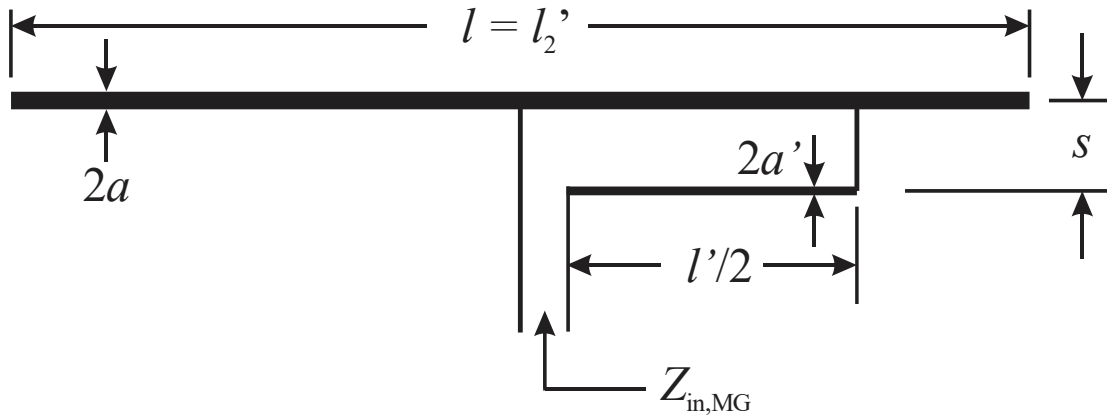


**Example:** Use a modified Gamma-Match to drive the previously designed 5-element UHF Channel 43 Yagi-Uda antenna without boom with a  $50 \Omega$  coaxial transmission line. The matching specification is that the  $VSWR \leq 1.1$ .

- To save time, I'll use the final Gamma-Match design as a starting point.



### **First attempt at modified Gamma-Match:**

element diameters  $d = 2a = 0.25'' = 0.635 \text{ cm} \Rightarrow a = 0.125'' = 0.3175 \text{ cm}$

element spacings  $s_{ij} = 0.2\lambda = 9.274 \text{ cm}$

reflector length  $l_1' = \underline{22.7 \text{ cm}}$  (3 mm longer than 22.4 cm to make up for no capacitor.)

driven element length  $l_2' = 20.8 \text{ cm}$

director lengths  $l_3' = 19.1 \text{ cm}$

director length  $l_4' = 19.09 \text{ cm}$

director length  $l_5' = 19.41 \text{ cm}$

Gamma-Match diameter  $2a' = 0.125'' = 0.3175 \text{ cm} \Rightarrow a' = 0.15875 \text{ cm}$

Gamma-Match spacing  $s = 2 \text{ cm}$

Gamma-Match length  $l'/2 = 5.08 \text{ cm}$

Using NEC-2 and MathCad (see attached pages)-

- Using MathCad for modified  $\Gamma$ -match:  $Z_0 = 260.329 \Omega$ , current division factor  $\alpha = 1.36748$ , effective radius  $a_e = 0.666 \text{ cm}$ , & transmission line mode input impedance  $Z_t = j214.36 \Omega$ .
- From NEC:  $Z_a = 18.2244 + j1.28708 \Omega$  & Gain = 11.5057 dBi
- Using MathCad:  $Z_{in,MG} = \underline{46.826 + j14.52 \Omega}$ . With this input impedance,  $|\Gamma| = 0.152$ , and  $VSWR = 1.358 > 1.1$  (high).

**NEC input file for first modified Gamma-Match attempt**

```

CM Yagi-Uda Antenna for UHF channel 43 (NO BOOM)
CM
CM THIS FILE IS USED TO DETERMINE THE INPUT IMPEDANCE OF THE DRIVEN
CM ELEMENT OF A 5 ELEMENT ANTENNA. CENTER FREQUENCY IS 647 MHZ
CM W/ WAVELENGTH OF 0.46335 m.
CM
CM THE DIMENSIONS ARE:
CM element diameter d=0.635cm=0.25in, radius a=d/2=0.3175cm=0.125in,
CM equivalent radius of Gamma-Match portion of driven element
CM is ae=0.00666 m and has a length of l'/2=0.0508 m < l2/2
CM
CM l1=0.227 m, l2=0.4489 l= 0.208m, l3=0.191 m, l4=0.1909m, l5=0.1941 m
CM ELEMENT SPACINGS Sij=0.2 l = 0.09267m
CM SELECT SEGMENT LENGTH OF APPROX. 1.25cm=0.025 l
CE THE DRIVEN SEGMENT IS #1 on GW3 of l2.
GW 1 17 -0.1135 0.0 0.0 0.1135 0.0 0.0 0.003175 !Reflector
GW 2 8 -0.104 0.0 0.09267 0.0 0.0 0.09267 0.003175 !Driven tip
GW 3 4 0.0 0.0 0.09267 0.0508 0.0 0.09267 0.00666 !Driven mid
GW 4 4 0.0508 0.0 0.09267 0.104 0.0 0.09267 0.003175 !Driven tip
GW 5 15 -0.0955 0.0 0.18534 0.0955 0.0 0.18534 0.003175 !Director 1
GW 6 15 -0.09545 0.0 0.27801 0.09545 0.0 0.27801 0.003175 !Director 2
GW 7 15 -0.09705 0.0 0.37068 0.09705 0.0 0.37068 0.003175 !Director 3
GE 0 0
FR 0 1 0 0 647 0
EX 0 3 1 0 1.0 0.0
RP 0 2 3 0000 0.0 0.0 180.0 90.0
PT -1
XQ 0
EN

```

**NEC output file excerpt for first modified Gamma-Match attempt**

&lt;snip&gt;

FREQUENCY= 6.4700E+02 MHZ WAVELENGTH= 4.6337E-01 METERS

- - - ANTENNA INPUT PARAMETERS - - -

TAG NO.	SEG. NO.	VOLTAGE (V) REAL	VOLTAGE (V) IMAG.	CURRENT (A) REAL	CURRENT (A) IMAG.	IMPEDANCE (OHMS) REAL	IMPEDANCE (OHMS) IMAG.	ADMITTANCE (MHOS) REAL	ADMITTANCE (MHOS) IMAG.	POWER (WATTS)
3	26	1.0E+00	0.0	5.46E-02	-3.856E-03	<b>1.82244E+01</b>	<b>1.28708E+00</b>	5.46E-02	-	3.86E-03
			2.72995E-02							

- - - RADIATION PATTERNS - - -

THETA DEGREES	PHI DEGREES	MAJOR DB
0.00	0.00	<b>11.50571</b>
180.00	0.00	-0.71554

&lt;snip&gt;

**MathCad file for first modified Gamma-Match attempt****Modified Gamma-Match equations- First Try**

$$\underline{c} := 2.9979 \cdot 10^8 \text{ m/s} \quad f_c := 647 \cdot 10^6 \text{ Hz} \quad \lambda := \frac{c}{f_c} \quad \lambda = 0.46335 \text{ m}$$

$$k := \frac{2 \cdot \pi}{\lambda} \quad k = 13.56023 \text{ rad/m} \quad Z_{\text{desired}} := 50 \quad \Omega$$

$$d := 0.635 \cdot 10^{-2} \text{ m} \quad a := d \cdot 0.5 \quad a = 0.003175 \text{ m} \quad \underline{s} := 2 \cdot 10^{-2} \text{ m}$$

$$d_{\text{prime}} := 0.3175 \cdot 10^{-2} \text{ m} \quad a_{\text{prime}} := d_{\text{prime}} \cdot 0.5 \quad a_{\text{prime}} = 0.0015875 \text{ m}$$

$$Z_0 := \frac{376.7303}{2 \cdot \pi} \cdot \operatorname{acosh} \left[ \frac{(s^2 - a^2 - a_{\text{prime}}^2)}{2 \cdot a \cdot a_{\text{prime}}} \right] \quad Z_0 = 260.329 \quad \Omega \quad u := \frac{a}{a_{\text{prime}}} \quad v := \frac{s}{a_{\text{prime}}}$$

$$u = 2 \quad v = 12.5984$$

$$\alpha := \frac{\operatorname{acosh} \left[ \frac{(v^2 - u^2 + 1)}{2 \cdot v} \right]}{\operatorname{acosh} \left[ \frac{(v^2 + u^2 - 1)}{2 \cdot v \cdot u} \right]} \quad \alpha = 1.36748 \quad \alpha e := a_{\text{prime}} \cdot e^{\frac{u^2 \cdot \ln(u) + 2 \cdot v \cdot \ln(v)}{(1+u)^2}}$$

$$ae = 0.00666 \quad ae \cdot 100 = 0.66609 \text{ cm}$$

$$l_{\text{prime}} := 10.16 \cdot 10^{-2} \text{ m} \quad l_{\text{prime}} \cdot 0.5 = 0.0508 \text{ m}$$

$$Z_t := j \cdot Z_0 \cdot \tan \left( \frac{k \cdot l_{\text{prime}}}{2} \right) \quad Z_t = 214.3602i \quad \Omega \quad Y_t := \frac{1}{Z_t} \quad Y_t = -4.665i \cdot 10^{-3}$$

**Za from NEC (a MoM program)**

$$Z_a := 18.2244 + j \cdot 1.28708 \quad \Omega \quad Y_a := \frac{1}{Z_a} \quad Y_a = 0.0546 - 0.00386i \quad \text{Mhos}$$

$$Y_{\text{in}} := Y_t + \frac{Y_a \cdot 2}{(1 + \alpha)^2} \quad Y_{\text{in}} = 0.019 - 6.041i \times 10^{-3} \quad \text{S} \quad \frac{1}{Z_{\text{desired}}} = 0.02 \quad \text{Mhos}$$

$$Z_{\text{inMG}} := \frac{1}{Y_{\text{in}}} \quad Z_{\text{inMG}} = 46.826 + 14.52i \quad \Omega \quad Z_{\text{desired}} = 50 \quad \Omega$$

$$\underline{\Gamma} := \frac{(Z_{\text{inMG}} - Z_{\text{desired}})}{Z_{\text{inMG}} + Z_{\text{desired}}} \quad \Gamma = -0.01 + 0.151i \quad |\Gamma| = 0.152$$

$$\text{VSWR} := \frac{(1 + |\Gamma|)}{1 - |\Gamma|} \quad \text{VSWR} = 1.358 \quad \text{First Try- VSWR} > 1.1$$

$$l_{\text{suggested2}} := \frac{1}{k} \cdot \operatorname{atan} \left[ \frac{1}{Z_0 \cdot \operatorname{Im} \left[ \frac{2Y_a}{(1 + \alpha)^2} \right]} \right] \quad l_{\text{suggested2}} = -0.0905 \text{ m, NOT realizable}$$

**Second attempt at modified Gamma-Match:**

element diameters  $d = 2a = 0.25'' = 0.635 \text{ cm} \Rightarrow a = 0.125'' = 0.3175 \text{ cm}$

element spacings  $s_{ij} = 0.2\lambda = 9.274 \text{ cm}$

reflector length  $l_1' = 22.7 \text{ cm}$

**Shorten** driven element length  $l_2' = \mathbf{20.56 \text{ cm}}$  (down from 20.8 cm to try to eliminate/minimize reactance)

director lengths  $l_3' = 19.1 \text{ cm}$

director length  $l_4' = 19.09 \text{ cm}$

director length  $l_5' = 19.41 \text{ cm}$

Gamma-Match diameter  $2a' = 0.125'' = 0.3175 \text{ cm} \Rightarrow a' = 0.15875 \text{ cm}$

Gamma-Match spacing  $s = 2 \text{ cm}$

Gamma-Match length  $l'/2 = 5.08 \text{ cm}$

Using NEC-2 and MathCad (see attached pages)-

- Using MathCad for modified  $\Gamma$ -match:  $Z_0 = 260.329 \Omega$ , current division factor  $\alpha = 1.36748$ , effective radius  $a_e = 0.666 \text{ cm}$ , & transmission line mode input impedance  $Z_t = j214.36 \Omega$ .
- From NEC:  $Z_a = 17.378 - j4.09449 \Omega$  & Gain = 11.4924 dBi
- Using MathCad:  $Z_{in, MG} = \mathbf{51.404 + j0.216 \Omega}$ . With this input impedance,  $|\Gamma| = 0.014$ , and  $\mathbf{VSWR = 1.028} < 1.1$  (meets spec  $\Rightarrow$  DONE!).

## NEC input file for second modified Gamma-Match attempt

```

CM Yagi-Uda Antenna for UHF channel 43 (NO BOOM)
CM
CM THIS FILE IS USED TO DETERMINE THE INPUT IMPEDANCE OF THE DRIVEN
CM ELEMENT OF A 5 ELEMENT ANTENNA. CENTER FREQUENCY IS 647 MHZ
CM W/ WAVELENGTH OF 0.46335 m.
CM
CM THE DIMENSIONS ARE:
CM element diameter d=0.635cm=0.25in, radius a=d/2=0.3175cm=0.125in,
CM equivalent radius of Gamma-Match portion of driven element
CM is ae=0.00666 m and has a length of l'/2=0.0508 m < l2/2
CM
CM l1=0.227 m, l2=0.2056 m, l3=0.191 m, l4=0.1909m, l5=0.1941 m
CM ELEMENT SPACINGS Sij=0.2 l = 0.09267m
CM SELECT SEGMENT LENGTH OF APPROX. 1.25cm=0.025 l
CE THE DRIVEN SEGMENT IS #1 on GW3 on l2.
GW 1 17 -0.1135 0.0 0.0 0.1135 0.0 0.0 0.003175 !Reflector
GW 2 8 -0.1028 0.0 0.09267 0.0 0.0 0.09267 0.003175 !Driven tip
GW 3 4 0.0 0.0 0.09267 0.0508 0.0 0.09267 0.00666 !Driven mid
GW 4 4 0.0508 0.0 0.09267 0.1028 0.0 0.09267 0.003175 !Driven tip
GW 5 15 -0.0955 0.0 0.18534 0.0955 0.0 0.18534 0.003175 !Director 1
GW 6 15 -0.09545 0.0 0.27801 0.09545 0.0 0.27801 0.003175 !Director 2
GW 7 15 -0.09705 0.0 0.37068 0.09705 0.0 0.37068 0.003175 !Director 3
GE 0 0
FR 0 1 0 0 647 0
EX 0 3 1 0 1.0 0.0
RP 0 2 3 0000 0.0 0.0 180.0 90.0
PT -1
XQ 0
EN

```

## NEC output file excerpt for second modified Gamma-Match attempt

<snip>

FREQUENCY= 6.4700E+02 MHZ WAVELENGTH= 4.6337E-01 METERS

- - - ANTENNA INPUT PARAMETERS - - -

TAG NO.	SEG. NO.	VOLTAGE (V)		CURRENT (A)		IMPEDANCE (OHMS)		ADMITTANCE (MHOS)		POWER
		REAL	IMAG.	REAL	IMAG.	REAL	IMAG.	REAL	IMAG.	(WATTS)
3	26	1.0E+00	0.0E+00	5.45E-02	1.28E-02	<b>1.7378E+01</b>	<b>-4.09449E+00</b>	5.45177E-02		
		1.28451E-02	2.72588E-02							

- - - RADIATION PATTERNS - - -

THETA DEGREES	PHI DEGREES	MAJOR DB
0.00	0.00	<b>11.49238</b>
180.00	0.00	-0.70477

<snip>

**MathCad file for second modified Gamma-Match attempt****Modified Gamma-Match equations- Second Try**

$$\underline{c} := 2.9979 \cdot 10^8 \text{ m/s} \quad f_c := 647 \cdot 10^6 \text{ Hz} \quad \lambda := \frac{c}{f_c} \quad \lambda = 0.46335 \text{ m}$$

$$k := \frac{2 \cdot \pi}{\lambda} \quad k = 13.56023 \text{ rad/m} \quad Z_{\text{desired}} := 50 \quad \Omega$$

$$d := 0.635 \cdot 10^{-2} \text{ m} \quad a := d \cdot 0.5 \quad a = 0.003175 \text{ m} \quad \underline{s} := 2 \cdot 10^{-2} \text{ m}$$

$$d_{\text{prime}} := 0.3175 \cdot 10^{-2} \text{ m} \quad a_{\text{prime}} := d_{\text{prime}} \cdot 0.5 \quad a_{\text{prime}} = 0.0015875 \text{ m}$$

$$Z_0 := \frac{376.7303}{2 \cdot \pi} \cdot \text{acosh} \left[ \frac{(s^2 - a^2 - a_{\text{prime}}^2)}{2 \cdot a \cdot a_{\text{prime}}} \right] \quad Z_0 = 260.329 \quad \Omega \quad u := \frac{a}{a_{\text{prime}}} \quad v := \frac{s}{a_{\text{prime}}}$$

$$\alpha := \frac{\text{acosh} \left[ \frac{(v^2 - u^2 + 1)}{2 \cdot v} \right]}{\text{acosh} \left[ \frac{(v^2 + u^2 - 1)}{2 \cdot v \cdot u} \right]} \quad \alpha = 1.36748 \quad \text{ae} := a_{\text{prime}} \cdot e^{\frac{u^2 \cdot \ln(u) + 2 \cdot v \cdot \ln(v)}{(1+u)^2}}$$

$$l_{\text{prime}} := 10.16 \cdot 10^{-2} \text{ m} \quad l_{\text{prime}} \cdot 0.5 = 0.0508 \text{ m}$$

$$Z_t := j \cdot Z_0 \cdot \tan \left( \frac{k \cdot l_{\text{prime}}}{2} \right) \quad Z_t = 214.3602i \quad \Omega \quad Y_t := \frac{1}{Z_t} \quad Y_t = -4.665i \cdot 10^{-3}$$

**Za from NEC (a MoM program)**

$$Z_a := 17.378 + j \cdot -4.09449 \quad \Omega \quad Y_a := \frac{1}{Z_a} \quad Y_a = 0.05452 + 0.01285i \quad \text{Mhos}$$

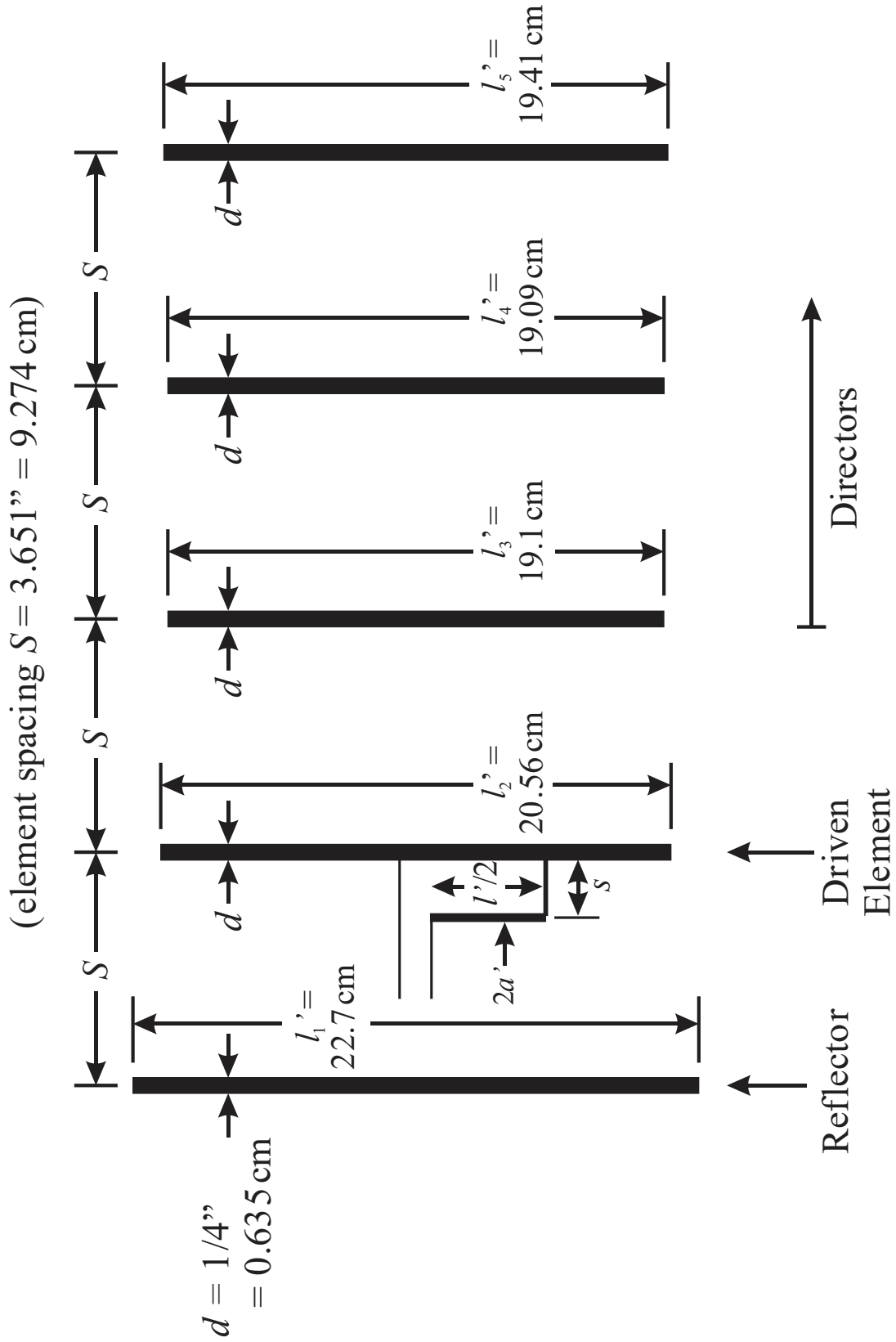
$$Y_{\text{in}} := Y_t + \frac{Y_a \cdot 2}{(1 + \alpha)^2} \quad Y_{\text{in}} = 0.019 - 8.159i \times 10^{-5} \quad \text{S} \quad \frac{1}{Z_{\text{desired}}} = 0.02 \quad \text{Mhos}$$

$$Z_{\text{inMG}} := \frac{1}{Y_{\text{in}}} \quad Z_{\text{inMG}} = 51.404 + 0.216i \quad \Omega \quad Z_{\text{desired}} = 50 \quad \Omega$$

$$\underline{\Gamma} := \frac{(Z_{\text{inMG}} - Z_{\text{desired}})}{Z_{\text{inMG}} + Z_{\text{desired}}} \quad \Gamma = 0.014 + 2.097i \times 10^{-3} \quad |\Gamma| = 0.014$$

$$\text{VSWR} := \frac{(1 + |\Gamma|)}{1 - |\Gamma|} \quad \text{VSWR} = 1.028 \quad \text{Second Try- VSWR} < 1.1 \text{ DONE!}$$

# 5 element, CH 43 Yagi-Uda antenna w/ modified Gamma-Match



Modified Gamma-Match Dimensions:  $2a' = 1/8'' = 0.3175 \text{ cm}$ ,  $s = 2 \text{ cm}$ , and  $l'/2 = 5.08 \text{ cm}$ .