Using Geometry in FLL Missions

Presented by:
K.K. Quah – President
Technology Learning Classes for Kids

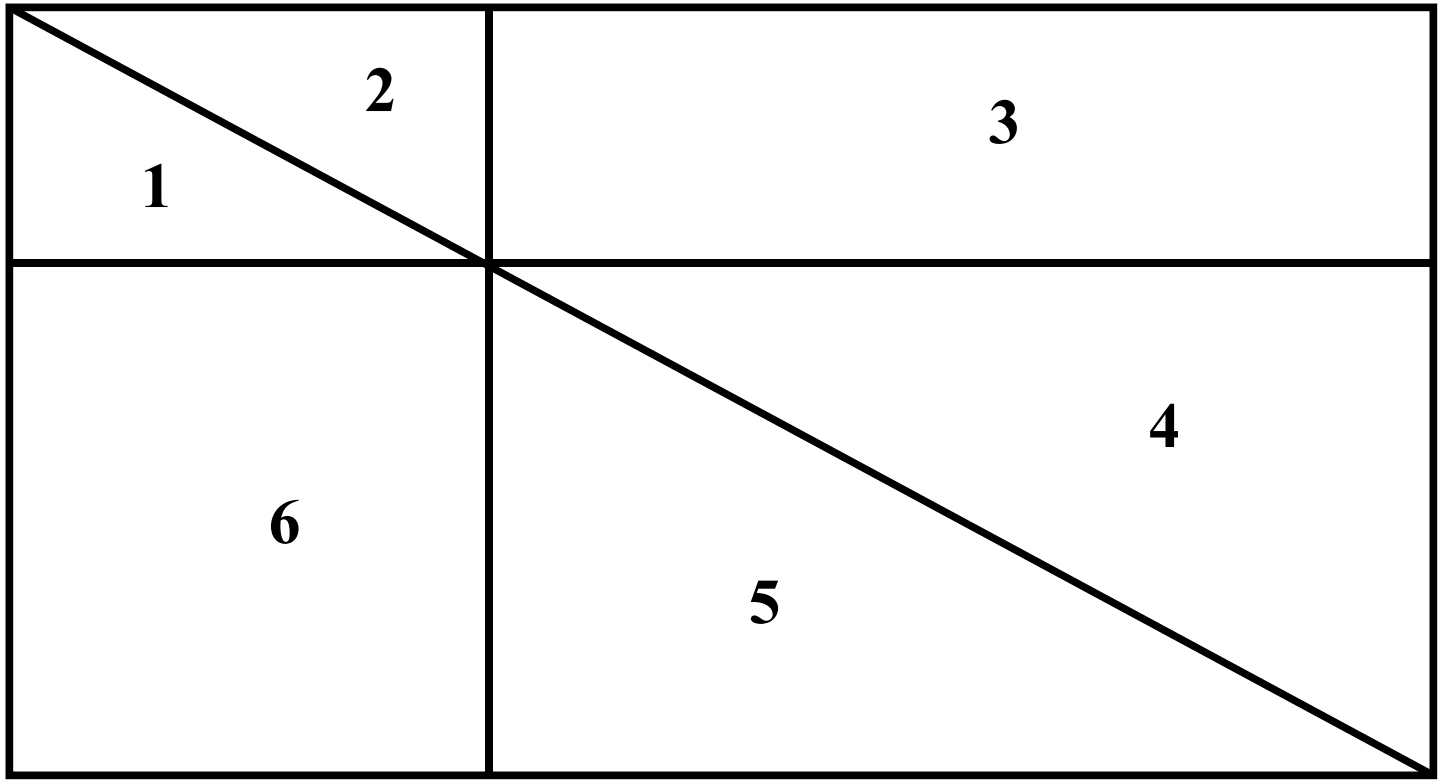
Outline of Presentation

- What is Geometry and Why Geometry?
- Geometry in Solutions Involving Shapes
- Geometry in Basic Navigation
- Geometry in Understanding Paths
- Geometry at the Contact Point with Mission Target
- Summary

What is Geometry & Why Geometry?

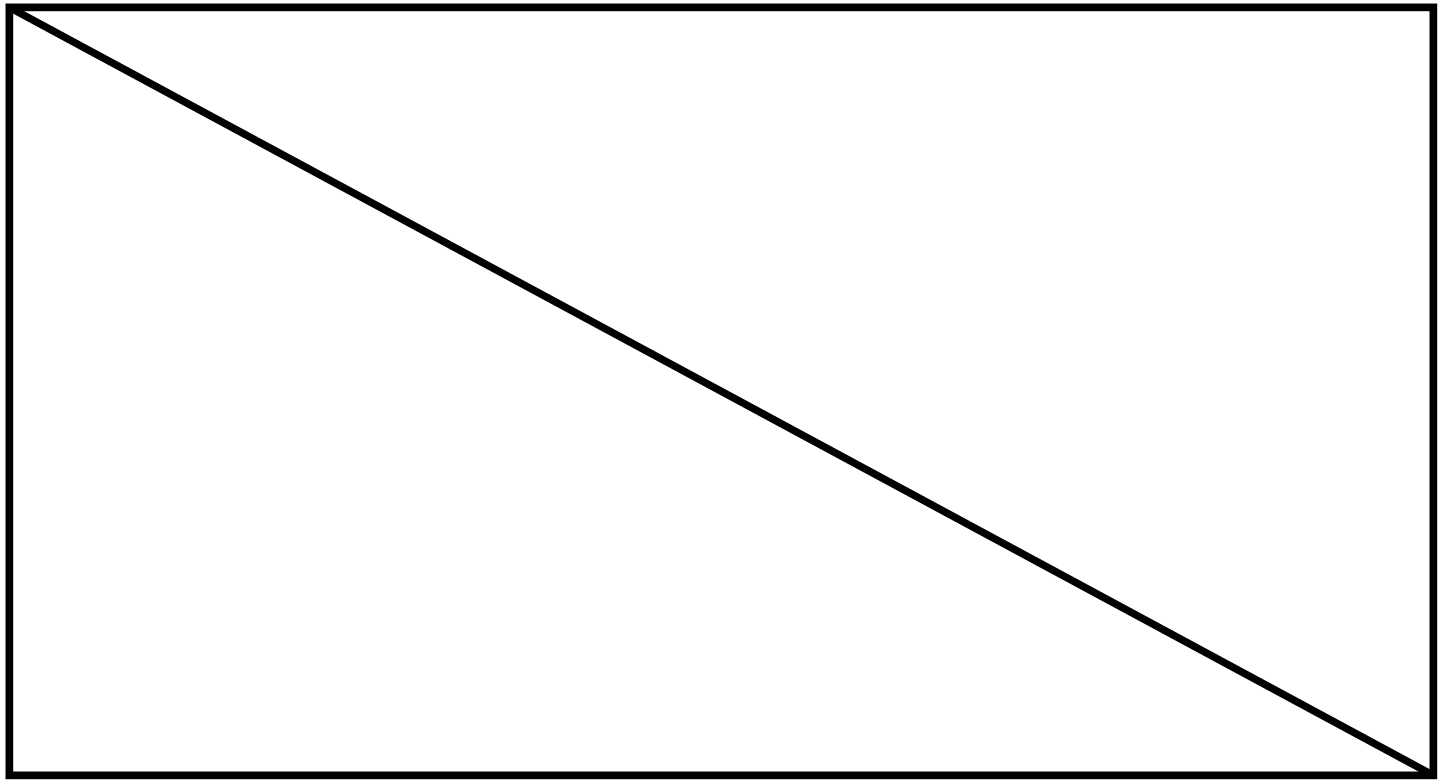
- Geometry 1. Math of points, lines & surfaces.
- Geometry 2. Math of spatial relationships. Basic tool in the use of building things.
- As coaches, we need to provide math and science relevance to FLL participants.
- Believe that solid grounding in fundamentals will enable interesting solutions.
- Geometry is the starting point in a lot of solutions.

Geometry Puzzle - Rectangle



Which rectangle is bigger #3 or #6?

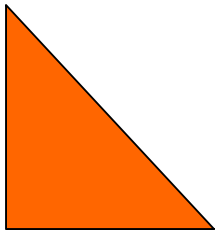
The Only Geometry Needed is This



Letter “T” Puzzle by Sam Lloyd

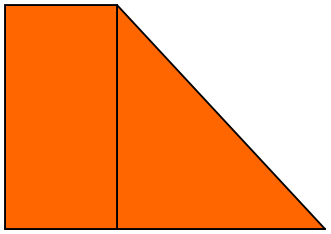
Form the 4 pieces into Letter ‘T’

#1



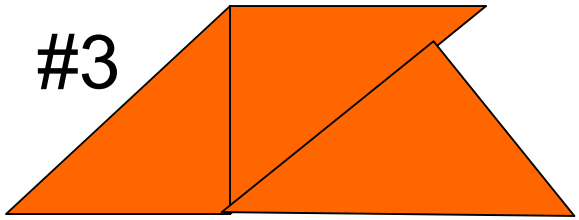
3 sides

#2



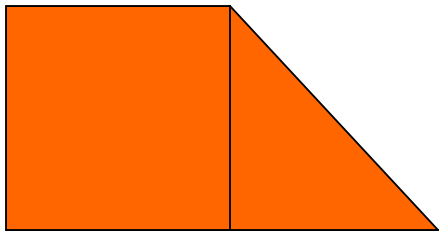
4 sides

#3



5 sides

#4



4 sides

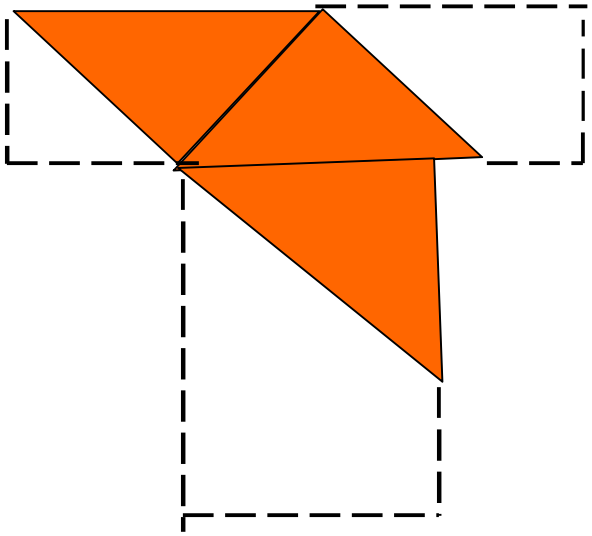
What are number of combinations?

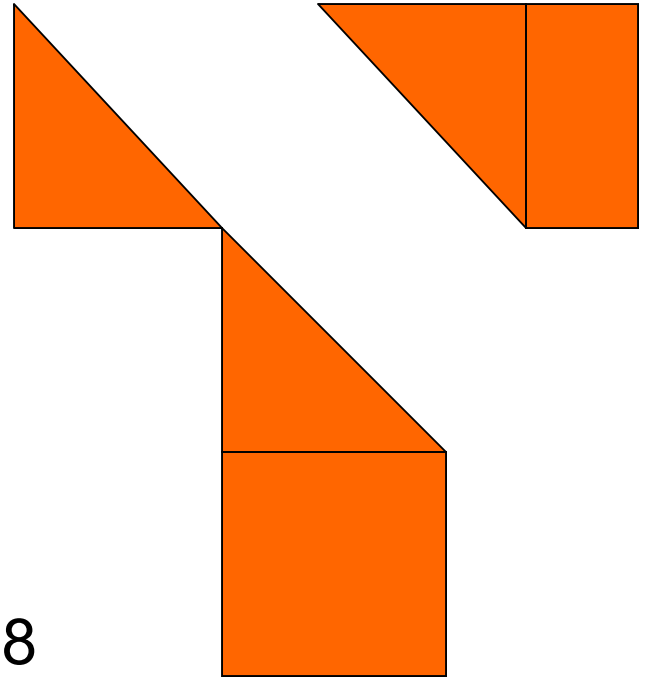
- Quick and dirty answer - multiply the number of sides of all pieces
- So 3 x 4 x 4 x 5 = 240 combinations
- Can you solve it by sheer brute force (trial and error) in 4 minutes? Would need 1 trial per second. Too slow.
- What other quick ways? Apply geometry.
- But how ……

Using Geometry to Solve Letter “T”

- By deduction, which is the hardest piece to place correctly? Or which piece stands out? #3.
- Why? Because it has the weird corner.
- Can any of the other pieces fit with #3 placed horizontally?
- Can any of the other pieces fit with #3 placed vertically?
- Hence shape #3 can only be use DIAGONALLY !!

Solution with #3 placed diagonally



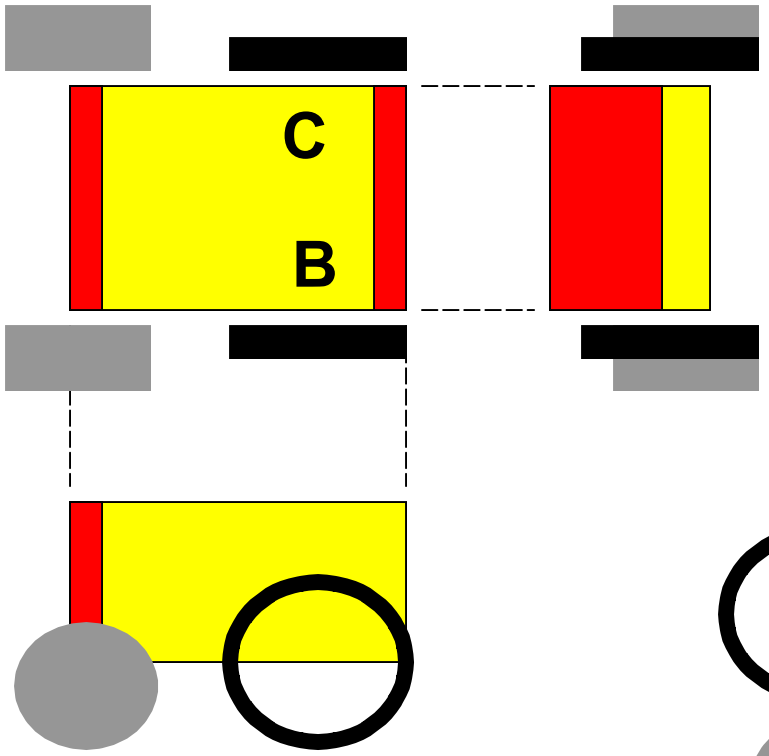


If #3 placed correctly

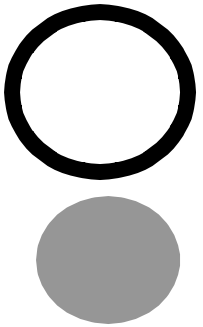
Combinations left 3 x 4 x 4 = 48

Geometry is a powerful weapon

Basic Differential Drive robot



<u>Starting Point</u>
Robot has one motor
Each side, B and C.
Red areas can hold attachments
Driven Wheels in back.
Skid Wheels in front.

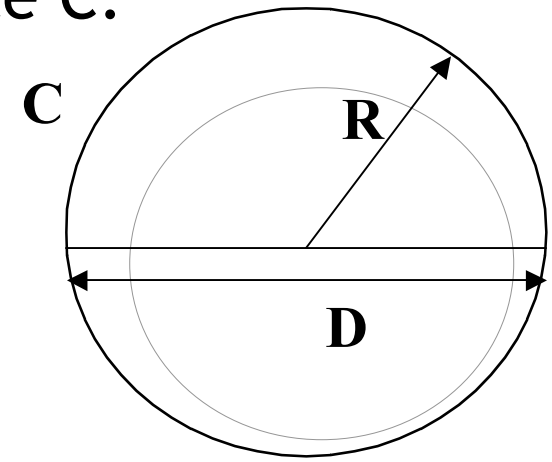


Driven wheels

Skid wheels

Geometry in Basic Navigation

- With a Differential Drive robot the driven wheels are the key to navigation.
- Wheels are circles.
- Diameter (D) used to calculate circumference (C).
- Use C = pi * D.
- Each rotation will move the distance C.
- Review properties of circles.



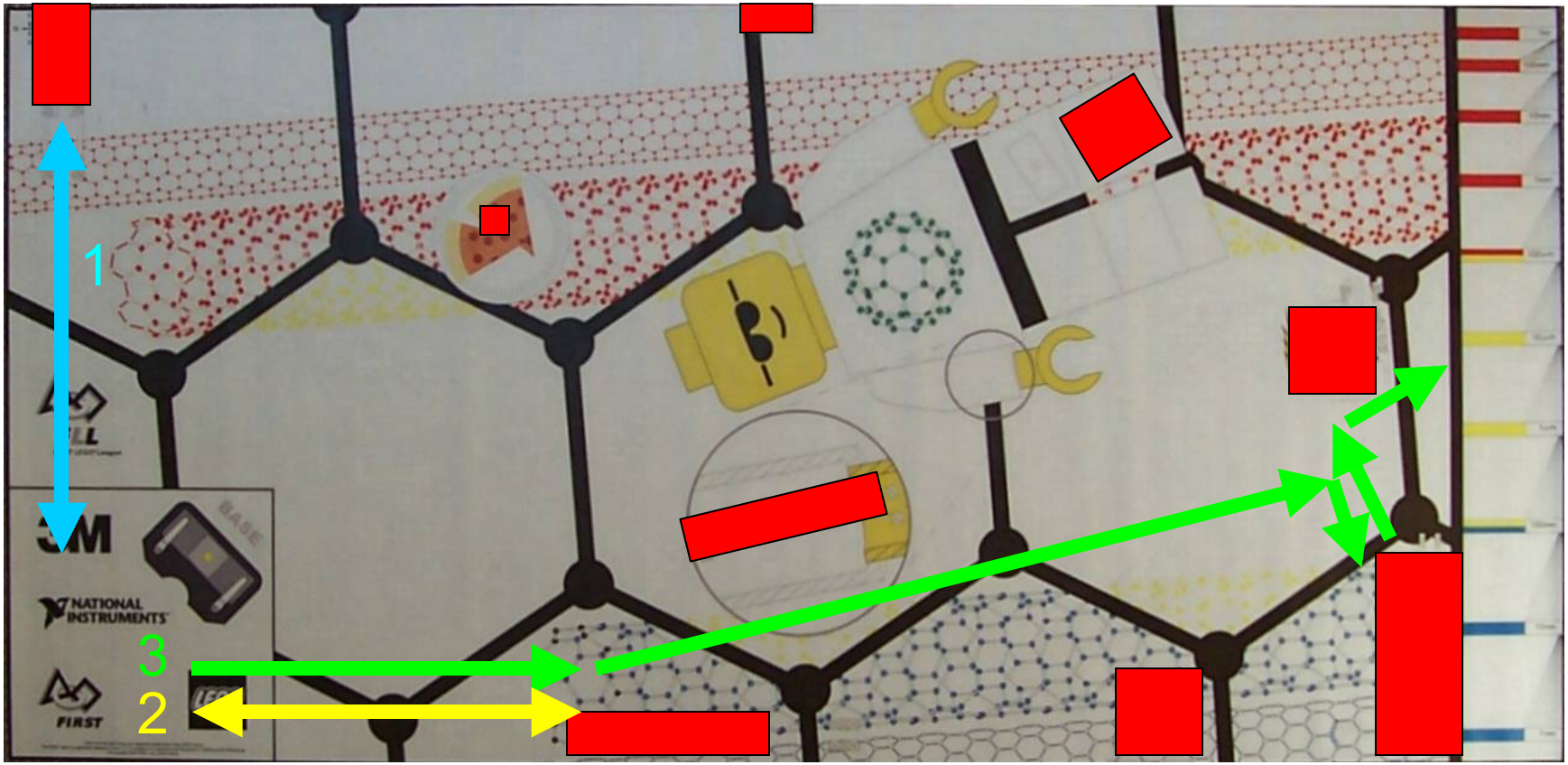
How To Find Wheel Diameter?

- The LEGO Group is a Danish company so metric.
- C = 3.14 * 81.5 mm
- C = 256 mm or 25 cm

C = 3.14 * 56 mm

C = 176 mm or 17.6 cm

Geometry in Understanding Paths



Mission solving involves paths to targets.

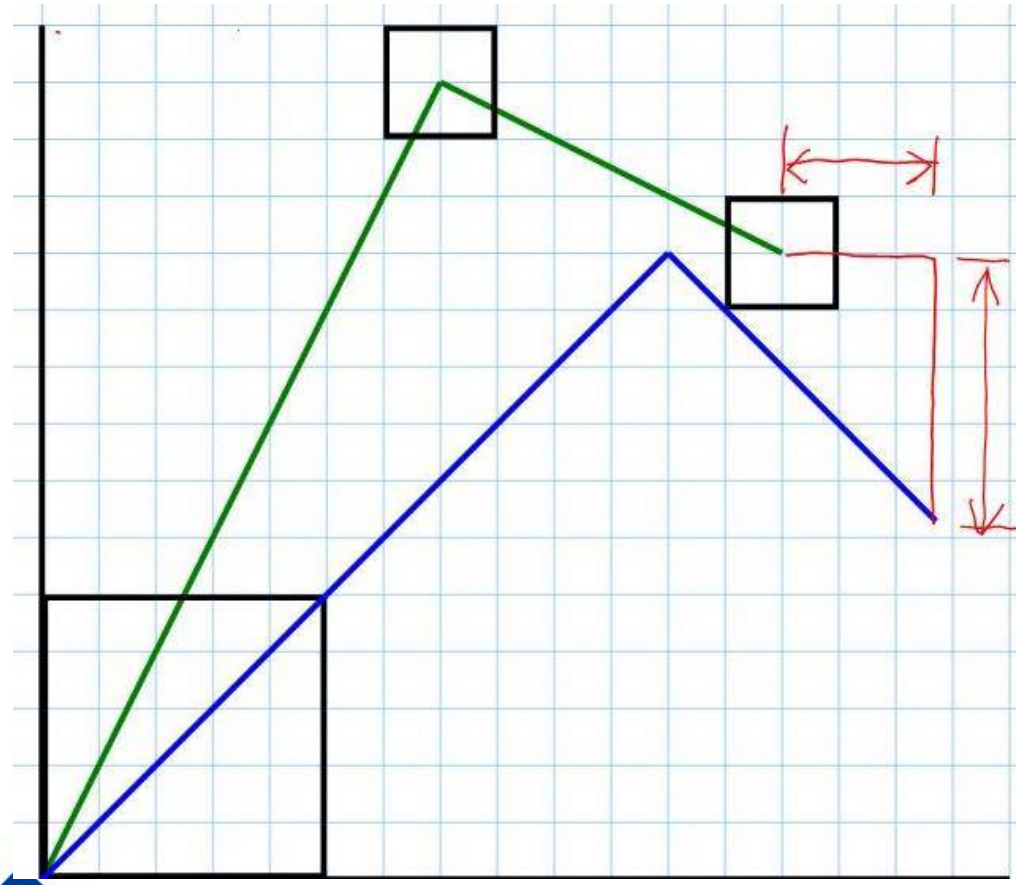
Straight Line Path v. Path with Turns

- Straight Line Path
- Easy to imagine
- Easy to program
- Highly recommended

- Path with Turns
- Involves one or more turns in the path
- Harder to program
- Less repeatable cause more variation

- Rule of Thumb – Use straight line unless obstacles forces a turn. If you have turns, then spend time to make the path with turns reliable (see later).

Why are Paths with Turns Less Reliable?

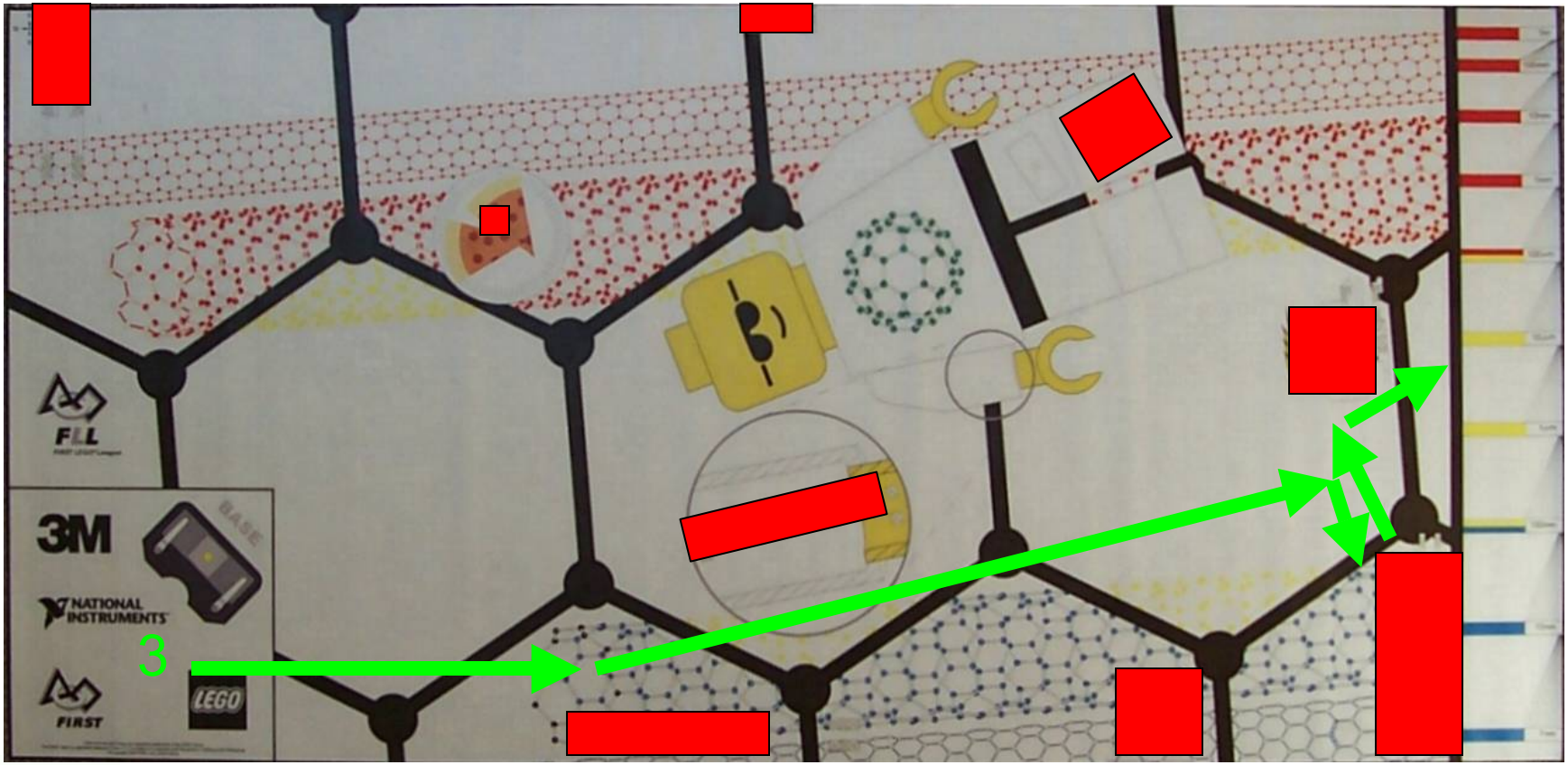


Ideal path in green. Variation in rotation (18.4 deg.) gives blue path - off by about 3 units in horizontal and 5 in vertical (about 5.8). Changes in starting point usually involve both rotation and translation which is worse.

Reducing Errors in Paths with Turns

- **Must** have a controllable, predictable robot.
- Simplify the program as much as possible (less turns are better.
- Use jigs to help fix starting points. Jigs are guides to help locate starting points of robots.
- Use wall guides whenever possible (path 1 & 2)
- Variation may still exist so use the target object as a reference point. The edges of the solid target might be used to help adjustments.

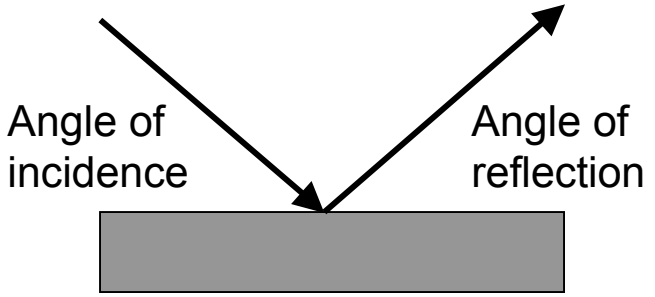
Mission Study: Molecular Motor (MM) and Self Assembling Nanotube (SAN)



Note we aim for spot in between MM & SAN.

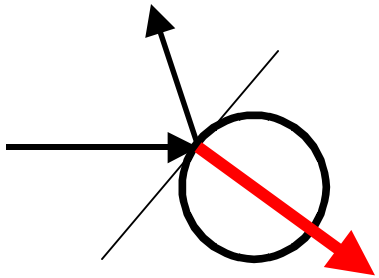
Geometry at the Contact Point with Mission Target

Basic physics/math which can help.
Angle of incidence = angle of reflection



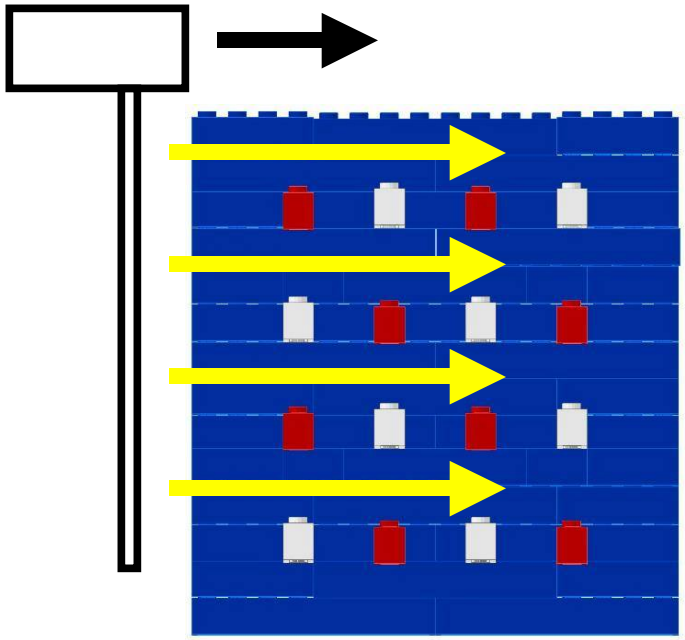
Apply this to objects that are hit during A mission and you have …

Hit an object at an angle and it will bounce off at an angle.

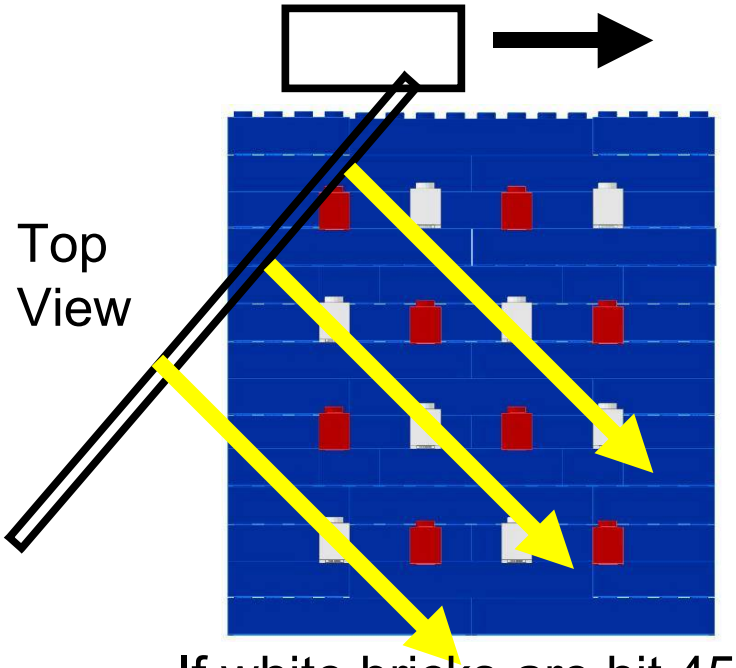


Force Generated And Direction Traveled

Mission Study: Manipulate Atoms



Top View



If white bricks are hit parallel to line of travel, they fall on red bricks and may knock them off platform.

If white bricks are hit 45 degrees to line of travel, they will likely miss red bricks.

Summary of Concepts

- Use geometry in basic navigation by applying the formula pi*D to help determine distance traveled. Can simplify to 3*Diameter.
- Use geometry in path trials for missions by trying the easiest paths (straight line) then paths with turns if obstacles present.
- Use geometry at the point of contact with target as there may be opportunity to make interesting solutions on contact.