28".

Step 2  Find the take out for a 4" factory made ell from the chart below.

Step 3  Find the Offset

\[
\text{Face to Face} - 2 \text{ Take Outs} = \text{Offset}
\]

\[
\begin{align*}
28" & \quad - 2(\ ) = \text{Offset} \\
28" & \quad - \quad = \text{Offset} \\
28" & \quad = \text{Offset}
\end{align*}
\]

Step 4  Find the Run

Multiply the Csc 45° (or 1.4142) x the Offset = Run

\[
\begin{align*}
1.4142 \times 28" & \quad = \text{Run} \\
\end{align*}
\]

Step 5  Find the cut length of pipe to connect the pipes.

\[
\text{Run} - 2 \text{ Take Outs} - 2 \text{ Welder's Gaps} = \text{Cut Length}
\]

\[
\begin{align*}
" & \quad - 2(\ ) \quad - 2 (\frac{3}{8}) \quad = \text{Cut Length} \\
" & \quad - \quad \quad = \text{Cut Length} \\
" & \quad - \quad \quad = \text{Cut Length}
\end{align*}
\]

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<td>0.4375&quot;</td>
</tr>
<tr>
<td>1&quot;</td>
<td>0.6213&quot;</td>
<td>0.875&quot;</td>
</tr>
<tr>
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<td>0.7767&quot;</td>
<td>1&quot;</td>
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<tr>
<td>1 1/2&quot;</td>
<td>0.9320&quot;</td>
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<td>1.2426&quot;</td>
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<td>3 1/2&quot;</td>
<td>2.1746&quot;</td>
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<td>4&quot;</td>
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<tr>
<td>8&quot;</td>
<td>4.9706&quot;</td>
<td>5&quot;</td>
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</tbody>
</table>
Pipefitting Problems

Now try to do the following problems. Go back to the example problems if you need help.

1. The face to face distance between two 3" pipes that will be connected with factory made 45° ells is 40". What is the cut length of pipe needed to connect these pipes. (The answer is on page 12.)

   Step 1

   Step 2

   Step 3

   Step 4

   Step 5
2. The face to face distance between two 8" pipes that will be connected with factory made 45° ells is 72". What is the cut length of pipe needed to connect these pipes.

Step 1

Step 2

Step 3

Step 4

Step 5

3. The face to face distance between two 16" pipes that will be connected with factory made 45° ells is 200". What is the cut length of pipe needed to connect these pipes.

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<td>16&quot;</td>
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<td>18&quot;</td>
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</tr>
<tr>
<td>24&quot;</td>
<td>14.9117&quot;</td>
<td>15&quot;</td>
</tr>
</tbody>
</table>
4. The face to face distance between two 20" pipes that will be connected with factory made 45° ells is 10' (or 120"). What is the cut length of pipe needed to connect these pipes.

Step 1

Step 2

Step 3

Step 4

Step 5

5. The face to face distance between two 24" pipes that will be connected with factory made 45° ells is 12' (12" x 12' = 144"). What is the cut length of pipe needed to connect these pipes.

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<tr>
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<td>0.875&quot;</td>
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<td>0.7767&quot;</td>
<td>1&quot;</td>
</tr>
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<td>1 1/2&quot;</td>
<td>0.9320&quot;</td>
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</tr>
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ANSWERS

1. The face to face distance between two 3" pipes that will be connected with factory made 45° ells is 40". What is the cut length of pipe needed to connect these pipes.

   **Step 1** The "face to face" distance between the two pipes is 40".

   **Step 2** The take out for a 3" factory made ell is 2".

   **Step 3** The Offset is:
   
   \[
   \text{Face to Face - 2 Take Outs} = \text{Offset} \\
   40" - 2(3") = \text{Offset} \\
   40" - 6" = 34"
   \]

   **Step 4** The run is:
   
   \[
   1.4142 \times 34" = \text{Run} \\
   48.08" = \text{Run}
   \]

   **Step 5** The cut length of pipe is:
   
   \[
   \text{Run} - 2 \text{ Take Outs} - 2 \text{ Welder's Gaps} = \text{Cut Length} \\
   48" - 2(2") - 2(\frac{1}{8}"") = \text{Cut Length} \\
   48" - 4" - 2/8" = \text{Cut Length} \\
   48" - 4" - .25" = \text{Cut Length} \\
   48" - .25" = 43.75"
   \]

2. The face to face distance between two 8" pipes that will be connected with factory made 45° ells is 72". What is the cut length of pipe needed to connect these pipes.

   **Step 1** The "face to face" distance between the two pipes is 72".

   **Step 2** The take out for an 8" factory made ell is 5".

   **Step 3** The Offset is:
   
   \[
   \text{Face to Face - 2 Take Outs} = \text{Offset} \\
   72" - 2(5") = \text{Offset} \\
   72" - 10" = 62"
   \]

   **Step 4** The run is:
   
   \[
   1.4142 \times 62" = \text{Run} \\
   87.68" = \text{Run}
   \]

   **Step 5** The cut length of pipe is:
   
   \[
   \text{Run} - 2 \text{ Take Outs} - 2 \text{ Welder's Gaps} = \text{Cut Length} \\
   87.68" - 2(5") - 2(\frac{1}{8}"") = \text{Cut Length} \\
   87.68" - 10" - 2/8" = \text{Cut Length} \\
   87.68" - 10" - .25" = 77.43"
   \]
3. The face to face distance between two 16" pipes that will be connected with factory made 45° ells is 200". What is the cut length of pipe needed to connect these pipes.

Step 1 The "face to face" distance between the two pipes is 200".

Step 2 The take out for a 16" factory made ell is 10".

Step 3 The Offset is:
Face to Face - 2 Take Outs = Offset
200" - 2(10") = Offset
200" - 20" = 180"

Step 4 The run is:
1.4142 x 180" = Run
254.56" = Run

Step 5 The cut length of pipe is:
Run - 2 Take Outs - 2 Welder's Gaps = Cut Length
254.56" - 2(10") - 2 (½") = Cut Length
254.56" - 20" - 2/8" = 234.31"

4. The face to face distance between two 20" pipes that will be connected with factory made 45° ells is 10' (or 120"). What is the cut length of pipe needed to connect these pipes.

Step 1 The "face to face" distance between the two pipes is 120".

Step 2 The take out for a 20" factory made ell is 12.5".

Step 3 The Offset is:
Face to Face - 2 Take Outs = Offset
120" - 2(12.5") = Offset
120" - 25" = 95"

Step 4 The run is:
1.4142 x 95" = Run
134.35" = Run

Step 5 The cut length of pipe is:
Run - 2 Take Outs - 2 Welder's Gaps = Cut Length
134.35" - 2(12.5") - 2 (½") = Cut Length
134.35" - 25" - 2/8" = 109.1"
5. The face to face distance between two 24" pipes that will be connected with factory made 45° ells is 12' (12" x 12" = 144"). What is the cut length of pipe needed to connect these pipes.

Step 1. The "face to face" distance between the two pipes is 144".

Step 2. The take out for a 24" factory made ell is 15".

Step 3. The Offset is:

\[
\begin{array}{ccc}
\text{Face to Face} & -2 \times \text{Take Outs} & = \text{Offset} \\
144'' & -2(15'') & = 114'' \\
144'' & -30'' & = 114'' \\
\end{array}
\]

Step 4. The run is:

\[
1.4142 \times 114'' = 161.22'' = \text{Run}
\]

Step 5. The cut length of pipe is:

\[
\begin{array}{ccc}
\text{Run} & -2 \times \text{Take Outs} & -2 \times \text{Welder's Gap} = \text{Cut Length} \\
161.22'' & -2(15'') & -2(\frac{1}{4}'') = 130.97'' \\
161.22'' & -30'' & -\frac{3}{8}'' = 130.97'' \\
161.22'' & -30'' & -.25'' = 130.97'' \\
\end{array}
\]

\[
\text{Run} - 2 \text{T.O.} - 2 \text{gaps} = \text{cut length}
\]
Practicing Problem Solving for Pipefitters

Associated Builders & Contractors, Inc. EBR Adult & Continuing Education
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Problem Solving Exercises

In the problems below use the pipes labeled "A", "B", "C", "D", "E", "F" and "G" located in the TDC center classroom. These colored plastic pipes are located on the movable wall between the teacher's desk and the classroom tables. For purposes of these exercises we will use plastic rather than metal pipes as they are easier to use even though butt welding is used on metal pipes.

Example

How long is the cut length of the connecting pipe between the two blue, 2" pipes labeled "A" and "B"?

Step 1  Measure the "face to face" distance between the blue pipes.

Step 2  Find the take out for a 2" factory made ell from the chart below.

<table>
<thead>
<tr>
<th>Pipe Size</th>
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<td>15&quot;</td>
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</tbody>
</table>

Take Out for a 2" factory made 45 ell is 1.375"
Step 3 Find the Face to Face.

<table>
<thead>
<tr>
<th>Face to Face</th>
<th>- 2(Take Outs) Offset</th>
<th>- 2(1.375&quot;) Offset</th>
<th>- 2.75&quot; Offset</th>
<th>31&quot; Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>33.75&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>33.75&quot;</td>
<td></td>
<td></td>
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</tbody>
</table>

Step 4 Find the Run.

Multiply the Csc 45° (or 1.4142) x the Offset = Run

\[ 1.4142 \times 31" = 43.8402" \]

Step 5 Find the cut length of pipe to connect the pipes.

<table>
<thead>
<tr>
<th>Run</th>
<th>- 2(Take Outs)</th>
<th>- 2 Welder’s Gaps</th>
<th>= Cut Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>43.84&quot;</td>
<td>2(1.375&quot;&quot;)</td>
<td>2(1/8&quot;)</td>
<td>= Cut Length</td>
</tr>
<tr>
<td>43.84&quot;</td>
<td>2.75&quot;</td>
<td>2/8&quot;</td>
<td>= Cut Length</td>
</tr>
<tr>
<td>43.84&quot;</td>
<td>2.75&quot;</td>
<td>.25&quot;</td>
<td>= Cut Length</td>
</tr>
<tr>
<td>43.84&quot;</td>
<td></td>
<td></td>
<td>40.84&quot;</td>
</tr>
</tbody>
</table>
1. How long is the cut length of the connecting pipe between the two blue, 2" pipes labeled "A" and "C"?

Step 1: Measure the "face to face" distance between the two pipes.

Step 2: Find the take out for a 2" factory made ell from the chart found in Step 2 of the example problem (2 pages before).

Take Out for a 2" factory made ell = ?".

Step 3: Find the Offset.

Face to Face - 2(Take Outs) = Offset

Step 4: Find the Run.

Multiply the Csc 45° (or 1.4142) x the Offset = Run

1.4142 x ? = Run

Step 5: Find the cut length of pipe to connect the pipes.

Run - 2 Take Outs - 2 Welder's Gaps = Cut Length
" - 2 (" ) - 2 (1/8") = Cut Length
" - - 2/8" = Cut Length
" - - .25" = Cut Length

Run -- 2 Take Outs -- 2 Welder's Gaps = Cut Length
" -- 2 (" ) -- 2 (1/8") = Cut Length
" -- - 2/8" = Cut Length
" -- - .25" = Cut Length
2. How long is the cut length of the connecting pipe between the two orange 3/4" pipes labeled "D" and "E"?

Step 1  Measure the "face to face" distance between the two pipes.

Step 2  Find the take out for a 3/4" factory made ell from the chart found in Step 2 of the example problem (3 pages before).

Take Out for 3/4" factory made ell = ? "

Step 3  Find the Offset

Face to Face  - 2(Take Outs) = Offset

Step 4  Find the Run

Multiply the Csc 45° (or 1.4142) x the Offset = Run

1.4142 x = Run

Step 5  Find the cut length of pipe to connect the pipes.

Run  - 2 Take Outs  - 2 Welder’s Gaps = Cut Length
"  - 2 (")  - 2 (1/8") = Cut Length
"  -      - 2/8" = Cut Length
"  -      - .25" = Cut Length

= Cut Length
3. How long is the cut length of the connecting pipe between the orange 3/4" pipe labeled "D" and the green 3/4" pipe labeled "F"?

**Step 1** Measure the "face to face" distance between the two pipes.

![Diagram showing "face to face" measurement]

**Step 2** Find the take out for a 3/4" factory made ell from the chart found in Step 2 of the example problem (4 pages before).

Take Out for 3/4" factory made ell = ?

**Step 3** Find the Offset

Face to Face - 2(Take Outs) = Offset

? = Offset

**Step 4** Find the Run

Multiply the Csc 45° (or 1.4142) x the Offset = Run

1.4142 x ? = Run

? = Run

**Step 5** Find the cut length of pipe to connect the pipes.

Run - 2 Take Outs - 2 Welder's Gaps = Cut Length

" - 2 (1/8"") = Cut Length

" - 2/8" = Cut Length

" - .25" = Cut Length

? = Cut Length
4. How long is the cut length of the connecting pipe between the yellow 1 1/2" pipes labeled "G" and "H"?

Step 1  Measure the "face to face" distance between the two pipes.

Step 2  Find the take out for 1 1/2" factory made ell from the chart found in Step 2 of the example problem (chart on page 1).

Take Out for 1 1/2" factory made ell = ? "

Step 3  Find the Offset

Face to Face - 2(Take Outs) = Offset

\[ ? = \text{Offset} \]

Step 4  Find the Run

Multiply the Csc 45 (or 1.4142) x the Offset = Run

\[ 1.4142 \times ? = \text{Run} \]

Step 5  Find the cut length of pipe to connect the pipes.

Run - 2 Take Outs - 2 Welder's Gaps = Cut Length

" - 2 ( ) - 2 (1/8") = Cut Length

" - - 2/8" = Cut Length

" - - .25" = Cut Length

? = Cut Length
Answers

1. How long is the cut length of the connecting pipe between the two blue, 2" pipes labeled "A" and "C"?

Step 1  Measure the "face to face" distance between the two pipes.

\[
\text{face to face} = 18.625''
\]

Step 2  Find the take out for a 2" factory made ell from the chart found in Step 2 of the example problem (2 pages before).

Take Out for a 2" factory made ell = 1.375''

Step 3  Find the Offset

\[
\begin{align*}
\text{Face to Face} &- 2(\text{Take Outs}) = \text{Offset} \\
18.625'' &- 2(1.375'') = \text{Offset} \\
18.625'' &- 2.75'' = \text{Offset} \\
15.875'' & = \text{Offset}
\end{align*}
\]

Step 4  Find the Run

\[
\text{Multiply the Csc 45° (or 1.4142) x the Offset = Run} \\
1.4142 \times 15.875'' = \text{Run} \\
22.45'' = \text{Run}
\]

Step 5  Find the cut length of pipe to connect the pipes.

\[
\begin{align*}
\text{Run} &- 2 \text{ Take Outs} - 2 \text{ Welder's Gaps} = \text{Cut Length} \\
22.45'' &- 2 (1.375'') - 2 (1/8'') = \text{Cut Length} \\
22.45'' &- 2.75'' - 2/8'' = \text{Cut Length} \\
22.45'' &- 2.75'' - .25'' = \text{Cut Length} \\
19.45'' & = \text{Cut Length}
\end{align*}
\]
2. How long is the cut length of the connecting pipe between the two orange 3/4" pipes labeled "D" and "E"?

Step 1  Measure the "face to face" distance between the two pipes.

\[ \frac{f_{\text{Face 1}}}{f_{\text{Face 2}}} = 13\frac{3}{4}'' \]
\[ c = 13.75'' \]

Step 2  Find the take out for a 3/4" factory made ell from the chart found in Step 2 of the example problem (3 pages before).

Take Out for 3/4" factory made ell = 1.4375''

Step 3  Find the Offset

Face to Face  - 2(Take Outs) = Offset
13.75''  - 2(1.4375'') = Offset
13.75''  - .875''  = Offset
12.875'' = Offset

Step 4  Find the Run

Multiply the Csc 45° (or 1.4142) x the Offset = Run
1.4142 x 12.875'' = Run
18.21'' = Run

Step 5  Find the cut length of pipe to connect the pipes.

Run  - 2 Take Outs  - 2 Welder’s Gaps = Cut Length
18.21'' - 2 (1.4375'') - 2 (1/8'') = Cut Length
18.21'' - .75'' - 2/8'' = Cut Length
18.21'' - .75'' - .25'' = Cut Length
17.55'' = Cut Length
3. How long is the cut length of the connecting pipe between the orange 3/4" pipe labeled "D" and the green 3/4" pipe labeled "F"?

Step 1 Measure the "face to face" distance between the two pipes.

Step 2 Find the take out for a 3/4" factory made ell from the chart found in Step 2 of the example problem (3 pages before).

Take Out for 3/4" factory made ell = .4375"

Step 3 Find the Offset

Face to Face - 2(Take Outs) = Offset

10.875" - 2(.4375") = Offset

10.875" - .875" = Offset

10" = Offset

Step 4 Find the Run

Multiply the Csc 45° (or 1.4142) x the Offset = Run

1.4142 x 10" = Run

14.142" = Run

Step 5 Find the cut length of pipe to connect the pipes.

Run - 2 Take Outs - 2 Welder's Gaps = Cut Length

14.142" - 2 (.4375") - 2 (.125" or 1/8") = Cut Length

14.142" - .875" - 2/8" = Cut Length

14.142" - .575" - .25" = Cut Length

13.017" = Cut Length
4. How long is the cut length of the connecting pipe between the yellow 1 1/2" pipes labeled "G" and "H"?

Step 1  Measure the "face to face" distance between the two pipes.

\[
\text{Face to Face} = 24.14'' \\
\text{or} \quad 24.25''
\]

Step 2  Find the take out for 1 1/2" factory made ell from the chart found in Step 2 of the example problem (4 pages before).

Take Out for 1 1/2" factory made ell = 1.125"

Step 3  Find the Offset

\[
\text{Face to Face} - 2(\text{Take Outs}) = \text{Offset} \\
24.25'' - 2(1.125'') = \text{Offset} \\
24.25'' - 225'' = \text{Offset} \\
22'' = \text{Offset}
\]

Step 4  Find the Run

\[
\text{Multiply the Csc 45 (or 1.4142) x the Offset} = \text{Run} \\
1.4142 \times 22'' = \text{Run} \\
31.1124'' = \text{Run}
\]

Step 5  Find the cut length of pipe to connect the pipes.

\[
\text{Run} - 2 \text{ Take Outs} - 2 \text{ Welder's Gaps} = \text{Cut Length} \\
31.1'' - 2(1.125'') - 2(1/8'') = \text{Cut Length} \\
31.1'' - 2.25'' - 2/8'' = \text{Cut Length} \\
31.1'' - 2.25'' - .25'' = \text{Cut Length} \\
28.61'' = \text{Cut Length}
\]
These instructional materials were made possible through a National Workplace Literacy Grant funded through the U.S. Department of Education from November 1, 1992, to December 31, 1993, at the training center of the Pelican Chapter of Associated Builders and Contractors in Baton Rouge, Louisiana. The public/private partnership involved in the project included the East Baton Rouge Parish Schools Adult and Continuing Education Department and the Greater Baton Rouge Chamber of Commerce. The contents do not necessarily represent the policy of the Department of Education, and you should not assume endorsement by the Federal Government.

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Pipefitter Vocabulary

Many of the vocabulary words pipefitters use are listed on pages 1 - 4. Practice using these words in the exercises beginning on page 5.

Center Line - The line that is equal distant from all sides of a pipe that is in the middle of a pipe. A center line goes along the very middle of a pipe. (To know where to find the center line, we could think of it as in a baked pie, it is the point where someone would first place a knife in order to cut out a piece of pie.)

Cut Length - Is the length of the pipe needed to connect two pipes together (it does not include the take outs or welder's gaps included in the face to face distance between the pipes to be connected).
Elbows

There are three types of elbows used in pipefitting.

**Butt Weld Elbows** - Made of metal, a butt weld elbow can be cut and rebeveled to any angle that is needed. It is used to connect metal pipes. A butt weld elbow is a "welder's gap" away from the pipe it is connected to. Large metal pipes used in the petrochemical industry are welded together with butt weld elbows. These are often written as b.w. ells.

![Butt Weld Elbow Diagram]

**Screwed Elbows** - These elbows are attached to a pipe by threads. The pipe which has male threads, is screwed into the elbow, which has female threads. The elbows are factory made, with the female threads already in place. The male threads on the pipe are cut into the pipe at the job site, using a threading machine.

![Screwed Elbow Diagram]

**Socket Weld Elbows** - A socket weld elbow has a hole, called a socket, cut into the faces of the elbow. The socket is a little larger than the outer diameter of the pipe. The pipe is put inside the socket of the fitting, pulled back 1/16", then tacked. After the fit is complete, a welder welds the pipe into the socket if it is made of metal.

![Socket Weld Elbow Diagram]
Factory Cut or Field Cut Elbows - When you work with 45° Butt Weld elbows, you must first decide if the elbow has been made either in a factory or by an individual on the job. Usually a factory made ell has stamped on the outside of the ell, "made by ____." If it is made by someone outside of a factory, it is called a "field cut" (someone made it in the field). How an ell is made will help you to know its correct size. Not all ells are made the same size. Generally, factory cut and field cut elbows have not been made with the same dimensions.

Face to Face - The distance between two pipes that are to be connected.

Offset - It is the distance between the center lines of two pipes. Usually it is a combination of two ells and a cut length of pipe that moves a line of pipe to a new position. When you are connecting two pipes that are level to the ground, it is called a simple offset. Most pipes in the industrial plants are laid in north/south or east/west directions. What you must do is figure the distance between the two pipes you want to connect.
**Run** - The path that a pipe takes to get from one center line to another center line.

**Take Out** - The take out of a fitting is the distance that a fitting extends the center line of a run of pipe past the end of the pipe.

**Welder's Gap** - The space between a fitting and the pipe that is filled by a weld. It is the distance a welder leaves between a pipe and an elbow. The width of the gap is how much space a welder needs to make a good weld. It is best to ask the welder how wide a gap he/she wants before making any calculations. A common welder's gap is 3/32" or 1/4".
In the following problems what pipefitter vocabulary word best fits each problem?
Number a blank sheet of paper 1 - 15. Write down the pipefitter vocabulary word that is described in each problem. Answers can be found on page 7.

1. Jack must find out how long a piece of pipe he needs to connect two lines of pipe. The name of the connecting length of pipe is ________________.

2. Pam wondered what the middle point within a pipe is called? It is the ____________________________.

3. Ronnie worked with a welder who liked him to leave 3/32" for his weld between a butt weld elbow and a pipe. This 3/32" is called a ____________________________.

4. Winton makes his butt weld elbows at his job site. When a butt weld elbow is made at the job site it is called a ____________________________ elbow.

5. Jessie found the distance between the center lines of two pipes was 12". This distance is called ____________________________.

6. Jeff wanted to find out how much length an elbow added to the center line of a run of pipe past the face of the pipe. Jeff was trying to find the ____________________________.
7. Jean noticed the elbows she was to use on a run had been threaded. This type of elbow is called a __________________________ elbow.

Should the pipe connected with these elbows need to be threaded? _____

8. Lee picked up an elbow that had "made by Fisher" stamped on it. This type of elbow is called a __________________________ elbow.

In the diagram below use the vocabulary words found on pages 1 - 4 to label each part.

9. __________________

10. __________________

11. __________________

12. __________________

13. __________________

14. __________________
Answers

1. Cut Length
2. Center Line
3. Welder's Gap
4. Field Cut
5. Run
6. Take Out
7. Screwed, Yes
8. Factory Cut
9. Center Line
10. Face to Face
11. Take Out
12. Offset
13. Cut Length
14. Run

Face
Basic Trig for Pipefitters

Associated Builders & Contractors, Inc.
EBR Adult & Continuing Education
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Basic Trigonometry for Pipefitters

Trigonometry sounds hard. It isn't. It helps a pipefitter to do two things in order to figure how to connect two lines of pipe to complete a run.

1. A pipefitter must be able to "see" a right triangle in an elbow.

2. Determine the lengths of the sides of the triangle to find an elbow's "take out." This information will be used to figure out the cut length of the connecting pipe.

Seeing Right Triangles in Elbows

A right triangle has three sides and three angles. One angle is $90^\circ$ (it looks like a corner of a box). Which of the triangles below are right triangles?

A. 

B. 

C. 

D. 

E. 

F.
All the triangles (A, B, C, D, E, and F) were right triangles. They all had one angle that was 90°. The size of the other two angles doesn't matter.

Which of the triangles below are right triangles? (Remember, a right triangle must have one angle that is 90°.)

A.  

B.  

C.  

D.  

E.  

F.  
The triangles on page 2 that were right triangles were A, D, and F. They each had a 90° angle. Triangles B, C, and E were not right triangles because they did not have a 90° angle.

Look at the pictures of pipe elbows below and "see" how the right triangles have been drawn in them.

A. This is a 90° elbow.

B. This is a 45° elbow.

C. This is a 37° elbow.
On another sheet of paper draw pictures of four different sizes of pipe elbows. Can you "find" the right triangles in them? Good luck.

Different sides of a triangle have special names. These names are:

- hypotenuse
- adjacent
- opposite

In the elbow pictured below which side of the triangle is the:
- hypotenuse
- adjacent side
- opposite side

Answer: A = hypotenuse; B = adjacent; C = opposite
The "adjacent legs" of a right triangle are made up by the lines that come from the vertex of the elbow's angle which extend to the center lines of the pipe faces. This is also the radius of the elbow.

The hypotenuse is created by a line that divides the angle of the elbow. The hypotenuse ends at the point where the center lines of the elbow meet.

The drawings below show the adjacent sides are equal to the radius. The opposite sides are equal to the "take out" of an elbow.
Finding Take Outs

In the elbow below you know the following:

1. The angle (it is always half the angle of the elbow because its divided it in half), and

2. The size of the adjacent side (it is the same as the radius).

You do not know:

1. The length of the opposite side (which is also the take out of the elbow).

To find the opposite side, first "see" the right triangle in the elbow, then plug in what you know into this formula:

\[
\text{opposite} = \tan \theta \times \text{adjacent}
\]

Let's look at this formula in a different way. Use the diagram above to review what you know: the opposite side is the take out of the ell, so we can replace take out with opposite.

\[
\text{take out of elbow} = \tan \theta \times \text{adjacent}
\]

Next, we also know that the adjacent side of a right triangle is equal to the radius of the elbow.

\[
\text{take out of elbow} = \tan \theta \times \text{radius of ell}
\]

We know, too, that the angle of the triangle is equal to \(\frac{1}{2}\) the angle of the elbow:

\[
\text{take out of elbow} = \tan \frac{\theta}{2} \times \text{radius of ell}
\]
In the elbow below use the take out formula to find take out:

\[
\text{take out} = \tan \frac{\theta}{2} \times \text{radius of ell}
\]

\[
\text{Take out} = 0.4142 \times 9''
\]

\[
\text{take out} = 3.7278''
\]

Radius = 9''
\[
\tan \frac{\theta}{2} = 0.4142
\]

Take out is the length of pipe the elbow (ell) adds to a pipe offset. It is the distance an ell extends the center line of a run of pipe past the end of the pipe. To connect Pipe "A" to Pipe "B" in the example below, "take out" or how much length the elbows (ells) add to the length of a run of pipe, in order to connect these pipes together.

Below are some examples of take outs. Look at how much length a take out adds to a run of pipe. Different angles of elbows have different take outs.
### Tangent Values

In order to figure **take outs** you must be able to find the Tangent (Tan) of an angle. Use the chart below to find these Tangents:

\[
\begin{align*}
45^\circ & \text{ Tan } = 1.0000 \\
22.5^\circ & \text{ Tan } = 0.4142 \\
56^\circ & \text{ Tan } = 1.067 \\
\end{align*}
\]

To read this chart:

- If the degree of the angle is less than 45°: find the degree listed in the far left column marked "Deg" then find its Tan θ (5th column from left).
- If the degree is greater than 45°: read the degree in the far right column then go to the Tan θ column (5th column from the right labeled Tan θ on the bottom of the chart).

To find the Tan of an angle let us look at the chart below:

<table>
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<tr>
<th>Deg</th>
<th>Radian</th>
<th>Sin θ</th>
<th>Cos θ</th>
<th>Tan θ</th>
<th>Cot θ</th>
<th>Sec θ</th>
<th>Csc θ</th>
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Take Out Exercises

Now let's try some problems to find take outs by using the Tan θ and radius. Use the chart of page 8 to find Tan. Again, the formula for take out is:*

\[ \text{take out} = \text{Tan} \frac{\theta}{2} \times \text{radius of the ell} \]

**Examples**

1. Find the take out when the angle of the Tan is 35° and the radius is 24".

\[ \begin{align*}
\text{take out} & = \frac{\text{Tan 35°}}{2} \times 24" \\
& = \text{Tan 55°} \times 12" \\
& = \text{Tan 27.5°} \times 12" \\
& = 0.5206 \times 12" \\
& = 6.2472"
\end{align*} \]

2. Find the take out when the angle of the Tan is 75° and the radius is 10".

\[ \begin{align*}
\text{take out} & = \frac{\text{Tan 75°}}{2} \times 10" \\
& = \text{Tan 37.5°} \times 10" \\
& = 0.7673 \times 10" \\
& = 7.673"
\end{align*} \]

*Please note: Do not use \( \frac{\text{Tan } \theta}{2} \) as a substitute for \( \frac{\text{Tan } \theta}{2} \). In other words, don't take the tangent of the whole angle and divide it by 2. Divide the angle by 2, and then get the tangent of the half angle. It makes a difference.
Exercises

1. Find the **take out** when the angle of the Tan is 80° and the radius is 25".

   \[
   \text{take out} = \frac{\tan 80^\circ}{2} \times \text{radius of the ell}
   \]

   \[
   \text{take out} = \tan 80^\circ \times 25"
   \]

   \[
   \text{take out} = \frac{\tan ?^\circ}{2} \times \text{radius of the ell}
   \]

   \[
   \text{take out} = 0.2 \times 25"
   \]

   \[
   \text{take out} = ?" 
   \]

2. Find the **take out** for a 45° ell with an 8" radius.

   \[
   \text{take out} = \frac{\tan 45^\circ}{2} \times \text{radius of the ell}
   \]

   \[
   \text{take out} = \tan 45^\circ \times 8"
   \]

   \[
   \text{take out} = \frac{\tan ?^\circ}{2} \times \text{radius of the ell}
   \]

   \[
   \text{take out} = 0.2 \times 8"
   \]

   \[
   \text{take out} = ?" 
   \]

3. Find the **take out** for the elbow shown below:

   \[
   \text{take out} = \frac{\tan \theta}{2} \times \text{radius}
   \]

   \[
   \text{take out} = \tan 45^\circ \times 1"
   \]

   \[
   \text{take out} = \frac{\tan ?^\circ}{2} \times \text{radius}
   \]

   \[
   \text{take out} = ? \times 1"
   \]

   \[
   \text{take out} = ?"
   \]
4. Find the **take out** for the elbow shown below:

\[
\text{take out} = \frac{\tan \theta}{2} \times \text{radius}
\]

\[
\text{take out} = \frac{\tan 65^\circ}{2} \times 25''
\]

\[
\text{take out} = \frac{\tan ?^\circ}{2} \times 25''
\]

\[
\text{take out} = ?''
\]

5. Find the **take out** for the elbow shown below:

\[
\text{take out} = \frac{\tan \theta}{2} \times \text{radius}
\]

\[
\text{take out} = \frac{\tan ?^\circ}{2} \times ?''
\]

\[
\text{take out} = \frac{\tan ?^\circ}{2} \times ?''
\]

\[
\text{take out} = ?''
\]

6. Find the **take out** for the elbow shown below:

\[
\text{take out} = \frac{\tan \theta}{2} \times \text{radius}
\]

\[
\text{take out} = \frac{\tan ?^\circ}{2} \times ?''
\]

\[
\text{take out} = \frac{\tan ?^\circ}{2} \times ?''
\]

\[
\text{take out} = ?''
\]

If you would more practice on finding takeouts, go to the TDC notebook entitled **Reading and Solving Pipefitter Takeout Problems**.
Answers to Exercises

1. Find the take out when the angle of the Tan is 80° and the radius is 25".

\[ \text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell} \]

\[ \text{take out} = \frac{\tan 80°}{2} \times 25" \]
\[ \text{take out} = \frac{\tan 40°}{2} \times 25" \]
\[ \text{take out} = 0.8391 \times 25" \]
\[ \text{take out} = 20.9775" \]

2. Find the take out for a 45° ell with an 8" radius.

\[ \text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell} \]

\[ \text{take out} = \frac{\tan 45°}{2} \times 8" \]
\[ \text{take out} = \frac{\tan 22.5°}{2} \times 8" \]
\[ \text{take out} = 0.4142 \times 8" \]
\[ \text{take out} = 3.3136" \]

3. Find the take out for the elbow shown below:

\[ \text{take out} = \frac{\tan \theta}{2} \times \text{radius} \]

\[ \text{take out} = \frac{\tan 45°}{2} \times 14" \]
\[ \text{take out} = \frac{\tan 22.5°}{2} \times 14" \]
\[ \text{take out} = 0.4142 \times 14" \]
\[ \text{take out} = 5.7988" \]
4. Find the take out for the elbow shown below:

\[ \text{take out} = \frac{\tan \theta}{2} \times \text{radius} \]

\[ \text{take out} = \frac{\tan 65^\circ}{2} \times 25'' \]

\[ \text{take out} = \frac{\tan 32.5^\circ}{2} \times 25'' \]

\[ \text{take out} = 0.6371 \times 25'' \]

\[ \text{take out} = 15.9275'' \]

5. Find the take out for the elbow shown below:

\[ \text{take out} = \frac{\tan \theta}{2} \times \text{radius} \]

\[ \text{take out} = \frac{\tan 75^\circ}{2} \times 20'' \]

\[ \text{take out} = \frac{\tan 37.5^\circ}{2} \times 20'' \]

\[ \text{take out} = 0.7673 \times 20'' \]

\[ \text{take out} = 15.346'' \]

6. Find the take out for the elbow shown below:

\[ \text{take out} = \frac{\tan \theta}{2} \times \text{radius} \]

\[ \text{take out} = \frac{\tan 50^\circ}{2} \times 15'' \]

\[ \text{take out} = \frac{\tan 25^\circ}{2} \times 15'' \]

\[ \text{take out} = 0.4663 \times 15'' \]

\[ \text{take out} = 6.9945'' \]
Reading & Solving Pipefitter Takeout Problems
These instructional materials were made possible through a National Workplace Literacy Grant funded through the U.S. Department of Education from November 1, 1992, to December 31, 1993, at the training center of the Pelican Chapter of Associated Builders and Contractors in Baton Rouge, Louisiana. The public/private partnership involved in the project included the East Baton Rouge Parish Schools Adult and Continuing Education Department and the Greater Baton Rouge Chamber of Commerce. The contents do not necessarily represent the policy of the Department of Education, and you should not assume endorsement by the Federal Government.

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**Finding Take Outs**

**Take Out** is the length of pipe the elbow (ell) adds to a pipe offset. It is the distance an ell extends the center line of a run of pipe past the end of the pipe.

To connect Pipe "A" to Pipe "B" in the example below, you first need to find the "take out" or how much length the elbows (ells) add in order to connect these pipes together.

Below are some examples of take outs. Look at how much length a take out adds to a run of pipe. Different angles of ell have different take outs.
Finding 90° Ell Take Outs

In order to find the length of pipe needed to connect two pipes, we must first identify how much of the offset is taken up by the ells. This distance is called take out and is equal to 1½ times the nominal pipe size in a 90° ell.\(^1\) The radius and take out of a 90° ell are equal.

ex. pipe size = 4"

radius of a 4" 90° ell = 4" x 1½ = 6"

Exercises

1. When using a 90° butt weld ell, if the pipe size is 8", what is the take out?
   (Remember, the Take Out of a fitting is the distance that a fitting extends the center line of a run of pipe past the end of the pipe.)

   ex. Nominal Pipe Size = 8"

   Radius of an 8" pipe = 1½ x 8" = 12"

   If radius = take out

   What is take out of a 90° butt weld of an 8" pipe? = (12")

2. When using a 90° butt weld ell, if the pipe size is 12", what is the take out?

   ex. Nominal Pipe Size = 12"

   Radius of an 12" pipe = 1½ x 12" = 18"

   If radius = take out

   What is take out of a 90° butt weld of an 12" pipe? (18")

\(^1\)Nominal pipe size (NPS) is the size we call the pipe, not to be confused with the actual size of the pipe.
3. When using a 90° butt weld ell, if the pipe size is 3", what is the take out?
   ex. Nominal Pipe Size = 3"
   Radius of an 3" pipe = 1 1/2 x 3"
   If radius = take out
   What is the take out of a 90° butt weld of an 3" pipe? (4 1/2")

4. When using a 90° butt weld ell, if the pipe size is 14", what is the take out?
   ex. Nominal Pipe Size = 14"
   Radius of an 14" pipe = 1 1/2 x 14"
   If radius = take out
   What is take out of a 90° butt weld of an 14" pipe? (21")

5. In a 90° butt weld ell, what is the take out if you have a factory made 10" pipe?
   ex. Nominal Pipe Size = 10"
   Radius =
   take out =

6. In a 90° butt weld ell, what is the take out if you make a 24" pipe?
   ex. Pipe Size = 24"
   Radius =
   take out =

7. In a 90° butt weld ell, what is the take out if you have a factory made 6" pipe?
   ex. Nominal Pipe Size = 6"
   Radius =
   take out =
8. In a 90° butt weld ell, what is the take out if you have a 3" pipe?

Ex. Pipe Size = 3"

Radius =

take out =

Answers
5. take out = 15"
6. take out = 36"
7. take out = 9"
8. take out = 4½"

9. Can you think up a 90° butt weld ell problem? What size is the pipe and what will the take out be?

Ex. Pipe Size = ?"

Radius =

take out =

Now that you know how to find a take out for a 90° ell, it is time to use a formula you can use to find the take out for all ells (including 90°, 45°, 30°, etc., ells).

The formula for take out is:

\[
\text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell}
\]

(To be successful in finding take outs and to use the take out formula we recommend you use a calculator to work the multiplication of decimals.)

Let us first solve how to find a tangent of an angle (Tan \( \theta \)). To do so, we must use a trigonometry chart (found on the next page) that includes Tan \( \theta \). Read the degrees of the angle in your problem by looking at the left column marked "Deg" if the angle is between 22.5° and 45°. If the degree of the angle is between 45° and 67.5° then find it in the far right column with the word "Deg" at the bottom of the column.
To find the Tan of an angle let us look at the chart below:

<table>
<thead>
<tr>
<th>Deg</th>
<th>Radian</th>
<th>Sin θ</th>
<th>Cos θ</th>
<th>Tan θ</th>
<th>Cot θ</th>
<th>Sec θ</th>
<th>Csc θ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.000</td>
<td>0.000</td>
<td>1.000</td>
<td>0.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
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<tr>
<td>10</td>
<td>0.175</td>
<td>0.174</td>
<td>0.950</td>
<td>0.171</td>
<td>5.884</td>
<td>1.064</td>
<td>0.735</td>
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<tr>
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<td>0.262</td>
<td>0.259</td>
<td>0.906</td>
<td>0.272</td>
<td>3.650</td>
<td>1.017</td>
<td>0.738</td>
</tr>
<tr>
<td>20</td>
<td>0.349</td>
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<td>0.839</td>
<td>0.292</td>
<td>3.407</td>
<td>1.005</td>
<td>0.730</td>
</tr>
<tr>
<td>25</td>
<td>0.432</td>
<td>0.412</td>
<td>0.766</td>
<td>0.330</td>
<td>3.020</td>
<td>1.000</td>
<td>0.717</td>
</tr>
<tr>
<td>30</td>
<td>0.524</td>
<td>0.500</td>
<td>0.643</td>
<td>0.383</td>
<td>2.572</td>
<td>0.999</td>
<td>0.707</td>
</tr>
<tr>
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<td>0.518</td>
<td>0.450</td>
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<td>0.989</td>
<td>0.699</td>
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<td>40</td>
<td>0.707</td>
<td>0.694</td>
<td>0.383</td>
<td>0.531</td>
<td>1.975</td>
<td>0.979</td>
<td>0.691</td>
</tr>
<tr>
<td>45</td>
<td>0.800</td>
<td>0.800</td>
<td>0.000</td>
<td>1.000</td>
<td>0.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Find the degree of the angle and then look under that TAN θ.
If the degree of the angle is less than 45°:
find the degree listed in the far left column marked "Deg" then find its Tan θ
(5th column from left).
If the degree is greater than 45°:
read the degree in the far right column then go to the Tan θ column (5th
column from the right labeled Tan θ): (5° below the bottom of the chart).

Here are three correct answers from the chart above.

45° Tan is 1.0000
22.5° Tan is 0.4142
67.5° Tan is 2.4142

\[ \tan(45°) = 1.0000 \]
\[ \tan(22.5°) = 0.4142 \]
\[ \tan(67.5°) = 2.4142 \]
Find the Tangents (Tan θ) for the following angles by using the chart on the page before:

1. 37.5° Tan is ______

2. 43.5° Tan is ______

3. 48° Tan is ______

4. 57.5° Tan is ______

5. 65.5° Tan is ______

Make up your own problems:

6. ______

7. ______

8. ______

Answers:
1. 0.7673
2. 0.9490
3. 1.1106
4. 1.5697
5. 2.1943
Now let's try some problems that find take outs and by using the Tan $\theta$ and radius. The formula for take out is:

$$\text{take out} = \tan \frac{\theta}{2} \times \text{radius of the ell}$$

Please note: Do not use $\tan \frac{\theta}{2}$ as a substitute for $\tan \theta$. In other words, don't take the tangent of the whole angle and divide it by 2. Divide the angle by 2, and then get the tangent of the half angle. It makes a difference.

Exercises

1. Find the take out when the angle of the Tan is 45° and the radius is 24".

$$\text{take out} = \tan \frac{45^\circ}{2} \times 24"$$

$$\text{take out} = 0.4142 \times 24"$$

$$\text{take out} = 9.94"$$

2. Find the take out when the angle of the Tan is 60° and the radius is 8'.

$$\text{take out} = \tan \frac{60^\circ}{2} \times 8'$$

$$\text{take out} = 0.5774 \times 8'$$

$$\text{take out} = 4.6192'$$
3. Find the **take out** when the angle of the Tan is 75° and the radius is 36".

\[
\text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell}
\]

\[
\begin{align*}
\text{take out} &= \tan 75^\circ \times 36" \\
\text{take out} &= \tan 37.5^\circ \times 36" \\
\text{take out} &= 0.7673 \times 36" \\
\text{take out} &= 27.6228"
\end{align*}
\]

4. Find the **take out** for a 6" 45° ell".

\[
\text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell}
\]

(Remember: the radius of a 6" ell is 1\(\frac{1}{2}\) x NPS or 1\(\frac{1}{2}\) x 6"

\[
\begin{align*}
\text{take out} &= \tan 45^\circ \times 9" \\
\text{take out} &= \tan 22.5^\circ \times 9" \\
\text{take out} &= 0.4142 \times 9" \\
\text{take out} &= 3.7278"
\end{align*}
\]

5. Find the **take out** for a 16" 50° ell".

\[
\text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell}
\]

(Remember: the radius of a 16" ell is 1\(\frac{1}{2}\) x NPS or 1\(\frac{1}{2}\) x 16"

\[
\begin{align*}
\text{take out} &= \tan 50^\circ \times 24" \\
\text{take out} &= \tan 25^\circ \times 24" \\
\text{take out} &= 0.4663 \times 24" \\
\text{take out} &= 11.1912"
\end{align*}
\]
6. Find the take out for a 10" 45° ell".

\[ \text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell} \]

(Remember: the radius of a 10" ell is 1\(\frac{1}{2}\) x NPS)

\[
\begin{align*}
\text{take out} &= \frac{\tan 45^\circ}{2} \times \quad \text{"} \\
\text{take out} &= \frac{\tan \qquad^\circ}{2} \times \quad \text{"} \\
\text{take out} &= \quad \times \quad \text{"} \\
\text{take out} &= \quad \text{"}
\end{align*}
\]

7. Find the take out for a 18" 70° ell".

\[ \text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell} \]

(Remember: the radius of an 18" ell is 1\(\frac{1}{2}\) x NPS)

\[
\begin{align*}
\text{take out} &= \frac{\tan 70^\circ}{2} \times \quad \text{"} \\
\text{take out} &= \frac{\tan \qquad^\circ}{2} \times \quad \text{"} \\
\text{take out} &= \quad \times \quad \text{"} \\
\text{take out} &= \quad \text{"}
\end{align*}
\]

8. Find the take out for a 48" 68° ell".

\[ \text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell} \]

\[
\begin{align*}
\text{take out} &= \frac{\tan 68^\circ}{2} \times \quad \text{"} \\
\text{take out} &= \frac{\tan \qquad^\circ}{2} \times \quad \text{"} \\
\text{take out} &= \quad \times \quad \text{"} \\
\text{take out} &= \quad \text{"}
\end{align*}
\]
6. Find the take out for a 10" 45° ell".

\[ \text{take out} = \frac{\tan 45°}{2} \times \text{radius of the ell} \]

(Remember: the radius of a 10" ell is 1\(\frac{1}{2}\) x NPS)

\[ \text{take out} = \tan 45° \times 15" \]
\[ \text{take out} = \tan 22.5° \times 15" \]
\[ \text{take out} = 0.4142 \times 15" \]
\[ \text{take out} = 6.213" \]

7. Find the take out for a 18" 70° ell".

\[ \text{take out} = \frac{\tan 70°}{2} \times \text{radius of the ell} \]

(Remember: the radius of an 18" ell is 1\(\frac{1}{2}\) x NPS)

\[ \text{take out} = \tan 70° \times 27" \]
\[ \text{take out} = \tan 35° \times 27" \]
\[ \text{take out} = 0.7002 \times 27" \]
\[ \text{take out} = 18.9054" \]

8. Find the take out for a 48" 68° ell".

\[ \text{take out} = \frac{\tan 68°}{2} \times \text{radius of the ell} \]

\[ \text{take out} = \tan 68° \times 72" \]
\[ \text{take out} = \tan 34° \times 72" \]
\[ \text{take out} = 0.6745 \times 72" \]
\[ \text{take out} = 48.5640" \]
Some pipefitters like to use The Pipe Fitters Blue Book by W. V. Graves to help them find the Tan θ. This book fits into your pocket and is more accurate because it gives you the tangent to the 1/100,000 or one hundred thousands. Below is a page from the book that shows you all the Tangents for 30°. The column on the far left is the minutes (there are 60 minutes to each degree.) To help you read a Tan θ from this chart, go to the 4th column from the left labeled, "Tan".

### Examples:

**Tan 30°** = 0.57735

**Tan 30°30'** = 0.568904

**Tan 30°40'** = 0.59297

**Tan 30°59'** = 0.60046

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<td>0.9915</td>
<td>0.1734</td>
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<tr>
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### Chart for 59°

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</table>
To read this same page which has a 30° at the top center but for the Tan Θ for 59°, you would read it from the bottom up. The 4th column from the right side labeled at the bottom "Tan" is how you read the tangents for 59°. Find these examples for 59°.

### Examples:

- **Tan 59°**
  \[ \tan 59° = 1.6643 \]

- **Tan 59°30**
  \[ \tan 59°30 = 1.6977 \]

- **Tan 59°40**
  \[ \tan 59°40 = 1.7090 \]

- **Tan 59°59**
  \[ \tan 59°59 = 1.7309 \]

### Exercises

Using the page from *The Pipe Fitters Blue Book* shown above that shows the Tan for 30° (fourth column from the left read down the page) and the Tan for 59° (fourth column from the right read up the page), do the following word problems.

Example:

Find the take out when the angle of the Tan is 60°20 and the radius is 16".

\[
\begin{align*}
\text{take out} & = \frac{\tan 60°20}{2} \\
\text{take out} & = \frac{\tan 60°20 \times 16"}{2} \\
\text{take out} & = \text{Tan 30°10} \times 16" \\
\text{take out} & = 0.58123 \times 16" \\
\text{take out} & = 9.29968" 
\end{align*}
\]
In the problems below use a copy of page 160 from The Pipefitters Blue Book found on page 12.

1. Find the take out when the angle of the Tan is 60°44 and the radius is 28".

\[
\text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell}
\]

\[
\text{take out} = \frac{\tan 60°44}{2} \times 28"
\]

\[
\text{take out} = \tan \_\_\_\_ \times 28"
\]

\[
\text{take out} = \_\_\_\_ \times 28"
\]

\[
\text{take out} = \_\_\_\_"
\]

2. Find the take out when the angle of the Tan is 60°58 and the radius is 6".

\[
\text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell}
\]

\[
\text{take out} = \frac{\tan 60°58}{2} \times 6"
\]

\[
\text{take out} = \tan \_\_\_\_ \times 6"
\]

\[
\text{take out} = \_\_\_\_ \times 6"
\]

\[
\text{take out} = \_\_\_\_"
\]

3. Find the take out for a 12" 60°38 ell.

\[
\text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell}
\]

(Remember: the radius of a 12" ell is 1 1/2 x NPS or 1 1/2 x 12")

\[
\text{take out} = \frac{\tan 60°38}{2} \times 18"
\]

\[
\text{take out} = \tan \_\_\_\_ \times 18"
\]

\[
\text{take out} = \_\_\_\_ \times 18"
\]

\[
\text{take out} = \_\_\_\_"
\]

\[
80
\]
4. Find the **take out** for a 60" 60°46 ell.

\[
\text{take out} = \tan \frac{\theta}{2} \times \text{radius of the ell}
\]

(Remember: the radius of a 60° ell is 1\(\frac{1}{2}\) x NPS or 1\(\frac{1}{2}\) x 60")

\[
\text{take out} = \tan \frac{60°46}{2} \times 90"
\]

\[
\text{take out} = \tan \frac{\theta}{2} \times 90"
\]

\[
\text{take out} = \frac{\theta}{2} \times 90"
\]

5. Find the **take out** when the angle of the Tan is 60°8 and the radius is 72".

\[
\text{take out} = \tan \frac{\theta}{2} \times \text{radius of the ell}
\]

\[
\text{take out} = \tan \frac{60°8}{2} \times 72"
\]

\[
\text{take out} = \tan \frac{\theta}{2} \times 72"
\]

\[
\text{take out} = \frac{\theta}{2} \times 72"
\]

6. Find the **take out** when the angle of the Tan is 60°12 and the radius is 96".

\[
\text{take out} = \tan \frac{\theta}{2} \times \text{radius of the ell}
\]

\[
\text{take out} = \tan \frac{60°12}{2} \times 96"
\]

\[
\text{take out} = \tan \frac{\theta}{2} \times 96"
\]

\[
\text{take out} = \frac{\theta}{2} \times 96"
\]

\[
\text{take out} = \frac{\theta}{2} \times 96"
\]
Answers

1. Find the take out when the angle of the Tan is 60°44 and the radius is 28".

\[
\text{take out} = \frac{\tan 60°44}{2} \times \text{radius of the ell}
\]

\[
\text{take out} = \frac{\tan 60°44}{2} \times 28''
\]

\[
\text{take out} = \frac{\tan 30°22}{2} \times 28''
\]

\[
\text{take out} = 0.58591 \times 28''
\]

\[
\text{take out} = 16.40548''
\]

2. Find the take out when the angle of the Tan is 60°58 and the radius is 6".

\[
\text{take out} = \frac{\tan 60°58}{2} \times \text{radius of the ell}
\]

\[
\text{take out} = \frac{\tan 60°58}{2} \times 6''
\]

\[
\text{take out} = \frac{\tan 30°29}{2} \times 6''
\]

\[
\text{take out} = 0.58865 \times 6''
\]

\[
\text{take out} = 3.5319''
\]

3. Find the take out for a 12" 60°38 ell.

\[
\text{take out} = \frac{\tan 60°38}{2} \times \text{radius of the ell}
\]

\[
\text{(Remember: the radius of a 12" ell is } 1\frac{1}{2} \times \text{NPS or } 1\frac{1}{2} \times 12"
\]

\[
\text{take out} = \frac{\tan 60°38}{2} \times 18''
\]

\[
\text{take out} = \frac{\tan 30°14}{2} \times 18''
\]

\[
\text{take out} = 0.58279 \times 18''
\]

\[
\text{take out} = 10.49022''
\]
4. Find the take out for a 60° 60°46 ell.

\[ \text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell} \]

(Remember: the radius of a 60° ell is 1\(\frac{1}{2}\) x NPS or 1\(\frac{1}{2}\) x 60")

\[ \text{take out} = \frac{\tan 60°46}{2} \times 90" \]
\[ \text{take out} = \frac{\tan 30°23}{2} \times 90" \]
\[ \text{take out} = 0.58630 \times 90" \]
\[ \text{take out} = 52.767" \]

5. Find the take out when the angle of the Tan is 60°8 and the radius is 72".

\[ \text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell} \]
\[ \text{take out} = \frac{\tan 60°8}{2} \times 72" \]
\[ \text{take out} = 0.57890 \times 72" \]
\[ \text{take out} = 41.6808" \]

6. Find the take out when the angle of the Tan is 60°12 and the radius is 96".

\[ \text{take out} = \frac{\tan \theta}{2} \times \text{radius of the ell} \]
\[ \text{take out} = \frac{\tan 60°12}{2} \times 96" \]
\[ \text{take out} = 0.57968 \times 96" \]
\[ \text{take out} = 55.64928" \]
Reading & Solving
Basic
Pipefittings
Problems
# 3

Associated Builders & Contractors, Inc.
EBR Adult & Continuing Education
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Basic Pipefitting # 3

When you need to connect two pipes and you cannot use a 45° or 90° elbow, there are four steps you must add into the steps explained in *Reading and Solving Pipefitting Problems # 2*. You can use these additional steps in all pipefitter problems if you do not know the angles of the elbows you will use or the length of the offset.

**Step 1  Find Tangent**

Let us look at the problem below which has two pipes that are at odd angles to each other. In order to connect these pipes we must "see" a triangle between these two pipes.

We must find out the length of the two sides of the triangle. One side of the triangle is labeled "a" and the other side of the triangle is labeled "b." You need to measure the length of each of these sides. Be sure when you measure that if you measure from the bottom of one pipe, you measure to the bottom of the other pipe (or the top to the top).
What is the "a" and "b" distances between the pipes below?

1. a = 14, b = 8;
2. a = 24, b = 20;

When you are in the field, you can drop a plumb line and measure it to find out the length of side "b" (in math, this is called the length of the "opposite" side of an angle).
Find the length of side "a" by measuring the distance between from the plumb line to the face of the other pipe (in math, this is called the "adjacent" side of an angle).

Use the lengths of sides "a" and side "b" to find tangent. The formula for tangent is:

\[ \text{tangent} = \frac{\text{opposite}}{\text{adjacent}} \]

Here is an example of how to find a tangent in a pipefitter's work.

\[ \text{tangent} = \frac{16 \frac{3}{4}''}{20''} = 0.8375 \text{ (tan)} = 39.95^\circ \]

= the elbow is a 40° elbow.
Step 2  Find Offset (hypotenuse)

To find the length of the offset (in math this is called the hypotenuse of the triangle) use the formula:

\[ a^2 + b^2 = c^2 \]

\[ a^2 + b^2 = c \]

\[ 16.75^2 + 20^2 = c \]

\[ 280.5625 + 400 = c \]

\[ 680.5625 = c \]

\[ c = 26.0875" \]

Step 3  Find Take Out

Next, you should find the length of the take out. Let's say you have a 6" pipe and the elbow is a 40° elbow (from step 1). Use the take out formula to find the take out.

\[ \text{Take out} = \tan \frac{\theta}{2} \times \text{radius} \]

\[ \text{Take out} = \tan 20° \times 9" \]

\[ \text{Take out} = 0.3640 \times 9" \]

\[ \text{Take out} = 3.276" \]
Step 4  Find the cut length of the connecting pipe

The formula for cut length is:

\[
\text{Cut length} = \text{Run} - 2 \times \text{Take outs} - 2 \times \text{Gaps}
\]

Gap is 1/8"

\[
\begin{align*}
\text{Cut length} &= 26.0875 - 2(3.276) - 2(0.125) \\
&= 26.0875 - 6.552 - 0.25 \\
&= 19.205"
\end{align*}
\]

Let's look at some other simple offset problems.

1. You are connecting two 4" pipes. You measure the distances between the two pipes and find side a = 23" and side b = 17." What angle do the elbows need to be and what is the size of the cut length of pipe to connect these pipes?

   **Step 1  Find tangent**

   \[
   \text{tangent} = \frac{\text{opposite}}{\text{adjacent}} = \frac{23}{17} = 1.353 = 53.5°
   \]

   = the elbow is a 53.5° elbow.

   **Step 2  Find Offset (hypotenuse)**

   To find the length of the offset (in math this is called the hypotenuse of the triangle) use your calculator with the formula below:

   \[
   a^2 + b^2 = c^2
   \]

   \[
   \begin{align*}
   23^2 + 17^2 &= c \\
   529 + 289 &= c \\
   818 &= c \\
   28.6" &= c
   \end{align*}
   \]
Right angles can also be seen in other pipe problems. See the right triangles in the 90° elbow problem below. Do you see the hypotenuse, adjacent and opposite sides of the triangle?

Can you see the right triangle in the 45° elbow problem below? Do you see the hypotenuse, adjacent and opposite sides of the triangle?

Here is another layout of a 90° pipe problem. Do you see the hypotenuse, adjacent and opposite sides of the triangle?
Test yourself. In the pipe drawings below which side is the triangle’s hypotenuse, adjacent side, and opposite side?

1.

2.

3.

Answers
1a hypotenuse 1b opposite 1c adjacent
2a opposite 2b hypotenuse 2c adjacent
3a adjacent 3b opposite 3c hypotenuse
In the triangles below practice "seeing" the right triangles. When you think you found them, turn the page and compare your answers with the ones drawn on page 5d.

1.

2.

3.

5c.
Here are the triangles found on page 5c with the triangles drawn them. Did you "see" the hypotenuse, adjacent and opposite sides of the triangle?

1.

2.

3.
Step 3  Find Take Out

The take out of a 4" pipe is

\[
\text{Take out } = \tan \frac{53.5}{2} \times \text{radius}
\]

\[
\text{Take out } = \tan 26.75^\circ \times 6"
\]

\[
\text{Take out } = 0.4987 \times 6"
\]

\[
\text{Take out } = 2.992"
\]

Step 4  Find the cut length of the connecting pipe

The formula for cut length is:

\[
\text{Cut length } = \text{Run } - 2 \text{ Take outs } - 2 \text{ Gaps}
\]

\[
\text{Cut length } = 28.6" - 2(2.992) - 2(.125)
\]

\[
\text{Cut length } = 28.6" - 5.984" - .25"
\]

\[
\text{Cut length } = 22.366" \text{ or } 1' 10\frac{3}{8}"
\]

2. You are connecting two 6" pipes. You measure the distances between the two pipes and find side a = 2' and side b = 3'. What angle do the elbows need to be and what is the size of the cut length of pipe to connect these pipes?

\[
\text{tangent } = \frac{\text{opposite}}{\text{adjacent}} = \frac{2'}{3'} = 0.6667
\]

\[
\text{adjacent}
\]

\[
\text{opposite}
\]

\[
\text{2'}a
\]

(2)
Step 1  Find tangent

tangent = \frac{\text{opposite}}{\text{adjacent}} = \frac{2}{3} = 0.6667 = 53.5^\circ

Use the Tan chart below to find the Tan

<table>
<thead>
<tr>
<th>Deg</th>
<th>Radian</th>
<th>Sin θ</th>
<th>Cos θ</th>
<th>Tan θ</th>
<th>Cot θ</th>
<th>Sec θ</th>
<th>Csc θ</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.5</td>
<td>0.3927</td>
<td>0.7329</td>
<td>0.6474</td>
<td>0.5095</td>
<td>1.9626</td>
<td>1.1781</td>
<td>1.1781</td>
</tr>
<tr>
<td>25</td>
<td>0.4014</td>
<td>0.7329</td>
<td>0.6474</td>
<td>0.5095</td>
<td>1.9626</td>
<td>1.1781</td>
<td>1.1781</td>
</tr>
<tr>
<td>27.5</td>
<td>0.4020</td>
<td>0.7329</td>
<td>0.6474</td>
<td>0.5095</td>
<td>1.9626</td>
<td>1.1781</td>
<td>1.1781</td>
</tr>
<tr>
<td>30</td>
<td>0.4044</td>
<td>0.7329</td>
<td>0.6474</td>
<td>0.5095</td>
<td>1.9626</td>
<td>1.1781</td>
<td>1.1781</td>
</tr>
<tr>
<td>32.5</td>
<td>0.4071</td>
<td>0.7329</td>
<td>0.6474</td>
<td>0.5095</td>
<td>1.9626</td>
<td>1.1781</td>
<td>1.1781</td>
</tr>
<tr>
<td>35</td>
<td>0.4097</td>
<td>0.7329</td>
<td>0.6474</td>
<td>0.5095</td>
<td>1.9626</td>
<td>1.1781</td>
<td>1.1781</td>
</tr>
<tr>
<td>37.5</td>
<td>0.4123</td>
<td>0.7329</td>
<td>0.6474</td>
<td>0.5095</td>
<td>1.9626</td>
<td>1.1781</td>
<td>1.1781</td>
</tr>
<tr>
<td>40</td>
<td>0.4149</td>
<td>0.7329</td>
<td>0.6474</td>
<td>0.5095</td>
<td>1.9626</td>
<td>1.1781</td>
<td>1.1781</td>
</tr>
<tr>
<td>42.5</td>
<td>0.4175</td>
<td>0.7329</td>
<td>0.6474</td>
<td>0.5095</td>
<td>1.9626</td>
<td>1.1781</td>
<td>1.1781</td>
</tr>
<tr>
<td>45</td>
<td>0.4201</td>
<td>0.7329</td>
<td>0.6474</td>
<td>0.5095</td>
<td>1.9626</td>
<td>1.1781</td>
<td>1.1781</td>
</tr>
</tbody>
</table>

- the elbow is a 33.5° elbow.
Step 2  Find Offset (hypotenuse)

To find the length of the offset (in math this is called the hypothenuse of the triangle) use your calculator with the formula below and change to inches (1" = 12"):

\[ a^2 + b^2 = c^2 \]

\[ 24^2 + 36^2 = c \]

\[ 256 + 1296 = c \]

\[ 1552 = c \]

Step 3  Find Take Out

The take out formula for a 6" pipe is: radius of 6" pipe is 9"

\[ \text{Take out} = \tan \frac{33.5^\circ}{2} \times \text{radius} \]

\[ \text{Take out} = \tan 16.75^\circ \times 9" \]

(Use the chart on the page before to find the tan of 16.75°)

\[ \text{Take out} = \_\_\_\_\_ \times 9" \]

\[ \text{Take out} = \_\_\_\_\_" \]
Step 4 Find the cut length of the connecting pipe

The formula for cut length is:  

\[
\text{Cut length} = \text{Run} - 2 \text{ Take outs} - 2 \text{ Gaps}
\]

<table>
<thead>
<tr>
<th>Cut length</th>
<th>Run</th>
<th>-</th>
<th>2 Take outs</th>
<th>-</th>
<th>2 Gaps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut length</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut length</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut length</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\#2 answer: 37 11/16" or 3'1 11/16"

3. You are connecting two 14" pipes. You measure the distances between the two pipes and find side a = 16' and side b = 19'. What angle do the elbows need to be and what is the size of the cut length of pipe to connect these pipes?

**Step 1 Find tangent**

\[
tangent = \frac{\text{opposite}}{\text{adjacent}} = \frac{16'}{9'} = \frac{16}{9} = \frac{160}{90} = \frac{16}{9} = \theta^o
\]

Use the Tan chart on the page 7 to find the Tan.
Step 2  Find Offset (hypotenuse)

To find the length of the offset (in math this is called the hypothenuse of the triangle) use your calculator with the formula below and change to inches (1" = 12"):

\[ a^2 + b^2 = c^2 \]

\[ \text{________} + \text{________} = \text{c} \]

\[ \text{________} + \text{________} = \text{c} \]

\[ \text{________} = \text{c} \]

Step 3  Find Take Out

The take out formula for a 14" pipe is: radius of 14" pipe is ___"

\[ \text{Take out} = \tan \frac{\text{____}^\circ}{2} \times \text{radius} \]

\[ \text{Take out} = \tan \text{____}^\circ \times \text{____}" \]

\[ \text{Take out} = \text{____} \times \text{____}" \]

\[ \text{Take out} = \text{____}" \]

Step 4  Find the cut length of the connecting pipe

The formula for cut length is: Gap is 1/8"

\[ \text{Cut length} = \text{Run} - 2 \text{Take outs} - 2 \text{Gaps} \]

\[ \text{Cut length} = \text{____}" - 2(\text{_____}) - 2(.125) \]

\[ \text{Cut length} = \text{____}" - \text{____}" - .25" \]

\[ \text{Cut length} = \text{____}" \]

#3 answers: 40"; 23' 6 5/8"
4. You are connecting two 10" pipes. You measure the distances between the two pipes and find side $a = 8'3"$ and side $b = 6'$. What angle do the elbows need to be and what is the size of the cut length of pipe to connect these pipes?

**Step 1**  
Find tangent

\[
\text{tangent} = \frac{\text{opposite}}{\text{adjacent}} = \quad = \quad = \quad \circ
\]

**Step 2**  
Find Offset (hypotenuse)

To find the length of the offset (in math this is called the hypotenuse of the triangle) use your calculator with the formula below and change to inches ($1" = 12"$):

\[
a^2 + b^2 = c^2
\]

\[
\quad + \quad = \quad
\]

\[
\quad + \quad = \quad
\]

\[
\quad = \quad
\]

**Step 3**  
Find Take Out

The take out formula for a 10" pipe is: radius of 10" pipe is __"

\[
\text{Take out} = \tan \frac{\circ}{2} \times \text{radius}
\]

\[
\text{Take out} = \tan \quad \times \quad "
\]

\[
\text{Take out} = \quad \times \quad "
\]

\[
\text{Take out} = \quad "
\]
Step 4  Find the cut length of the connecting pipe

The formula for cut length is:

\[
\text{Cut length} = \text{Run} - 2 \text{ Take outs} - 2 \text{ Gaps}
\]

\[
\text{Gap is } 1/8''
\]

\[
\text{Cut length} = \underline{\text{____}}'' - \underline{\text{2(____)}} - 2(\underline{.125})
\]

\[
\text{Cut length} = \underline{\text{____}}'' - \underline{\text{____}}'' - .25''
\]

#4 answers: 54° and 8'10 15/16''

5. You are connecting two 2" pipes. You measure the distances between the two pipes and find side a = 4'8" and side b = 7'5". What angle do the elbows need to be and what is the size of the cut length of pipe to connect these pipes?

Step 1  Find tangent

\[
\text{tangent} = \frac{\text{opposite}}{\text{adjacent}} = \underline{\text{____}} = \underline{\text{____}} = \underline{\text{____}}°
\]

Step 2  Find Offset (hypotenuse)

To find the length of the offset (in math this is called the hypotenuse of the triangle) use your calculator with the formula below and change to inches (1" = 12"):

\[
a^2 + b^2 = c^2
\]

\[
\underline{\text{_____}} + \underline{\text{_____}} = \underline{\text{c}}
\]

\[
\underline{\text{_____}} + \underline{\text{_____}} = \underline{\text{c}}
\]

\[
\underline{\text{_____}} = \underline{\text{c}}
\]
Step 3   Find Take Out

The take out formula for a 2" pipe is:

\[ \text{Take out} = \tan \frac{\theta}{2} \times \text{radius} \]

\[ \text{Take out} = \tan \theta \times \_" \]

\[ \text{Take out} = \_ \times \_" \]

\[ \text{Take out} = \_" \]

Step 4   Find the cut length of the connecting pipe

The formula for cut length is:

\[ \text{Cut length} = \text{Run} - 2 \times \text{Take outs} - 2 \times \text{Gaps} \]

\[ \text{Cut length} = \_" - 2(\_\_\_) - 2(0.125) \]

\[ \text{Cut length} = \_" - \_" - .25" \]

\[ \text{Cut length} = \_" \]

#5 answers: 32" and 8'7 1/4"