DESIGNING SPIRALS

Below is a diagram of a spiral staircase as viewed from above. **4** items of information are needed to construct a spiral staircase. In this case we will design the outer spiral.

1- The horizontal **RADIUS** or **DIAMETER** of the staircase at the railing.
2- The **TOTAL HEIGHT** of the staircase.
3- The **TOTAL ANGLE OF ARC**, in degrees, of the staircase.
4- The **DIRECTION OF RISE** of the staircase, indicates whether the direction of rise is clockwise or counter-clockwise.

NOTE: *The **RISE** and **RUN** of each step at the outside railing and the total number of steps in the staircase may replace items 2 & 3, but may not be as accurate.*

FIG.1

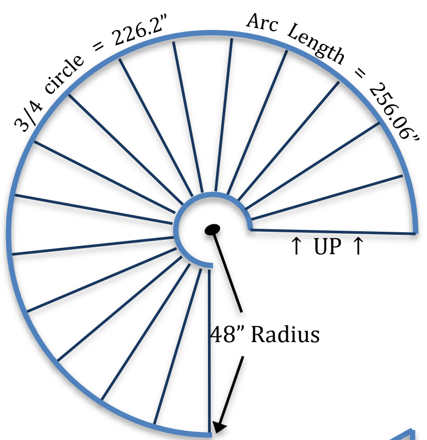
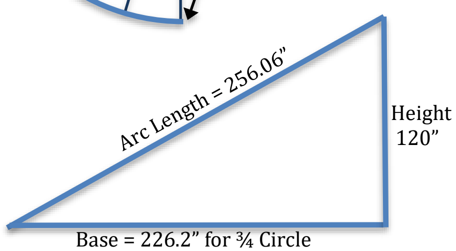


FIG. 2



In this exercise, our staircase railing will have:

1- A horizontal **Radius** of **48 inches**.
2- A **Total Height** of **120 inches**.
3- A **Total Angle** of **270 degrees.**
4- The staircase will **Rise** in a **Counter-clockwise** direction.

Continued-

The first step in determining a rolling radius is to find the **horizontal circumference** of the portion of a circle being used by the staircase, in this case **270°.**

<u>NOTE:</u> *A triangle **(FIG. 2)** best illustrates each of the following steps. The **horizontal circumference** is represented by the **Base Line** of the triangle.*

<u>Step #1 – Base Line of Triangle</u>

48” x π = 150.8”
Now **x 270°***(Degrees of Arc)* = **40715**
Then **40715 ÷180 = 226.2”.**

This is the base of our triangle. With a total height of **120”,** we will now figure the length of the hypotenuse of our triangle, which will represent the **Arc Length** of your work-piece.

<u>Step #2 – Figuring the Arc Length.</u>

120^2 + 226.2^2 = 65566.44,
Now $\sqrt{65566.44}$ **= 256.06”.**
This number represents the amount of material *(Arc Length)* required to do the project.

<u>Step #3 – Figuring the Rolling Radius.</u>

256.06” ÷ 226.2” = 1.132.
Now **1.132^2 = 1.2814**
Now **1.2814 x 48” = 61.509”**
Your rolling radius is 61.5”

<u>In Short:</u>

<u>Step #1</u>
Radius x π = ___ x Degrees of Arc = ___ ÷ 180 = <u>Base Line</u>

<u>Step #2</u>
Height^2 + Base Line^2 = $\sqrt{\_\_\_}$ = <u>Arc Length</u>

<u>Step #3</u>
Arc Length ÷ Base Line = ___^{2} x Radius = <u>Rolling Radius</u>.

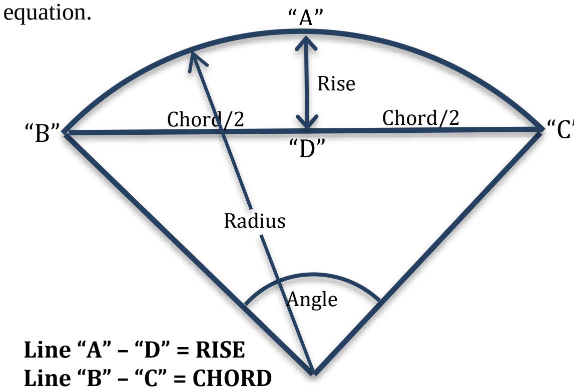
NOTE: *This method would work for any size spiral, including the **INSIDE** railing of a staircase.*

For more useful formulas, go to WWW.ARCMASTER.CA and see Working With Arcs

ARC MASTER RADIUS GAUGES

WORKING WITH ARCS

To help you gain an understanding and a working knowledge of arcs, I have devised some sample problems you are likely to encounter in the shop or at the jobsite. These are solutions to problems anyone can work out. All you need is a **Scientific Calculator** e.g. **Texas Instruments TI-30XA** or something similar, with these functions **SIN, COS, TAN, 1/X, X^2, (2nd** *or* **INV.)**, $\sqrt{\ }$ and π. Simply insert your numbers while following the instructions as they appear in the equation.



Line “A” – “D” = RISE
Line “B” – “C” = CHORD
Curve “B” – “C” = ARC LENGTH

A)- <u>In this first exercise we will determine the Arc Length of an arc, enough to make a 90° angle with a Radius of 36 inches</u>.

On your calculator punch in **36 x π***(3.14)* = you get **113.1**
Now **113.1** ÷ **180,** you get **.628.** Now **x 90** = you get **56.55”**.
The ARC LENGTH AT 90° with a 36” radius is 56.55”.

A)- <u>In Short:</u>
Radius x π = _____ ÷ 180 = _____ x Angle of the Arc = <u>ARC LENGTH.</u>

B)- <u>Here, we will determine the CHORD of an arc, if we know the RADIUS and the ARC LENGTH.</u>

Our **Radius** will be **120”** and the **Arc Length** will be 288**”.**
Punch in **120” x π** = you get **376**.99
Now **376.99** ÷ **288** = you get **1.309.**
Now hit the **1/X** key, you get **.7639**.
Now **x 180** = you get **137.51** Now divide by **2** = **68.755**
Punch **SIN** you get **.932** now **x 120”** = **111.845**
Now **111.845 x 2 =223.69”** **Your CHORD is 223.69”**

B)- <u>In Short</u>:
Radius x π = ____ ÷ Arc Length = ____ 1/X x 180 = Angle ÷ 2 = ____ SIN ____ x Radius = ____ x 2 = <u>CHORD</u>

Continued-

C)- We will now determine the RISE of an arc. If we know the RADIUS and the ARC LENGTH.

*Our **Radius** will be **300”** and the **Arc Length** will be **240”**.*

300 x π = 942.4778 Now ÷ 240 = 3.927 Now 1/x you get .2546 Now x 180 = 45.8366° Now ÷ 2 = 22.9183
Now COS -1 = .07894 Now x 300” = 23.6817”
Your Rise is 23.6817”

<u>In Short:</u>
Radius x π = __ ÷ Arc Length = __ 1/x __ x 180 = __ ÷ 2 = __ COS – 1 = Rise
(The negative number here does not matter.)
<u>This exercise is good for all ANGLES with less than 180 degrees of Arc.</u>

D)- We will now determine the CHORD of an arc. We must know the RISE and the RADIUS.

*Our **Radius** will be **96”** and the **Rise** will be **24”**.*

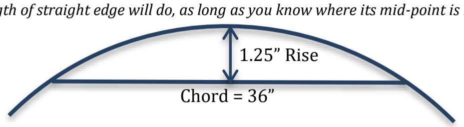
96 – 24 = 72 Now **$96^2 - 72^2$ = 4032.** Now **$\sqrt{4032}$,** you get **63.5**. Now **63.5 x 2 = 127**.
The CHORD of this arc is 127”.

<u>In Short:</u>
Radius – Rise =___ Radius^2 – Rise^2 = $\sqrt{\_\_\_}$ x 2 = CHORD.
<u>This exercise is good for all ANGLES with less than 180 degrees of Arc.</u>

E)- We will now determine the RADIUS of an arc. We must know the RISE and the CHORD.

In this exercise, the **CHORD** will be a **36”** long straight edge ruler. We will place it across an arc with both ends of the ruler touching the arc. The mid-point of the ruler in this case is at the **18”** mark. The vertical height at this point will be the **RISE** which in this case is **1.25”.**

(Any length of straight edge will do, as long as you know where its mid-point is located.)



The **RISE** is **1.25”** with the **CHORD** of **36”.**

1.25 ÷ 18*(1/2 Chord)* **=** You get **.06944**.
Punch in **2^{nd}** *or* **INV.** then **TAN x 2 =** You get **7.945°**
Now hit **SIN** then the key **1/X**, you get **7.2347**.
Now **7.2347 x 18 =** You get **130.225**.
The Radius of this arc is 130.23”.

<u>In Short:</u>
Rise ÷ (1/2 chord) =___ 2^{nd} *or* **INV., TAN x 2 =___ SIN 1/X x (1/2 chord) = Radius.**
<u>This exercise is good for all RADII with Angles less than 180 degrees of Arc.</u>

<u>BUMP-ROLLING STEEL PLATE</u>

Figuring, measuring and taking the guesswork out of adjusting the roll using the Arc Master Radius Gauge.

To bump roll steel plate on a brake, **3** variables must be known:
1- The Radius of the arc.
2- The Arc-Length or the Total Angle of the roll in degrees.
3- The spacing between each hit or bump.

<u>For our Bump-Rolling example we will use the following:</u>

Radius is **36 inches**
Arc-Length is **60 inches**
The Total Angle is 95.49°

If you only know the **Radius** and the **Arc-Length**, the **Total Angle** must be determined. See exercise **B).**

B)- { **36” x π = 113.1” ÷ 60 = 1.885**
1/X will give you **.5305**
.5305 x 180 = 95.49°*(degrees of arc).*

If you know the **Radius** and the **Total Angle**, the **Arc Length** must be determined. See exercise **A).**

A)- { **36” x π = 113.1 ÷ 180 = .628**
.628 x 95.49° = 60”*(Arc Length)*

<u>Bump-Roll Spacing:</u>
The spacing of each hit depends on the required smoothness of the arc and the size of vee*(bottom)* die you will be using for the job. For a more uniform roll the previous hit should *(where possible)* reach and **slightly pass** the edge of the vee die opening. This will ensure that the bend angle will be the same for all other hits.

For a tighter spacing between bends while using the same vee die opening:
When making the second bend, the first bend will fall **inside** the vee opening causing the angle of the second bend to **under-bend**. The angle for the second bend must then be adjusted. All further bends will have this same adjustment.

Continued-

In our sample exercise the vee die opening will be **2.5”** wide, the steel plate is **¼”** thick and our bend spacing will be **1.5”** apart. As mentioned before, the final **Radius** will be **36”** with an **Arc Length** of **60”.**

<u>NOTE:</u>
(Bend angle is calculated by the number of <u>spaces</u> between bends, not the number of hits.)

With an **Arc Length** of **60”** and bend spacing set at **1.5”**, there will be a total of **40 spaces** whether there are 2 tangents**,** 1 or no tangents. *(Tangents are unrolled sections at each end of the rolled section).*

(The number of hits you will need with 2 tangents is 41, 40 hits with 1 tangent and 39 hits with 0 tangents.)

60” ÷ 1.5” = 40 spaces.
95.49° ÷ 40 = 2.39° per bend.

If there are **2 tangents**, the first and last bend will be **1/2 the normal value** or in this case 1.2°.

<u>NOTE:</u>
(Any bend that is next to a tangent is ½ normal bend value.)

<u>Checking & Adjusting the Roll:</u>

Knowing the exact radius of a bump-rolled arc is essential to knowing how much you need to correct it.

Setting the brake to bend **2.39°** can at best be set and measured to within +/- 1/4°. A sample roll will have to be made. You will need **12 inches** of arc in order to take a radius measurement with the **Arc Master 3600** radius gauge or **6 inches** with the **Arc Master 750** radius gauge. For this exercise, the measured radius is **40”**. You need **36”**. How much must you adjust the bend angle to get the required radius? Do the following exercise.

36” ÷ 40” = .9
.9 x 2.39° = 2.151°
2.39° - 2.151° = .24°

Your bend angle must be increased by **.24°** in order to roll a radius of **36”**.

<u>In Short:</u>
Target Radius ÷ Formed Radius = ____ x Target Angle = Formed Angle.
Target Angle – Formed Angle = Adjustment Angle

Note:
(Arc Master 750 measuring maximum is 30” radius.)

For more useful formulas, go to <u>WWW.ARCMASTER.CA</u> and see Working With Arcs