INITIATE Lesson Plan: Routes – Designing a route for Autonomous Paratransit Service

Lesson plan at a glance...

Name	Routes – Designing a route for Autonomous Paratransit Service
Course	Geometry
Grade level	9th to 12th
Prerequisites	Speed, Distance and Time; Angle measurements.
Time	**Preparation:** 10 to 15 minutes **Instruction:** 70 minutes
Standards	*TPS:* *Math -* • *G-CO.12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.*

In this lesson plan…

Lesson Overview

Autonomous vehicles are the future of transportation. Various transit agencies are working on using autonomous buses for public transportation, including paratransit services. The paratransit services need some major changes as they are underperforming today. So how would an autonomous paratransit service of future would like? How will the transit agency determine which routes are the best and how will they program these smart buses to run on a fixed route? In this lesson we will design the bus routes for TARPS in the Toledo area. We already have information on what are some of the popular destinations and popular TARTA bus routes and using this information the routes will be planned for Toledo. A prototype of these routes will be traversed using the GoPiGo smart car to emulate a TARPS bus.

Driving Questions

Overarching Driving Question:

- How will autonomous vehicles affect the differently abled people of our society?

Lesson Specific Question:

- What routes need to be planned for these smart buses in Toledo?

Materials and Equipment

- For the student:
    - *Required:*
        - A smart car kit (one (1) kit per x students recommended)
        - An Android tablet connected to the smart car.
        - A cardboard with the map of the routes.
        - Scratch paper
        - Compass
        - GeoGebra
        - Ruler
        - Pencil

Preparation Tasks

	• Check whether all tablets are working, connected to the smart car, and have sufficient battery in them. • The markings on the cardboard must be clearly visible. • To check, whether the smart car is working, try to run the smart car using a single command to make the car move forward for 2 seconds.	5 to 10 minutes

The Lesson

Warm-up Activity: Information Gathering and Brainstorming	10 minutes
Activity 1: Route	1 hour 20 minutes
Activity 2: Implementing Route on GoPiGo	50 minutes
Wrap-up: Conclusions and Inferences	10 minutes

Warm-up Activity: Information Gathering and Brainstorming (10 minutes)

Activity Overview: In this activity, the lesson is introduced, and useful information is provided about the activities that follow.

- What are some of the things we need to consider while planning routes?
- What all information do we have?
- What more do we need?

Read the following article (ppiaf.org, 2006)**:**
https://ppiaf.org/sites/ppiaf.org/files/documents/toolkits/UrbanBusToolkit/assets/1/1d/1d4.html

- Which system of routes do you think will be optimum for Toledo?
- What types of route should suite Toledo the most?

Read the document from TARTA to get the required information: TARTA data.docx

Based on the information let us design the route for Toledo.

Activity 1: Route (30 minutes)

Problem Statement: Given the Map of Toledo, identify the potential destinations or stops for the passengers. Design the itinerary for the individual routes which includes the number of buses running on each route, in each hour, and the times at which a bus will reach at a destination for pick up and drop off (approx.).

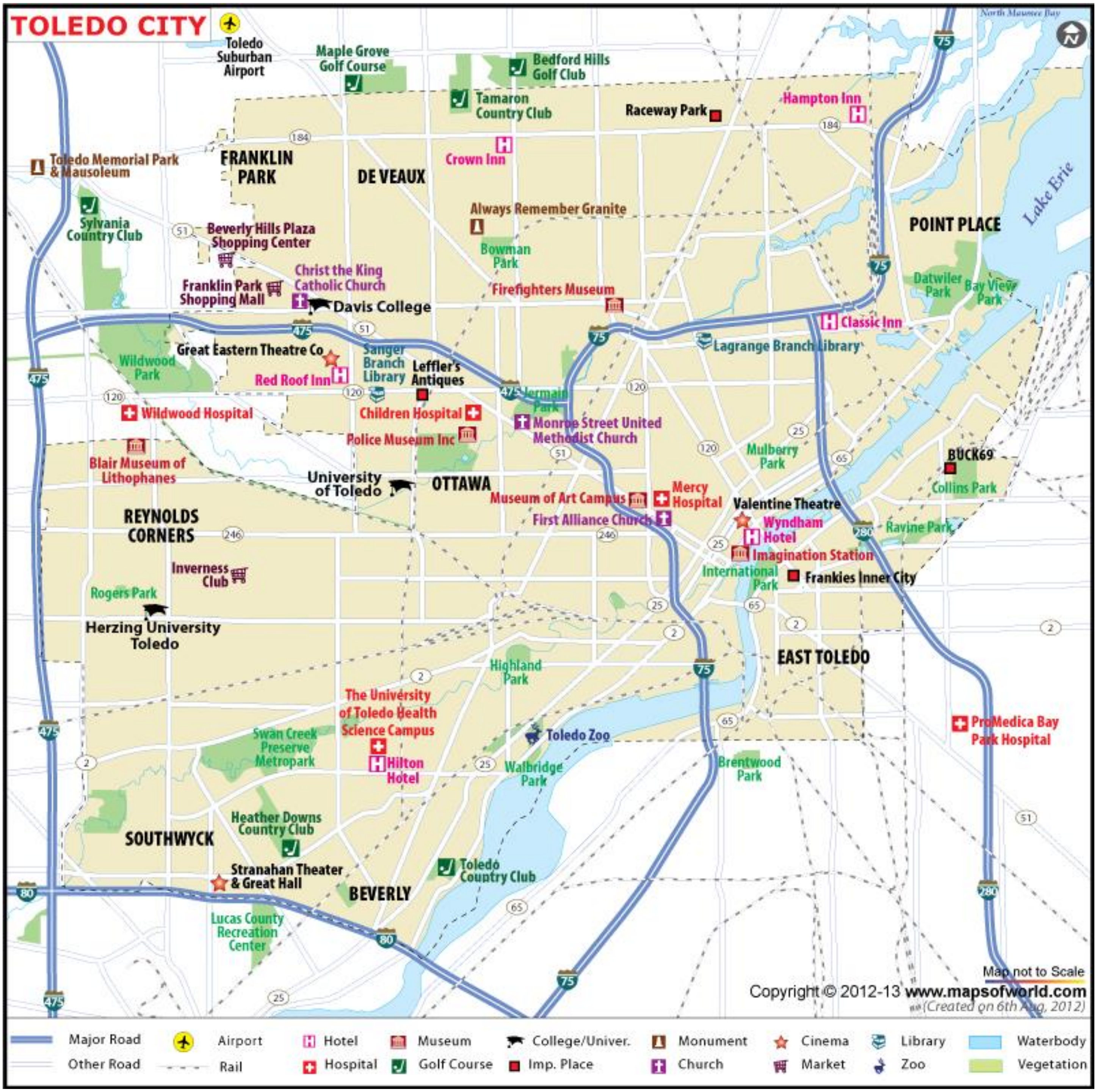

TOLEDO CITY
Toledo Suburban Airport
Maple Grove Golf Course
Bedford Hills Golf Club
Tamaron Country Club
Raceway Park
Hampton Inn
North Maumee Bay
Toledo Memorial Park & Mausoleum
FRANKLIN PARK
DE VEAUX
Crown Inn
Lake Erie
Always Remember Granite
Sylvania Country Club
Beverly Hills Plaza Shopping Center
Bowman Park
POINT PLACE
Christ the King Catholic Church
Franklin Park Shopping Mall
Firefighters Museum
Datwiler Park
Bay View Park
Davis College
Classic Inn
Great Eastern Theatre Co
Sanger Branch Library
Lagrange Branch Library
Wildwood Park
Red Roof Inn
Leffler's Antiques
Jermain Park
Wildwood Hospital
Children Hospital
Monroe Street United Methodist Church
Police Museum Inc
Mulberry Park
BUCK69
Blair Museum of Lithophanes
University of Toledo
OTTAWA
Mercy Hospital
Museum of Art Campus
Valentine Theatre
Collins Park
REYNOLDS CORNERS
First Alliance Church
Wyndham Hotel
Ravine Park
Imagination Station
Inverness Club
International Park
Frankies Inner City
Rogers Park
Herzing University Toledo
EAST TOLEDO
Highland Park
The University of Toledo Health Science Campus
ProMedica Bay Park Hospital
Swan Creek Preserve Metropark
Toledo Zoo
Hilton Hotel
Walbridge Park
Brentwood Park
Heather Downs Country Club
SOUTHWYCK
Stranahan Theater & Great Hall
Toledo Country Club
BEVERLY
Lucas County Recreation Center
Map not to Scale
Copyright © 2012-13 www.mapsofworld.com
(Created on 6th Aug, 2012)
Major Road
Other Road
Airport
Rail
Hotel
Hospital
Museum
Golf Course
College/Univer.
Imp. Place
Monument
Church
Cinema
Market
Library
Zoo
Waterbody
Vegetation

Figure 1

Section 1: Planning (2 minutes)

Divide the class into 4 groups. The map of Toledo is divided into 4 sections given below.

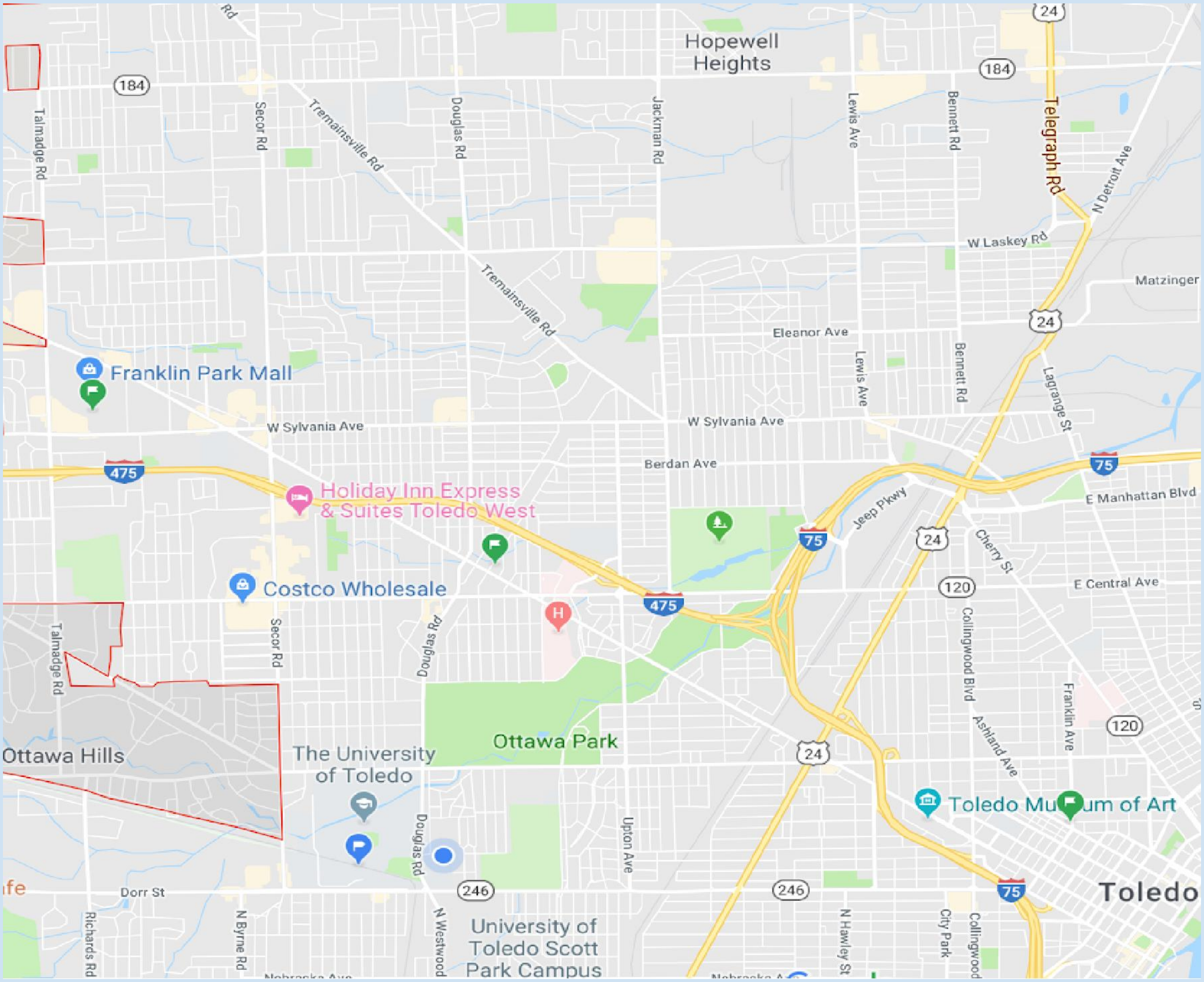
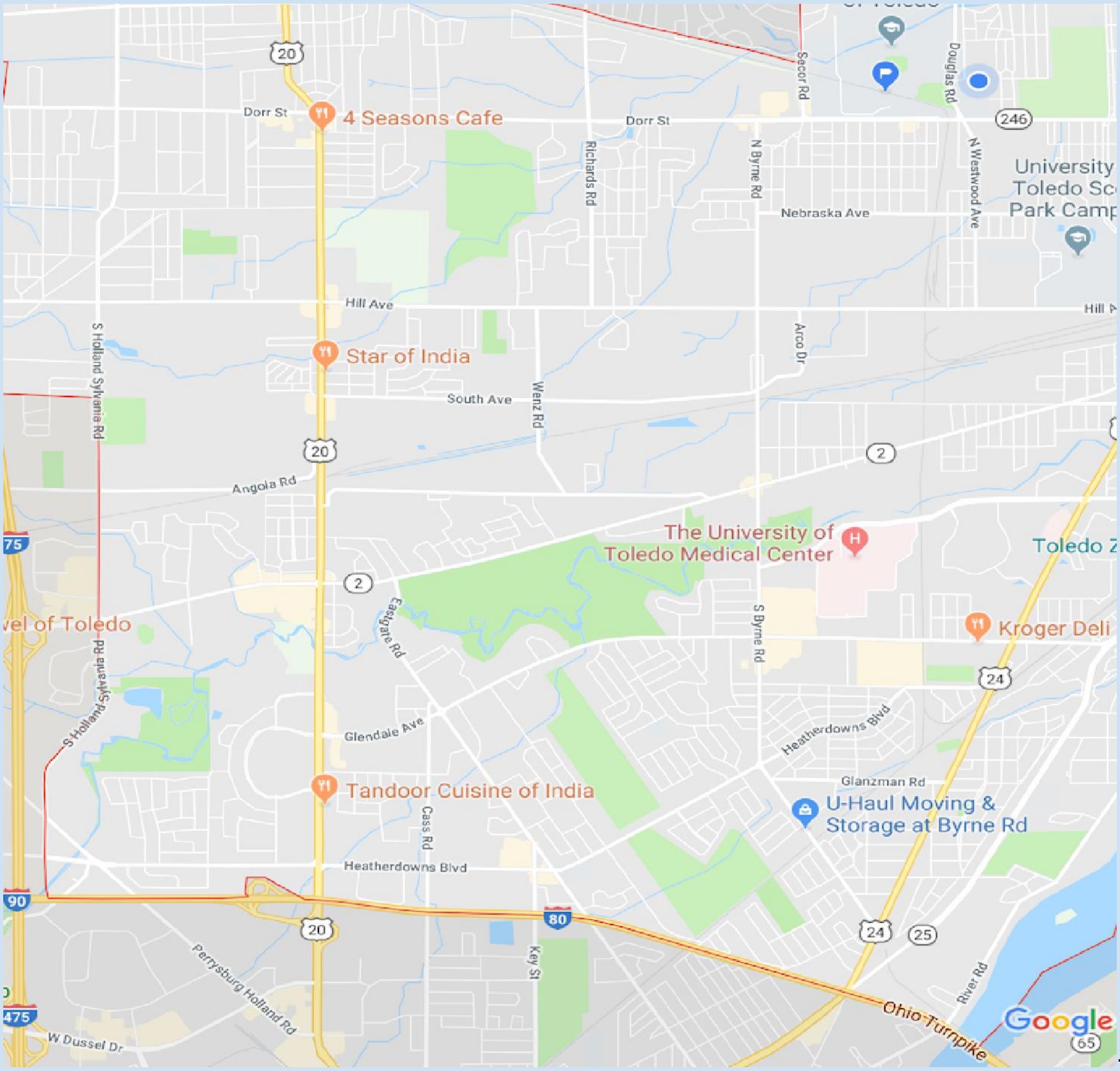


Fig 2: Area 1


Alexis Addition
Toledo North
Chrysler - Toledo Assembly Complex
BP Toledo Refinery
Toledo Museum of Art
Toledo
Telegraph Rd
W Laskey Rd
Matzinger Rd
E Manhattan Blvd
E Central Ave
Sherman St
Champlain St
N Erie St
N Summit St
New York Ave
Galena St
Front St
York St
Consaul St
Seaman Rd
Corduroy
Cedar Point Rd
Millard Ave
Wheeling Street
Summit St
131st St
108th St
Ottawa River Rd
Shoreland Ave
Suder Ave
Stickney Ave
Enterprise Blvd
Benore Rd
N Detroit Ave
Lagrange St
Bennett Rd
Cherry St
Collingwood Blvd
Ashland Ave
Franklin Ave
Main St
N Coy Rd
Edgewa

Fig 3: Area 2



4 Seasons Cafe
Star of India
Tandoor Cuisine of India
The University of Toledo Medical Center
Kroger Deli
U-Haul Moving & Storage at Byrne Rd
University Toledo Sc Park Camp
Dorr St
Hill Ave
South Ave
Angola Rd
Glendale Ave
Heatherdowns Blvd
Nebraska Ave
Glanzman Rd
Ohio Turnpike
Perrysburg Holland Rd
W Dussel Dr
S Holland Sylvania Rd
Richards Rd
N Byrne Rd
S Byrne Rd
Wenz Rd
Cass Rd
Key St
Eastgate Rd
Arco Dr
Secor Rd
Douglas Rd
N Westwood Ave
River Rd
Google

Fig 4: Area 3

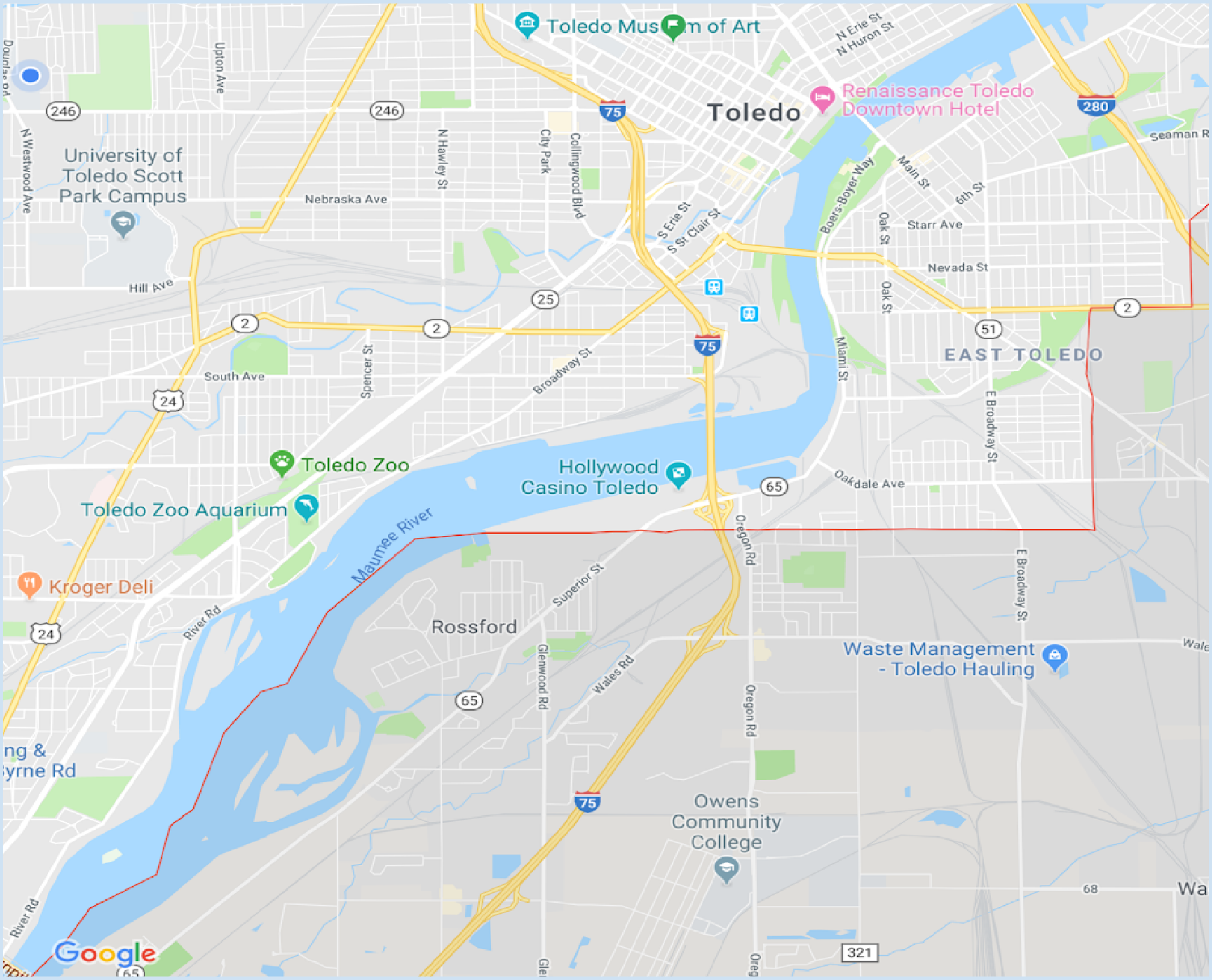


Fig 5: Area 4

Each group gets to work on 1 section of the map.

Teaching Tips:

- For students good in algorithm design, the teacher can ask those students to devise an algorithm that can traverse the path or give an idea on how this functionality can be achieved.

Section 2: Selecting popular destinations (20 minutes)

For each section of the Map the students will mark the popular destinations. Based on the information provided by TARTA in the document, the teachers will select some of the popular routes. To give a hint they can visit this link (http://tarta.com/routes/) to find the already existing TARTA routes. They will be using google to search for hospitals, shopping centers, malls, schools, workplaces, etc, while once they have selected the routes. Some of the necessary destinations have to be Franklin park Mall, Toledo Museum of Art and Toledo Zoo, Amtrack Train Station, and Toledo Airport. Based on this information they will change the route to suit the needs of people with disabilities and select the number of stops in the route.

Teaching Tips:

- If students came up with a different algorithm or program and it works fine, then let them go with their program. Just check for the values used in the program. They need to be the same as mentioned in the problem.

Section 3: Finding Time Taken (30 minutes)

Based on the destinations selected, find out the time taken to reach from one point to the other. This can be done using Google Maps. Enter a source and destination and select the route you want to take, then Google Maps will show you the time taken to reach from the source to the destination.

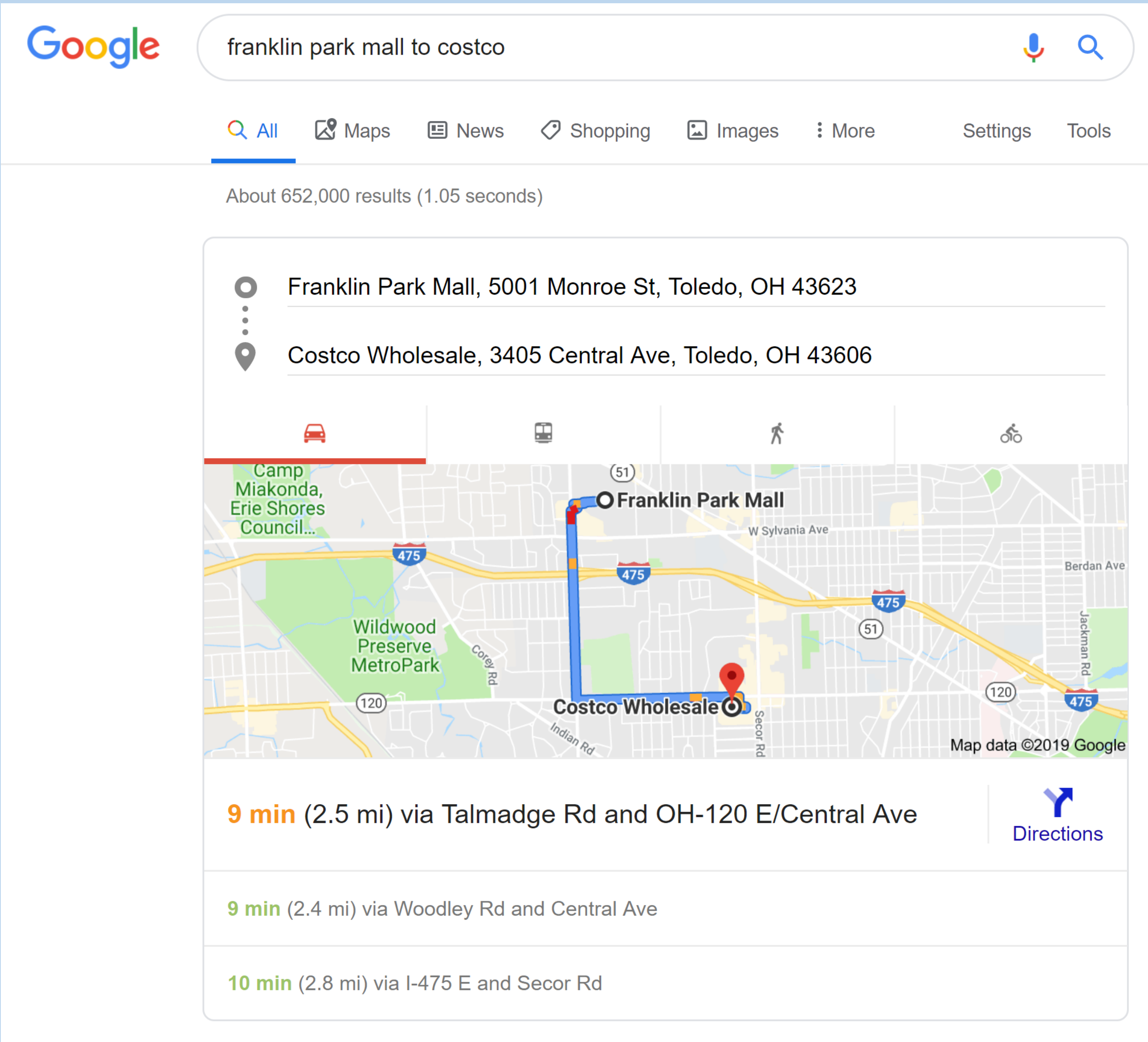


Fig. 6

Record this information in the form of a table. Keep a track of stop signs and traffic signals in the area while calculating the trip time. Number of stop signs and traffic lights can be determined using Google Maps 3D view (Show demo). Considering an average wait time of 1 minute at a traffic signal, and 3 seconds on a stop sign.

Stops	Time (mins)
A-B	10±2
B-C	5±1
…	…
I-J	2
A - J	$\sum time$

Calculate the roundtrip time for the route by multiplying total time taken by 2.

Section 4: Scheduling (30 minutes)

Now that you have determined the time taken for completing each trip, design a schedule for the buses to run, keeping in mind the rush hours, number of passengers and the number of buses running. For rush hours, i.e. 9-11 and 3-6, the minimum number of buses running on a route should be 4, and in the afternoon, the minimum number of buses running should be 2. You can add more if the route is busy.

Stops	9 am – 11 pm	11 pm- 3pm	3 pm – 6 pm
A	9:00, 9:20, 9:40, 10:00, etc.		
B	9:10, 9:30, 9:50, 10:10, etc.		
C	9:15, 9:35, 9:55, 10:15, etc.		
…	…		
J	9:45, etc.		

Activity 2: Implementing Routes on GoPiGo (50 minutes)

Problem Statement: Now that we have the routes prepared, we are going to implement the route on a GoPiGo? Some of the things we need to find are the distances between each of the stops, the turning angles, and the stops and traffic signs. Design the proposed route on trifold boards, and program the smart car to traverse that route. Make sure that the smart car stops at the pickup and drop off points (or destinations) by parking appropriately (parallel parking).

Section 1: Finding the distances and angles (15 minutes)

The map is not the best visual representation for designing the prototype. Hence, we use GeoGebra (an online geometry tool) to make a simplified model of the route. Suppose the starting point is Bowsher High School, and the destination is Franklin Park Mall.

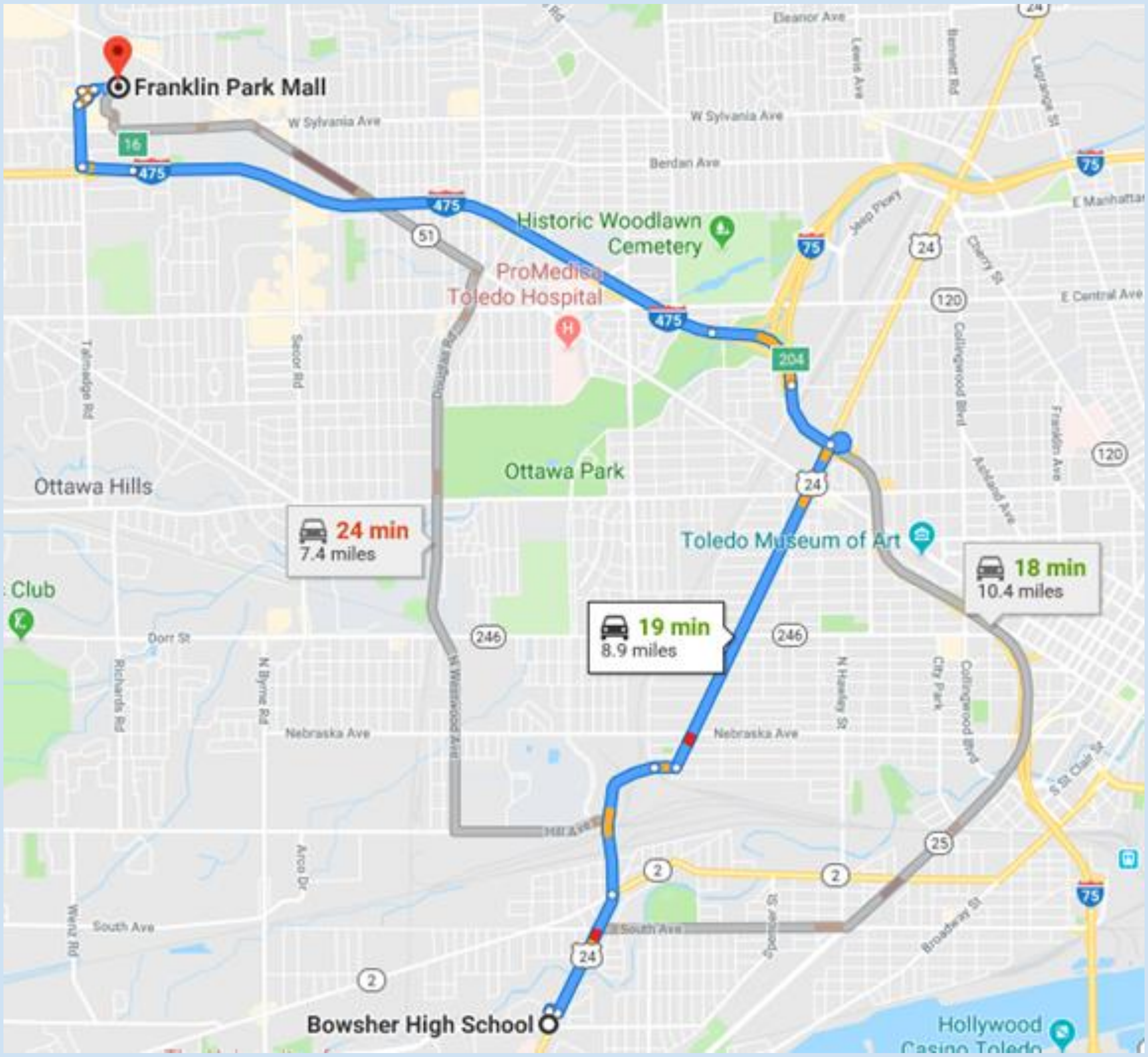


Fig. 7

Some of the things we need here are the distances, angles and the speed limits. We can find the speed limits using Google Street View and look up the speed limits there and the distances and angles can be found using “GeoGebra” (online tool for graphing and mapping).

Fig. 7 is uploaded to GeoGebra and the lines and curves displayed on the map are mapped using lines, as shown in Fig. 8.

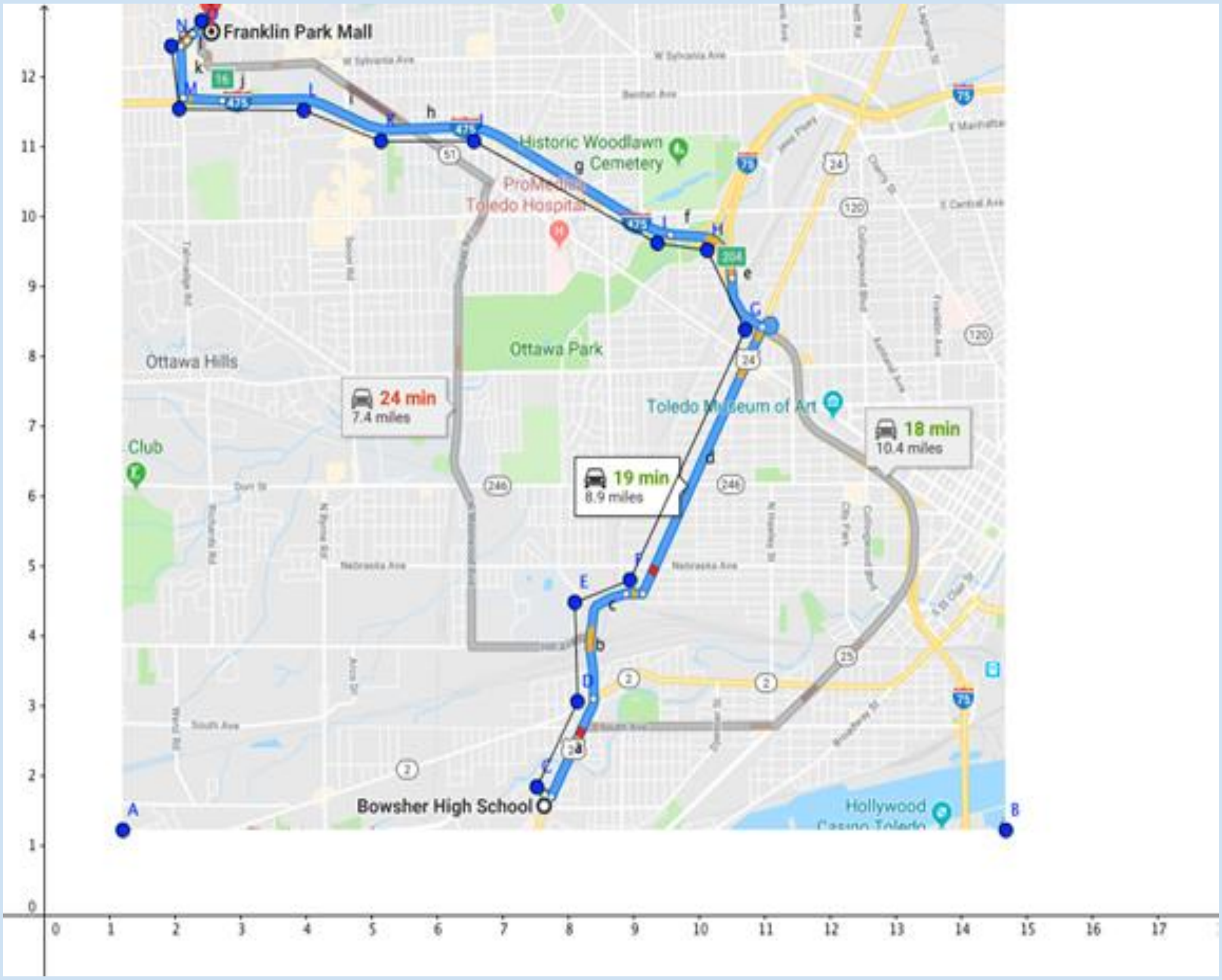
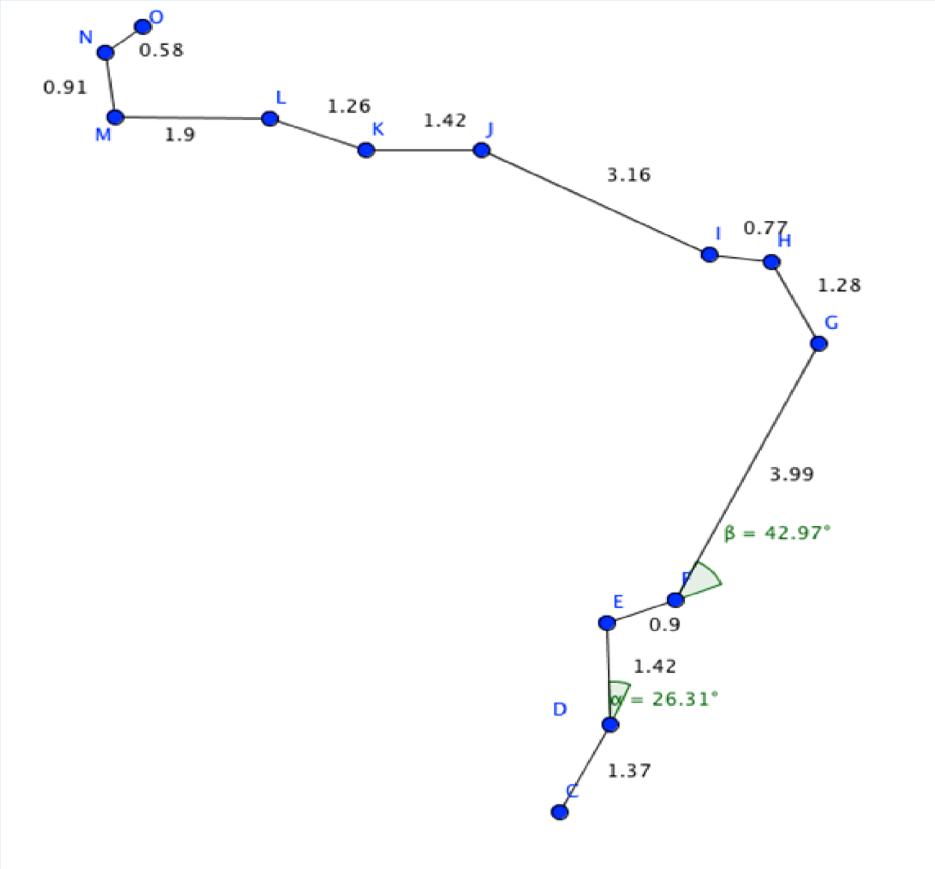


Fig. 8

Now the Skeleton is used for calculating lengths and angles of the turns, as shown in Fig. 9.



Now a program is made on Bloxter to traverse this route using the length of the lines and the turning angles to make the GoPiGo traverse the scaled down version of the route.

Teaching Tips:

- For students good in algorithm design, the teacher can ask those students to devise an algorithm that can traverse the path or give an idea on how this functionality can be achieved.

Wrap-up: Conclusions and Inferences (10 minutes)

Activity:

- Is this way the most efficient way of designing a route follower?
- Can we make this process dynamic?
- What are some of the advantages and challenges of using a fixed path route?

Assessment:
Collect students' reflections. Assess for thoughtful, complete responses and experimental understanding. The students' interest in STEM.

Learning Objectives and Standards

Learning Objectives	Standards
LO1: Analyze a problem and suggest possible solutions.	*Computer Science* CSTA L1:6.CT.6: Understand the connections between computer science and other fields. CCSS.MATH.PRACTICE.MP1: Make sense of problems and persevere in solving them.
LO2: Identify which route took the minimum time.	*Math -* • *G-CO.12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.*
LO3: Verbalize a plan (an algorithm) for the whole process.	
LO4: Code the smart car to run as per the requirement in the question.	
LO5: See the mathematics behind everyday things.	
LO6: Make inferences and justify conclusions based on the observations made both by numerical analysis and experimentation.	

Additional Information and Resources

Project-based Learning Features

Feature	Where does this occur in the lesson?
Driving Question	This lesson plan has a driving question which asks the attendants to create the itinerary for the autonomous paratransit buses.
Investigation & Problem Solving	A Problem Statement is presented at the beginning of each Activity. These problems are solved in the Activities using an Experimental Approach.
Technology Incorporation	This lesson requires the use of a robot car named GoPiGo(Dexter Industries) and a smart Android Tablet for experimental purposes, and the use of Google Classrooms and other Google products for Evaluation, Cloud Sharing, and Online Activities.
Collaborative Opportunities	In both the Activities designed, the people involved in the lesson are working in groups. They share their ideas and knowledge with each other, leading to Collaborative Learning Opportunities. They are also sharing their results and other observations in Google Classroom where they can see the results of others and learn as a group.
Assessment techniques	Assessment is done on whether the program is achieving the desired functionality, the efficiency of the program, the results obtained, and the conclusions are drawn based on the experiments conducted.

Computational Thinking Concepts

Concept	Where does this occur in the lesson?
Algorithm Design	Activity 2 requires the use of a computer program for which an algorithm is necessary. In Activity 1 – Section 2, we are developing algorithms to make the car achieve a certain functionality.
Pattern recognition	To follow the routes precisely, a pattern is observed in Activity 1. In Activity 2, the pattern needs to be observed in the power consumed by each algorithm.
Decomposition	The whole route needs to be broken down into smaller paths which is an example of decomposition.

Administrative Details

Contact info:	www.utoledo.edu/research/initiate
Sources:	ppiaf.org. (2006). *EVALUATE YOUR BUS SYSTEM - Factors Influencing Bus System Efficiency / Route Planning*. https://ppiaf.org/sites/ppiaf.org/files/documents/toolkits/UrbanBusToolkit/assets/1/1d/1d4.html
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