Irene Choi, Shreyas Ekanathan, Aidan Gao, Sylvia Zia Lee, Rajarshi Mandal, Vaibhav Rastogi,
Daniel Sheffield, Michael Yang, Angela Zhao, Corey Zhao

Mentored by Dr. Tanya Khovanova
MIT PRIMES STEP  Junior Group: The Struggles of Chessland

Bermuda

Apparent location of the Bermuda Triangle

Miami

San Juan, Puerto Rico

Cuba
Island 8

Island 5

Island 3

Island 2
Surveying
The Knight's Shoe Obsession
Shoelace Formula (Pt 1)

Shoelace in $7 \times k$ rectangle: $2k - 3$

Islands of size $7k$: $14k^2 - k - 2$
Shoelace Formula (Pt 2)

Islands of size $7k - 1$: $14k^2 - 3k - 3$

Islands of size $7k - r$: $14k^2 - (2r + 1)k - 2$

Islands of size $7k - 6$: $14k^2 - 20k + 4$

Note: When squares are repeated, the larger number is put in the square (61, 65, and 68 here.)
The Rook and the Bishop

MIT PRIMES STEP Junior Group: The Struggles of Chessland
Straight Spiral

(Divide $n$ by 6, and let $k$ be the quotient and $r$ be the remainder)

Let $f(n)$ denote the number of moves to survey Island $n$

$n = 6k + r$

Recursive Formula: $f(n+6) = f(n) + 4(n+3)$

General Formula:

$$f(n) = 16k^2 + 4rk + s(r)$$

$s(0) = -2$  $s(3) = 1$

$s(1) = -1$  $s(4) = 4$

$s(2) = 0$  $s(5) = 7$
The King: Part 2

Zig-zag Spiral

(Divide \( n \) by 8, and let \( K \) be the quotient and \( R \) be the remainder)
Let \( g(n) \) denote the number of moves to survey Island \( n \)

\[
n = 8K + R
\]

Recursive Formula: \( g(n+8) = g(n) + 4(n+5) \)

General Formula:

\[
g(n) = 16K^2 + (4R + 4)K + t(R)
\]

\[
t(0) = -2 \quad t(4) = 4
\]

\[
t(1) = -1 \quad t(5) = 8
\]

\[
t(2) = 1 \quad t(6) = 11
\]

\[
t(3) = 2 \quad t(7) = 14
\]
### Bishops

<table>
<thead>
<tr>
<th></th>
<th>n-2</th>
<th>n-3</th>
<th>n-4</th>
<th>n-5</th>
<th>n-6</th>
<th>n-7</th>
<th>n-8</th>
<th>n-9</th>
<th>n-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>n-2</td>
<td>n-3</td>
<td>n-4</td>
<td>n-5</td>
<td>n-6</td>
<td>n-7</td>
<td>n-8</td>
<td>n-9</td>
<td>n-10</td>
</tr>
<tr>
<td>n-2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>n-3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>n-4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>n-5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>n-6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>n-7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>n-8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>n-9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>n-10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Diagram

![Diagram of Bishops](image-url)
Kings

MIT PRIMES STEP  Junior Group: The Struggles of Chessland
The Queen’s to-do list:

- Eat (2 hrs)
- Beauty sleep (1 hr)
- Get makeup applied (8 hrs)
- Beauty sleep (1 hr)
- Pick out clothes (8 hrs)
- Sleep (4 hrs)
Queens

2 2 2 2
2 0 0 2
2 0 0 2
2 2 2 2

3 2 2 2 3
2 2 3 2 2
2 3 4 3 2
2 2 3 2 2
3 2 2 2 3

3 3 3 3 3
3 3 3 3 3
3 3 4 4 3
3 3 4 4 3
3 3 3 3 3
3 3 3 3 3
Acknowledgements

Thank you to the MIT PRIMES STEP program and Dr. Tanya Khovanova for providing us with this opportunity.

Special Thanks to:

Our Family and Friends,

Especially our Parents.
Thank You!
Any Questions?