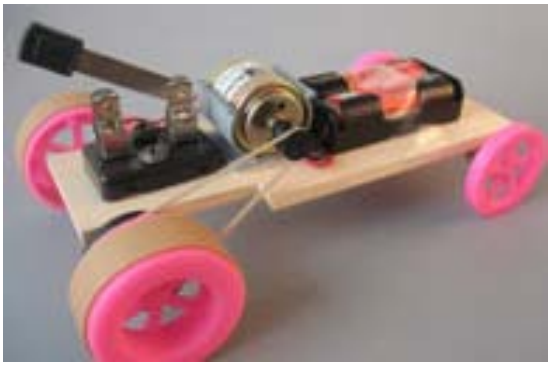
ثانويـة التكنولوجيـا التطبيقيـة
Applied Technology High School

Technology Exploration-II

Module 4: Project



PREPARED BY

Academic Services Unit

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Module 4: Project

Module Objectives

In this project-based module, students will be able to:

- Explore how simple machines could be used to build simple systems.
- Explore how electrical machines could be used to run compound machines.
- Explain the purpose of electric cars.
- Design and assemble an electric car using simple machines, batteries and other components and test its functioning.
- Present the project through a PowerPoint presentation.

Module Content:

4.1 Project Objective

Design and build a working prototype of a *Pulley Motor Car* that can travel with a constant speed. The speed can be any value within a range of 0.2m/s and 0.7m/s.

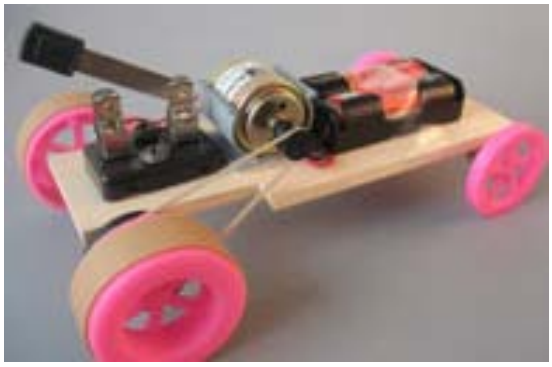

Figure 4.1: Pulley motor car

4.2 Curriculum Integration

Engineering concepts

- Use of simple machines to build a compound machine.
- Application of an electric motor.
- Mechanical advantage of pulleys.
- Gear ratio.
- Motion types, propulsion types and drive concepts.
- Basic soldering techniques.

Physical Science concepts

- Calculation of speed.
- Interpretation of motion graphs.
- Identification of action and reaction forces.
- Energy transformation.

Math concepts

- Literal Equations and Dimensional Analysis; solve for a specific variable.

4.3 Curriculum Framing Questions

Essential Question	➢ Why are engineers interested in simple machines? ➢ How can we use machines to make our life easier?
Unit Questions	How can you build an electric car using simple machines? What design aspects should you consider to set the desired speed limit for your car?
Content Questions	➢ What are simple machines, and compound machines? ➢ What are electric cars suited for? ➢ What are the advantages of using electric cars or battery powered cars? ➢ What is a Pulley motor car? ➢ How can you use the distance-time graph to compare the speed of your motor car with that of your classmate's? ➢ How can you identify the action and reaction forces in a given system? ➢ What is the relation between mechanical advantage and speed? ➢ What is the relation between gear ratio and speed?

4.4 Introduction

How can we use machines to make our lives easier?

The aim of machines is to make our work easier, or perhaps more enjoyable. Finding ways to make work easier is what drives people to invent machines. Thomas Alva Edison invented an electric car to make travel easy. Electric cars have been around for more than 100 years, and the one developed by Edison would run for six hours on a single charge.

Figure 4.2:Thomas Edison's electric car

What are electric cars suited for?

Because they are nonpolluting, quiet, and have short ranges, they are ideally suited for use as fleet cars. Commuters could also use them for traveling to and from work each day, with a brief overnight recharging.

What are the advantages of using electric cars or battery powered cars? How long do they take to charge?

Battery powered cars have few moving parts, require little maintenance, and are inexpensive to operate. However, the lead-acid batteries are heavy, have a limited capacity, are slow to charge, have a short life, and are expensive to replace. If lead acid batteries were replaced by lithium-ion battery packs, the range of the car would double and the batteries would last 10 years, but these are expensive. All these batteries have a high-energy capacity and they recharge within 4 to 6 hours.

Figure 4.3: Lead-acid battery

What are hybrid gas-electric cars?

Scientists are continuing to research new battery technologies to increase performance, reduce weight, and lower the cost of batteries. Both Honda and Toyota have recently introduced a hybrid gas-electric car.

Figure 4.4:Hybrid gas-electric car

These cars run on both electrical energy and gasoline and never need recharging. Hybrid cars capture the kinetic energy produced by braking, and store it in the battery for later use. Battery-charging systems are also currently under development. Some would look like parking meters and could charge a battery in about two hours.

What is a Pulley motor car?

A Pulley motor car is an electric car using pulleys to transfer the mechanical energy from the motor to the wheels. It uses pulleys and belts for its transmission system.

In this project, students will build a Pulley motor car using simple machines including pulleys, screws, wheel and axle, an electric motor, a battery, and various other components. The motor car's propulsion system includes two AA batteries and a DC motor with a Pulley and Rubber band drive. Students are encouraged to experiment with different size pulleys. Students are also encouraged to re-visit Technology Exploration-I course, in order to remind themselves of the functions of the various mechanisms that are used in this project.

4.5 Material List

1. Battery holder
2. AC motor
3. Rear wheels 1 9/16" diameter x 5/8" wide
4. Front wheels 1 3/8" diameter
5. 1/8" dowel for axles
6. Traction bands
7. Eyelets or washers
8. Straw
9. Eye screws
10. Pulleys (different sizes)
11. Wood sheet 5" x 2" x 3/32" (or larger, so you can cut to any size)
12. Axle guards, basswood 1/5" x 1/5" x 2" (5mm x 5mm x 5cm) sticks
13. Motor mount (with straps if needed)

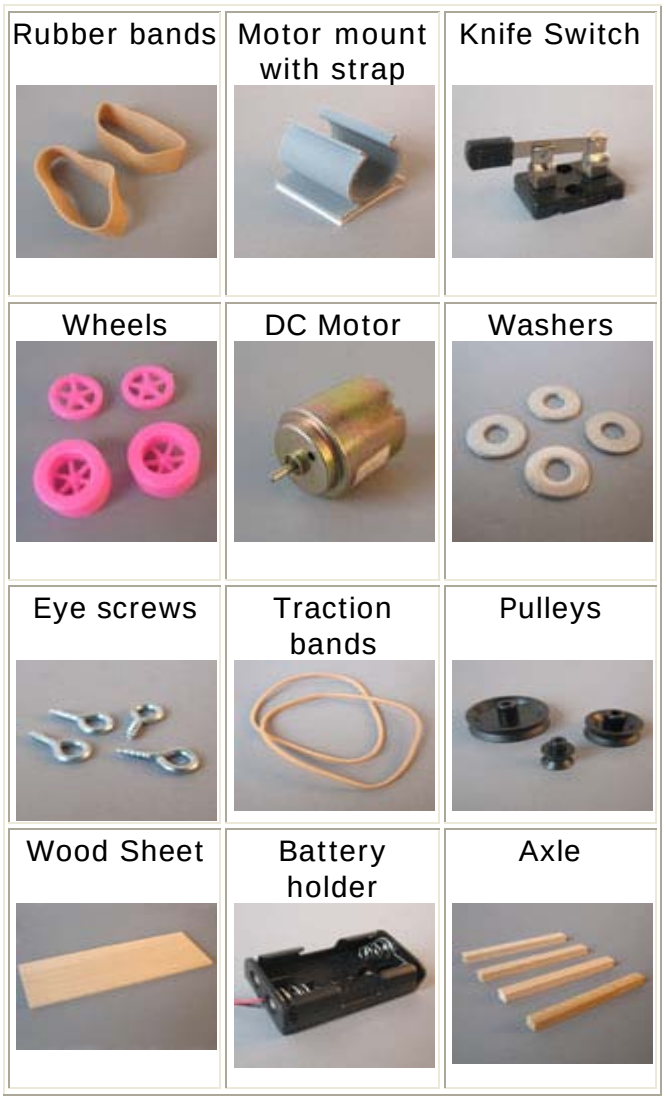

Figure 4.5: Pulley motor car parts

Basic Tools Required

These items may be required to build the pulley motor vehicle:

- Craft knife, used to cut or trim soft wood.
- White glue, wood glue or glue gun.
- Soldering Iron, needed if you need to solder wires.
- Pliers, used to connect and twist wires together if needed.
- Rulers, used for measurements.
- Pencil, used for marking.

4.6 Safety Requirements

During the construction of the vehicle, the following safety precautions should be observed.

1. Wear eye protection when working with tools and materials.
2. Follow all of your teacher's safety instructions when using tools.
3. Use special caution with the soldering iron, so as not to burn yourself or any equipment or materials.
4. Use extreme caution with sharp cutting blades.

4.7 Procedure

The steps below could be followed to build the prototype. However, in places where the dimensions are given in inches, students need to convert them to cm or mm. Also, students could alter the dimensions and come up creative designs for the body or chassis of the car.

Step 1: Construct the basic car chassis with four wheels.

1. Cut a strip of wood that is 2" (5cm) wide.
   Mark the location of axles by drawing two lines, one on each end of the car, parallel to the front or back side. Axle lines must be about 1 inch away from the front or back.
   On the axle lines, mark two points that are 1/4" (6mm) away from each side. Insert one eye screw in each of the points. Refer to figure 4.6.

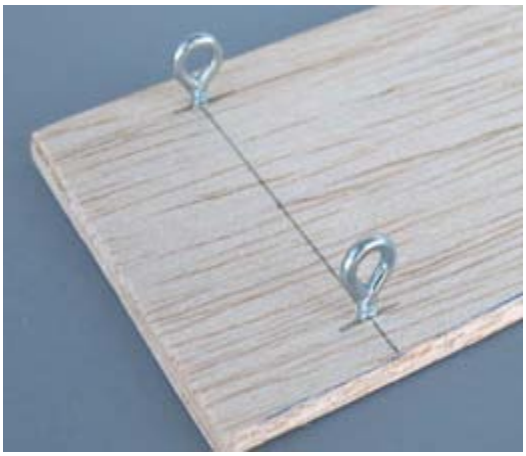

Figure 4.6

2. Eye screws are used to hold the axles. Insert the axle and make sure it is level and it can spin freely. If necessary, adjust the eye screws.
   For the back wheels cut a space for the pulley before inserting the eye screws (see figure 4.12). Without cutting a space for the pulley, one wheel will stay out about 3/8" more than the other.

Figure 4.7

3. Cut some plastic tubes or straws and use them as the spacer in both sides. See figure 4.8.
   If you have metal washers, insert them between the straw pieces and the eye screws.

Figure 4.8

4. Insert the wheels. Wheels may be inserted while the axle is in position. You can also insert the axle into one wheel and then pass it through the eye screws. Refer to figure 4.9 for illustration.

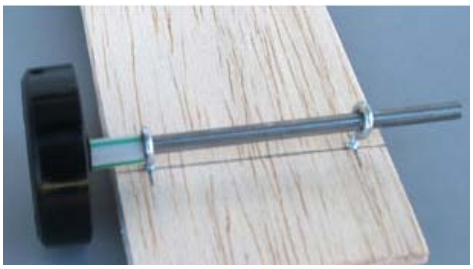

Figure 4.9

5. At the end your simple car will look similar to this. You can use it the way it is or you can turn it over as shown in figure 4.10

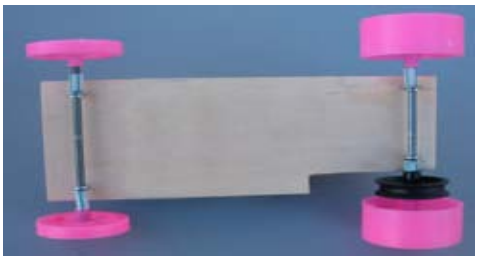

Figure 4.10

6. In the model shown in figure 4.11, the gears are built in the rear wheels. With plain wheels, you will have to insert a pulley or gear in the same axle with one wheel.

Figure 4.11

7. To mount a pulley or gear next to one wheel, it is a good idea to cut some space for that on your chassis; otherwise, one wheel will stand out and your model will not have a symmetrical shape. The size of this space may vary depending on the size of your pulley or gear. (3/8" x 1 1/2" cut is shown in this example in figure 4.12)

Figure 4.12

8. Figure 4.13 shows how a pulley or gear may be mounted beside one of the wheels. The pulley or gear must have a hole matching the axle diameter and must fit closely. Some pulleys and gears require a plastic insert and some drilling in order to adapt the diameter of the axle you are using. After mounting, make sure that the wheels can spin freely. If necessary, mount a metal washer between the spacer and eye screws.

Figure 4.13

Other methods of mounting the axle

9. In case you may not find eye screws for mounting the axles, this is an alternate method for mounting wheels and axle.
   Insert the axle in one wheel, slide a washer onto it. Insert a 5 1/2" straw over it and finally insert another washer and another wheel. Refer to figure 4.14.

Figure 4.14

10. Your final wheels and axle will look like the one shown in figure 4.15. Hold the straw and spin the wheels. Make sure the wheels can spin freely. If necessary, make some adjustments.

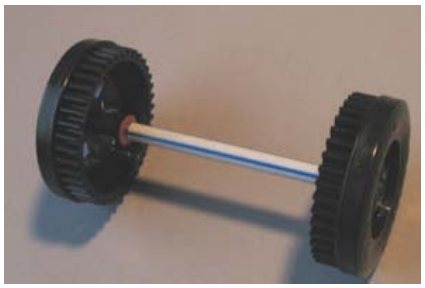

Figure 4.15

11. Cut 4 pieces of 2" (5cm) long wood strips and glue them about 1/5" (5mm) apart where you want to mount the axles. Refer to the illustration is figure 4.16.

Figure 4.16

12. Insert the axle in the space between the strips and secure them in place using some glue. Cover it with a strip of cardboard or heavy construction paper. Refer to figure 4.17.

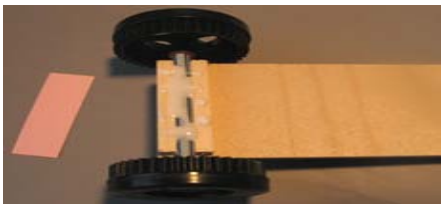

Figure 4.17

13. Note that the glue will touch the straw, not the axle. Figure 8.18 shows how the bottom of your car will look like after covering the axle holder with a strip of paper.

Figure 4.18

Step 2: Mount the motor

14. Insert the small gear or pulley onto the motor's shaft. Place the motor on the self adhesive motor mount and strap it securely and closely. Refer to figure 4.19.

Figure 4.19

15. Place the motor on the car while the car is on a flat surface. Move it towards the gears until the gears engage. Mark the location of the motor. Avoid too much pressure on the gears because it will increase the friction and make it difficult for the car to move.

16. If you use pulleys to transmit force, motor must be mounted away from the pulley so that the rubber belt is slightly stretched. Carefully peel off the protective cover of the adhesive pad. Make sure you will not remove the adhesive pad itself. Place the motor where you already marked. Push it down firmly to stick in place. Mount the rubber band belt between the wheel pulley and the motor pulley as in figure 4.20.

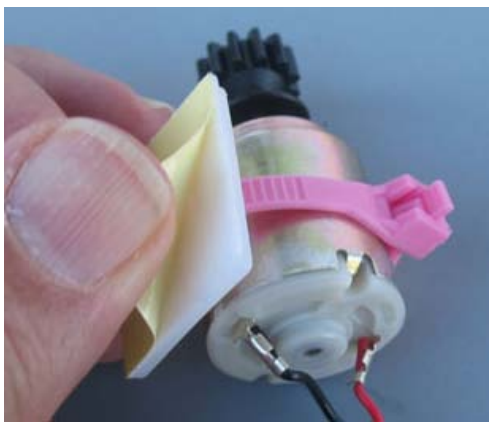

Figure 4.20

Step 3: Mount the battery holder.

Place the battery holder on the car, secure it in place with some glue. Connect the black wire of the battery holder directly to the motor. Connect the red wire of the battery holder to the switch, then connect another small piece of wire from the switch to the motor. Insert the batteries while the switch is open.

Step 4: Testing its operation.

Test the car while it is still in your hands. Do the wheels spin? In what direction? If the wheels are spinning backward, switch the wires around on the motor.

Place the car on the ground and test it. Does it run on the ground?

Does the speed limit fall within 0.2m/s and 0.7m/s? *Follow task-1 on page 15 to decide on the size of the gears. The objective is to set the required speed for your car (range: 0.2m/s to 0.7m/s).*

Step 5: Presentation

The final pulley motor car you make may appear different based on the materials you use. You may have additional decorations if you wish. Decoration may include wooden or cardboard pieces, and you can also paint your car if you wish.

4.8 Knowledge and Skills

What do you need to know to be able to do to complete the project tasks successfully? How and when will you learn the necessary knowledge and skills?

KNOWLEDGE AND SKILLS NEEDED	LEARNED DURING THE COURSE	TAUGHT BEFORE THE PROJECT	TAUGHT DURING THE PROJECT
Knowledge of the following engineering concepts: • basics of simple machines • basics of electric motors • mechanical advantage • gear ratio	Y		
Knowledge of the following Physical Science concepts: • speed measurement, • interpretation of motion graphs, • Newton's third law of motion, • energy transformation.		Y	
Knowledge of the following Math concepts: • solve for a specific variable.		Y	
Drawing and dimensions		Y	
Soldering			Y
Cutting, Filing			Y
Drilling			Y
Soldering			Y
Presentation			Y

4.9 Activities

Task1: Set the speed.

Install pulleys of different sizes in the rear wheel and the motor, and follow the instructions below to select the pulleys.

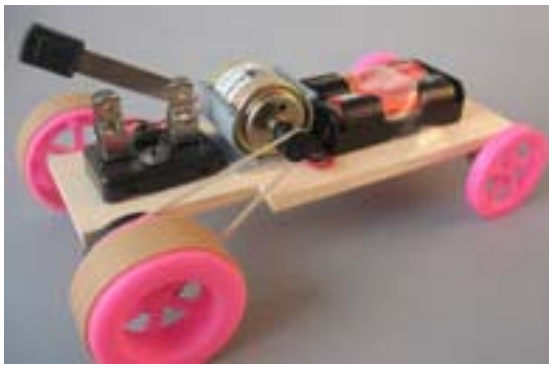

Figure 4.21

1. Install the first set of pulleys. Calculate the mechanical advantage. Also, measure the time taken by the car to travel a stretch of 2m, and calculate the speed of the car.

2. Change the combination of pulleys, and repeat the procedure until your car is able to meet the required speed (any speed between 0.2m/s and 0.7m/s).

Pulley Setup	Mechanical Advantage	Distance	Time	Speed
A		2m		
B		2m		
C		2m		

(Gears could also be used instead of/in addition to the pulleys to set the desired speed).

Task 2: Plot and interpret motion graphs

1. Record the time taken by your car to travel different distances, and plot a distance time graph.
2. Record the time taken by your friend's car to travel different distances, and plot the distance-time curve on the same graph.
3. Calculate the slope of the curves, and compare the average speed of both cars.

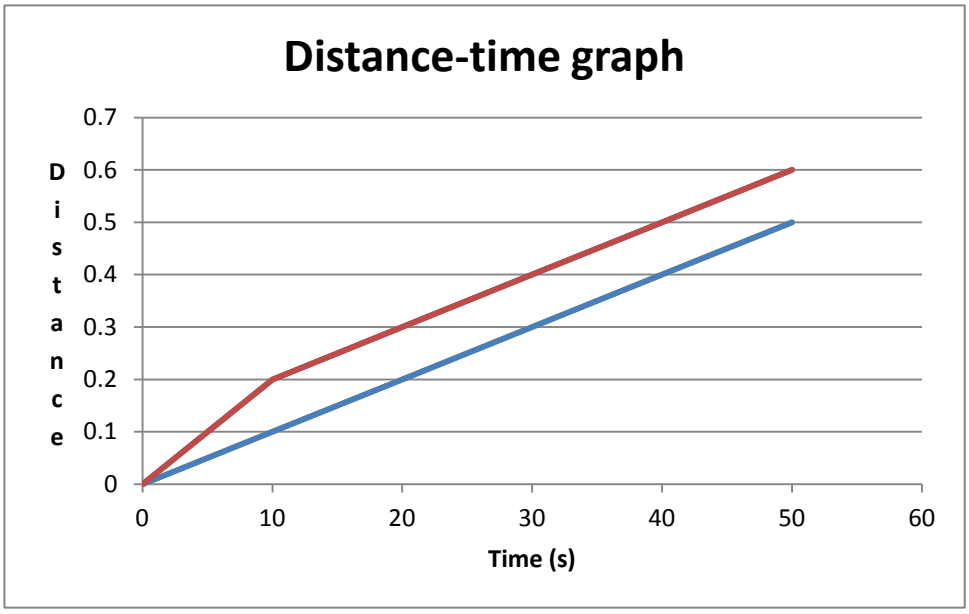

Figure 4.22

Task 3: Solve for a specific variable

1. Calculate the *time* taken by a car to travel a distance of 2m if its speed is 0.5m/s.

   _____

   _____

   _____

2. Calculate the *distance* traveled by a car in 50 seconds, if its speed is 2m/s.

   _____

   _____

   _____

Task 4: Identify simple machines.

1. Identify and mark the simple machines in your pulley motor car.

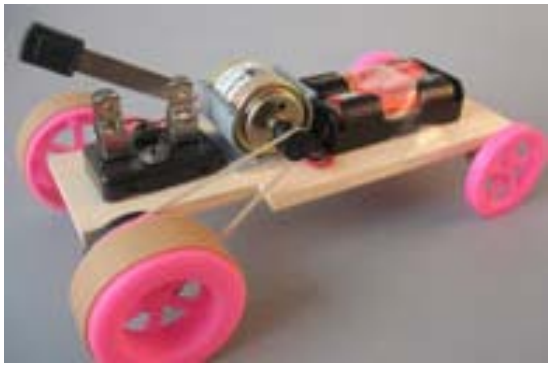

Figure 4.23

2. Name each simple machine used in this car, and describe how it is helping the car.

   a. _____

   b. _____

   c. _____

   d. _____

Task 5: Identify the action and reaction forces

The propulsion system of the *pulley motor car* includes a dc motor, pulley, and rubber band drive, and this contributes to the motion of the car. Apply Newton's third law of motion, and identify at least two action and reaction force pairs. Draw figures and arrows to support your description.

Action: _____ Reaction: _____	
Action: _____ Reaction: _____	

4.10 Project Scoring Guide

Students will be assessed based on the car's speed, design, drawings, final appearance, and presentation. The following scoring guides will be used to evaluate your project work:

Project Building

Component	Description	Excellent	Good	Fair	Poor
Knowledge & Understanding	Demonstrates understanding of concepts, tool, equipment, and component operation and applications.	4	3	2	1
Participation	Participates actively in building the prototype	4	3	2	1
Teamwork	Works effectively and collaboratively with team members.	4	3	2	1
Time-management & Completion	Follows the schedule and completes the project on time.	4	3	2	1
Design	Prototype design addresses the speed requirements.	4	3	2	1
Operation	Prototype travels at the required speed as per the challenge.	4	3	2	1

Total Score: 24

Presentation

Component	Description	Excellent	Good	Fair	Poor
Addresses Curriculum Framing Questions	Presentation effectively addresses the specified Curriculum-Framing Questions.	4	3	2	1
Preparation	Preparation is highly evident. There are smooth transitions between parts of the talk. There are no delays in the use of props or visual aids.	4	3	2	1
Eye Contact, Language & Voice	Makes direct eye-to eye contact with most of the members of the audience at some point in the talk. Speaks in standard English, using correct vocabulary. Every spoken word can be heard and understood clearly.	4	3	2	1
Visual Display	Visual display/Movie is highly relevant to oral presentation. The visual material enhances the purpose and meaning of the presentation.	4	3	2	1

Total Score: 16

4.11 Source:

http://www.miniscience.com/