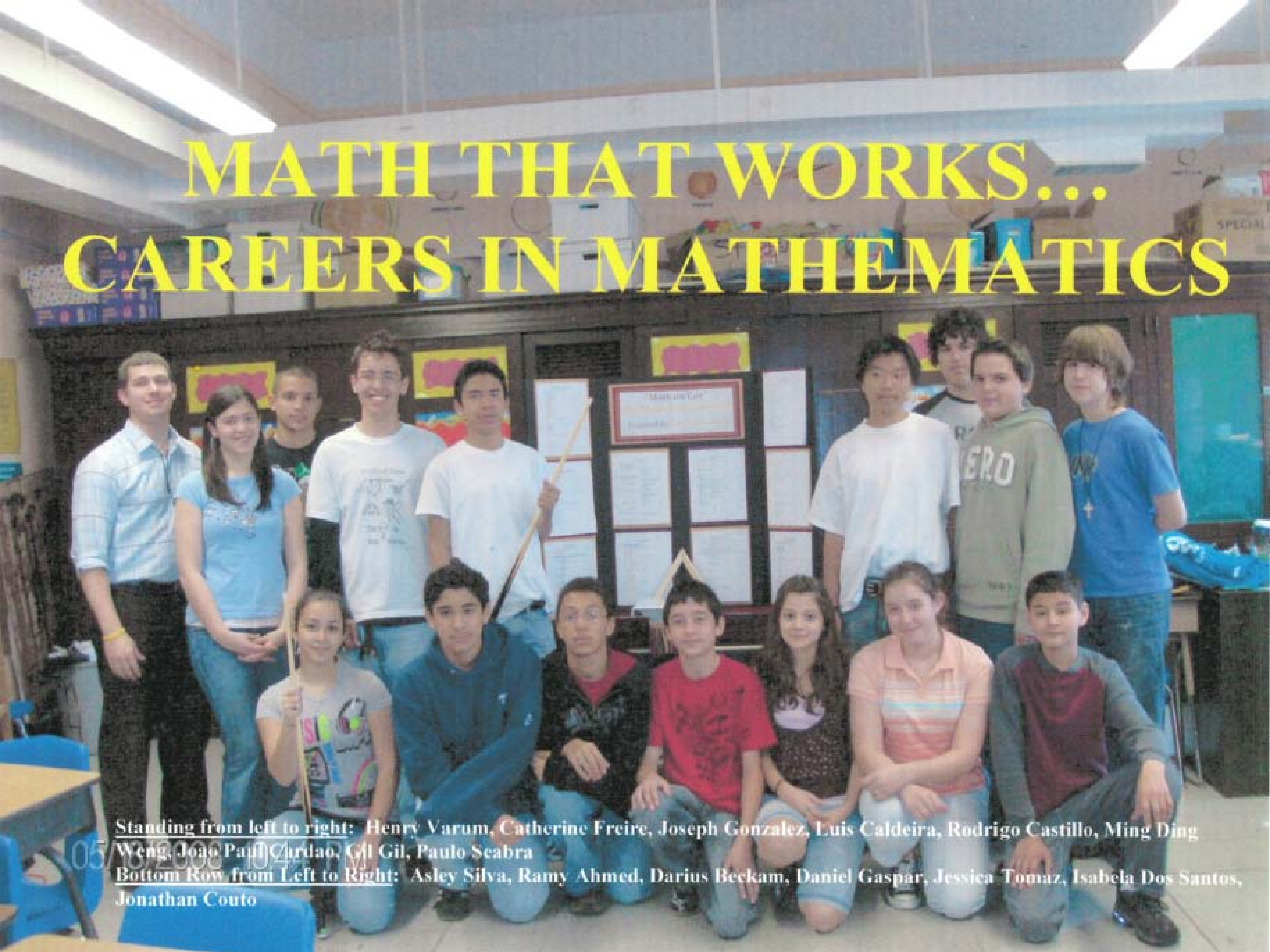
Math Connections to Earth and Space Science

Glen Schuster

Endeavor

NASA



Standing from left to right: Henry Varum, Catherine Freire, Joseph Gonzalez, Luis Caldeira, Rodrigo Castillo, Ming Ding Weng, Joao Paul Cardao, Gil Gil, Paulo Seabra
Bottom Row from Left to Right: Asley Silva, Ramy Ahmed, Darius Beckam, Daniel Gaspar, Jessica Tomaz, Isabela Dos Santos, Jonathan Couto

Math that Works…Careers in Mathematics
"Math on Cue"
The Mathematics of Billiards

"POOL TABLE!" Luis Caldeira screamed out. Everyone became dead silent. Minutes before, our Algebra class was debating ideas for our math fair project. We wanted something new, something fresh. Therefore, the average architecture project was out of the question. There was a glint of mischievousness in Mr. Varum's eyes. We had our project.

At first glance, the idea of a professional pool player as a mathematical career seemed far fetched. However, once we started analyzing all of the information we had collected, we realized that a professional pool player consciously performs more mathematical calculations than we could have imagined.

Mr. Varum then took this project one step further and surprised us with a miniature billiard ball. We were now building a table and the career of a carpenter became another part of our project. Isabela Dos Santos took on this job by scaling down a competition sized pool table so that it was proportional to the miniature ball.

We have also made diagrams of our shots to explain each step of our work in great detail. While we were working on our shots, we were also building our pool table. During the process, we had to cut, glue, and hammer various pieces of wood together.

We measured angles and side lengths, varnished and stained wood, as well as create all the pockets for the table.

This elaborate and intricate project took countless hours of work, patience, and effort. When everything was complete, our Algebra class and Mr. Varum stood proud as we observed our finished work of art.

Scaled Measurements of Pool Table

Pool Table Measurements

Scale Factor

Actual ball diameter – 2.25 in.
Model ball diameter – 1.375
-Scale factor from actual to model $\frac{1.375}{2.25} = \frac{11}{18}$

Actual	Model
Table- **4.5 by 9 ft**	4.5 × (11/18) = **2.75ft.** ↑ Scale factor from actual to model. 9 × (11/18) = **5.5 ft.**
Rail height must be over ½ of the diameter of the ball but less than 64.5% of the diameter of the ball	Diameter of ball for model. ↓ 1.375 × .645 = .886875 in. –maximum height 1.375 ÷ 2 = .6875 in. – minimum height We used **.75 in.** for our model.
Rail width- **4 - 7 ½** inches with cushions	4 × (11/18) = **2.444 in. minimum** 7.5 × (11/18) = **4.58333 in. maximum** Rail-bumper-1.25 in. Wood rail-1.75 in. Our model's width is 3 in.
18 sights- diamonds **12 ½** inches apart	12.5 × (11/18) = **7.638888889 in.** ≈ **7.639 in. apart**
Corner pocket mouth- **4.5- 4.625** inches	4.5 × (11/18) = 2.75 in. 4.625 × (11/18) = 2.826388889 in. ≈ **2.75- 2.8264 we used 2.75 in.**
Side mouth- **5 and 5.125** inches	5.125×(11/18) = 3.13944444 in. 5 × (11/18)= 3.05 in. **3.055 and 3.13944444** **We used 3.125 in.**

Cut angles of corner pockets = 142°

Cut angles of side =104°

Cloth- **4.5 × 9 = 40. 5** square feet of cloth

$40.5 \times (11/18)^2$ = **24.75 square feet of cloth needed for the playing surface of the model**

Pockets- usually rimmed with leather or plastic (pockets or ball returns)

Measurements for Table Diagram

Scale factor from actual table to diagram-

1in. on diagram = 1ft. on actual table

Scale factor = **1/12**

Scale factor from model table to diagram

5.5 x 12 = **66in.**

Model = **9in.**

Scale factor = **9/66 = 3/22**

Scaled Measurements

Diagram measurements

Dimensions – 4.5ft. x 9ft.

5.5ft. x 3/22 = .75f. x 12 = **9in.**

2.75ft. x 3/22 = .6136ft. = .375 x 12 = **4.5in.**

Rail Cushion

1.25in. x 3/22 = **$.170\overline{45}$in.**

1.75in. x 3/22 = **$.2386\overline{36}$in.**

Sights

7.639in. x 3/22 = **$1.0416\overline{81}$in.**

Corner Pockets

2.75in. x 3/22 = **.375in.**

Side Pockets

3.125in. x 3/22 = **$.4261\overline{36}$in.**

Cut angle of corner pocket

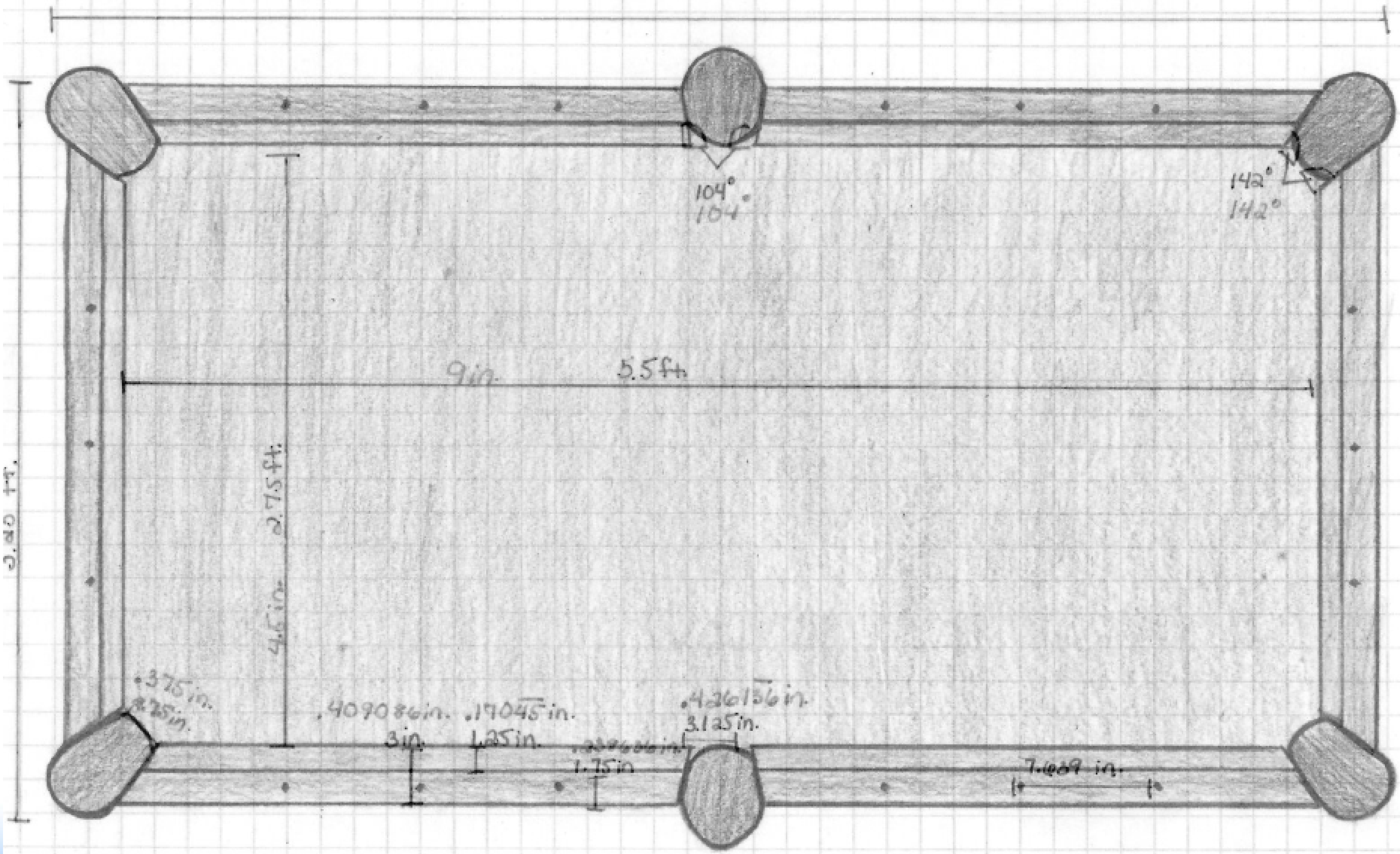
142°

Cut angle of side pocket

104°

Diagram of Model

scale factor – $\frac{3}{22}$ 3in.= 22 in.



Measurements of the Diagram based on Actual Pool Table Lengths

scale factor – $\frac{1}{12}$ 1in.=12 in.

Jessica's Angle Shot

Jessica's Angle Shot

Angle at Which Target Ball Travels

(5,1)
a= 5ft. - 4.5 ft. a = .5 ft.
b = 1 ft.
Tan-1(1/.5) = 63.43494882° = 63.43°
63.43°+ 90° = 153.43°
180°- 153.43° = **26.57°**

Measure of a\` and b\`

Cos63.43° = a\`/2.25
.4472908484 = a\`/2.25
1.006404490 = a\` **1in. = a\`**
Sin63.43° = b\`/2.25
.8943885604 = b\`/ 2.25
2.012374261= b\` **2.01= b\`**

Center of Target Ball in Feet

(5,1)

Center of Target Ball in Inches

5×12 = 60 in.
1×12 = 12 in. **(60,12 in.)**

Center of Cue Ball at Contact

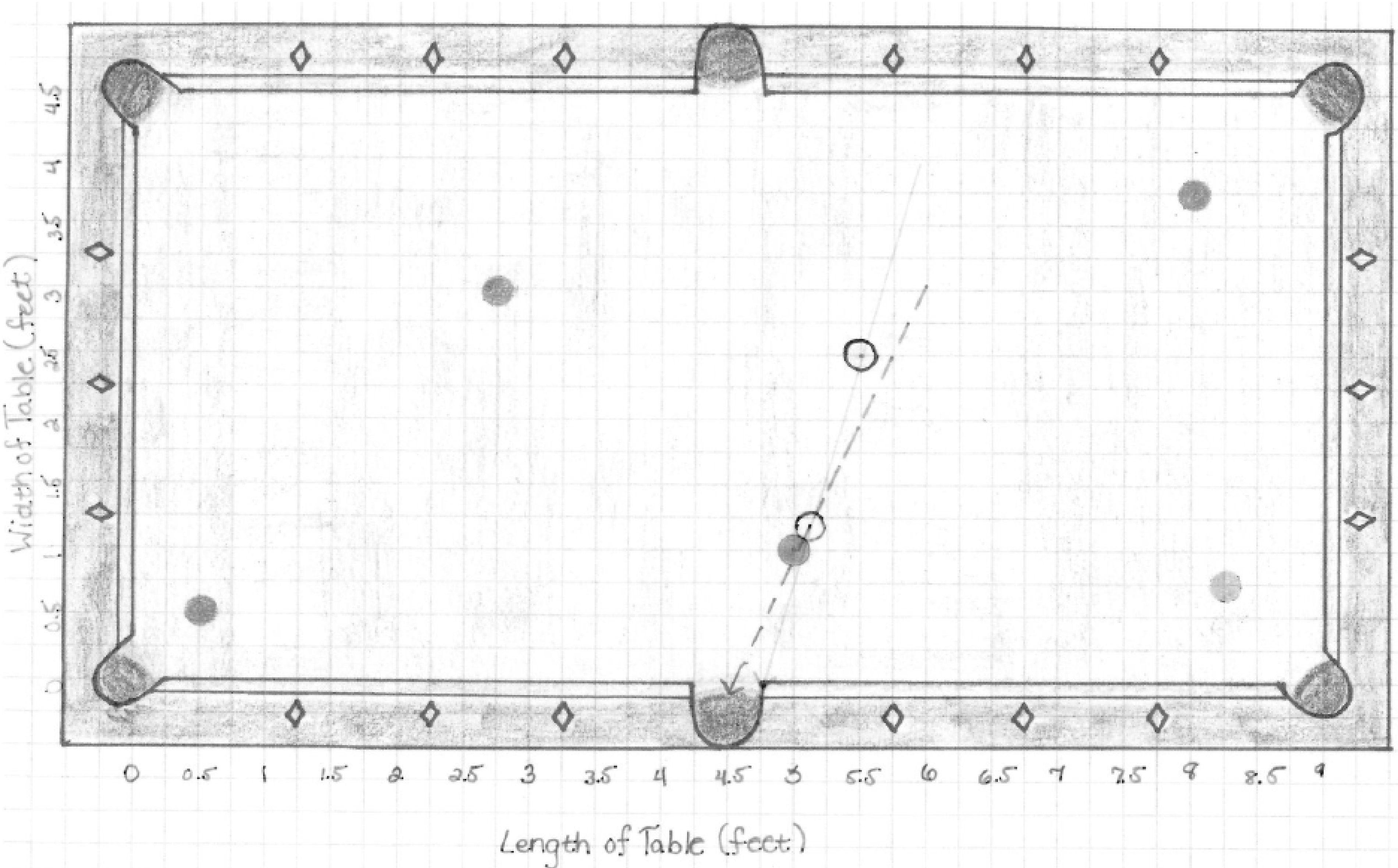
60 in.+1 in. = 61 in. (x)
12 in.+2.01 = 14.01 in. (y)
Convert **(61,14.01 in.)** to feet
61 in.÷12 in. = 5.08 ft.
14.01 in.÷12 in. = 1.1675 ft.
(5.08,1.1675 ft.)

Point of Contact Between Cue Ball and Target Ball

2.01÷2 = 1.005 in.
1÷2 = .5 in.
12+1.005 = 13.005 in.
60+.5 = 60.5 in.
Convert **(60.5,13.005 in.)** to feet
60.5 in.÷12 in.= 5.04 ft.
13.005 in.÷12 in. = 1.08 ft.
(5.04,1.08 ft.)

Angle Cue Ball Travels At

5.5 ft.-5.08ft. = .42 ft.
2.5 ft.-1.1675 ft. = 1.3325 ft.
Tan-1(1.3325/.42) = 72.50530497° = 72.5°
180°-72.5°-90° = **17.5°**



Width of Table (feet)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
Length of Table (feet)

Angle at Which Target Ball Travels

(5,1)

a = 5 ft. − 4.5 ft. a = .5 ft

b = 1 ft.

$\tan^{-1}\left(\frac{1}{.5}\right) = 63.43494882° = 63.43°$

63.43° + 90° = 153.43°

180° − 153° = 26.57

Measure of a' and b'

$\cos 63.43° = \frac{a'}{2.25}$

$.4472909484 = \frac{a'}{2.25}$

1.006404490 = a' 1 in. = a'

$\sin 63.43° = \frac{b'}{2.25}$

$.8943885604 = \frac{b'}{2.25}$

2.012374261 = b' 2.01 = b'

Center of Target Ball in Feet

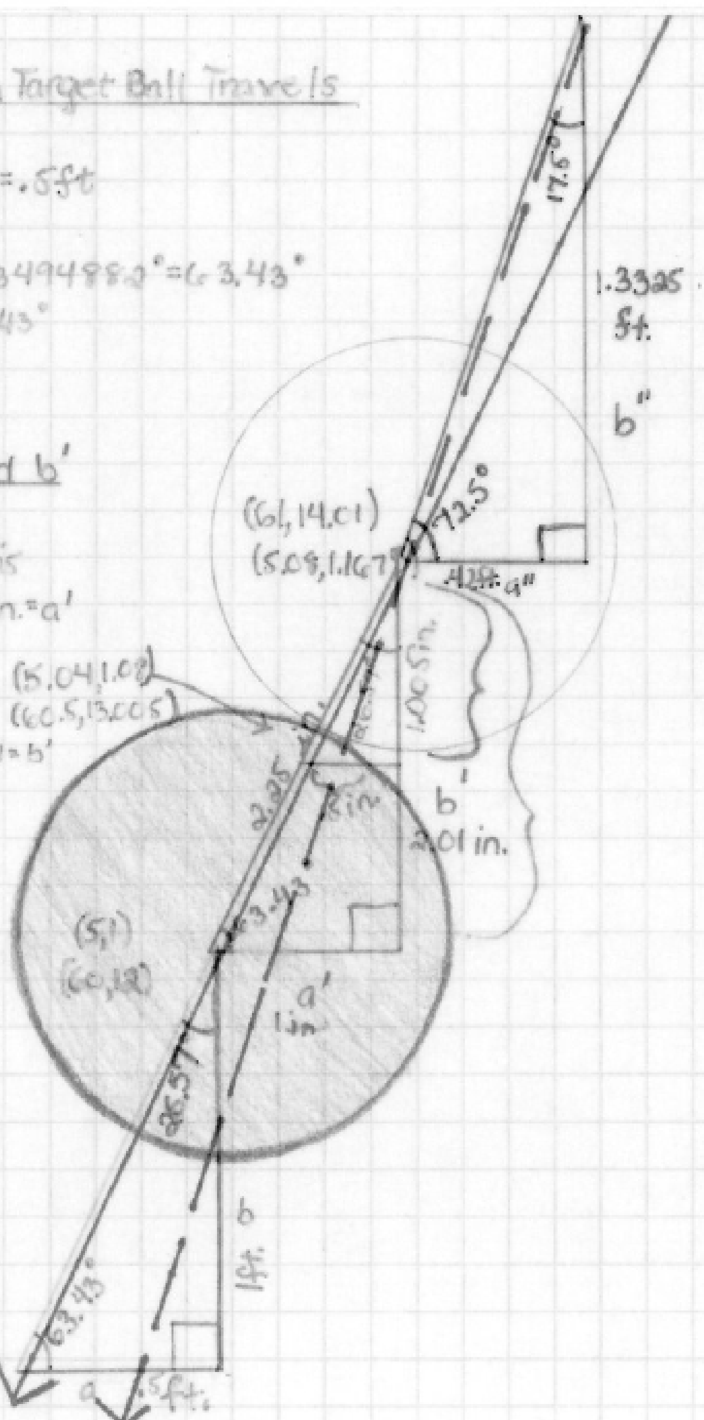
(5,1)

Center of Target Ball in Inches

5 × 12 = 60 in.

1 × 12 = 12 in.

(60, 12 in.)



Center of Cue Ball at Contact

60 in. + 1 in. = 61 in. (x)

12 in. + 2.01 = 14.01 in. (y)

Convert (61, 14.01 in.) to feet

61 in. ÷ 12 in. = 5.08 ft.

14.01 ÷ 12 in = 1.1675 ft.

(5.08, 1.1675 ft.)

Point of Contact Between Cue Ball and Target Ball

2.01 ÷ 2 = 1.005 in.

1 ÷ 2 = .5 in.

12 + 1.005 = 13.005 in.

60 + .5 = 60.5 in.

Convert (60.5, 13.005) to feet

60.5 in. ÷ 12 in = 5.04 ft.

13.005 in ÷ 12 in = 1.08 ft.

(5.04, 1.08 ft.)

Angle Cue Ball Travels At

5.5 ft. − 5.08 ft. = .42 ft.

2.5 ft. − 1.1675 ft. = 1.3325 ft.

$\tan^{-1}\left(\frac{1.3325}{.42}\right) = 72.50530497° = 72.5°$

180° − 72.5° − 90° = 17.5°

Measurements may not be to scale