Table of Contents

Teacher Procedure

Objective

Students implement design solutions for minimizing friction at various points on the CO_2 dragster and verify that their solutions contributed to a decrease in race times.

Teacher Notes

Create a grading rubric that you are comfortable with for assessing this activity. Do this ahead of time and be assessing student performance as the activity progresses. Students must have completed Activity 4 to continue with this activity. If time allows and computers are available, have students research various ways that friction can be reduced.

Photocopy the Student Procedure and its "Lab Report Template" and assign students to read the pages. If this is the first time using the "Lab Report Template," go over the template and have a brief class discussion of what is expected. This is a much more open-ended activity; not much procedural instruction is provided.

Put students into groups or three or four. As students work, complete the assessment rubric. Basically, students should have found a modest decrease in their dragster's race time. Reinforce the fact that mass is the biggest factor for dragster speeds.

Vocabulary

- friction
- force
- solution

Materials

- Built basswood dragster from Activity 4
- Sandpaper (150 and 300 grit)
- Graphite lubricant
- Teflon lubricant (optional)
- Sorted list of friction points from Activity 4
- Electronic balance
- "Lab Report Template"

Procedure

1 Take notes on this activity as you proceed through it. Read through the "Lab Report Template"; it is the format you will use to organize your thoughts and observations and communicate them.

2 Locate your basswood dragster and sorted list of friction points from Activity 4.

3 Break into groups as directed by your teacher and brainstorm possible solutions for each of the top two points on each team member's list. Solutions must use tools and supplies available within the classroom and must not change the mass of the dragster by more than one gram.

4 Return to working individually. From the group discussion, choose the solution you think will have the most benefit for each of your two top friction points.

5 Implement the solutions to the two friction points on your dragster. Try to get these two friction points to have the least amount of friction possible.

6 When the solutions have been implemented, race your dragster two more times. Observe the results. Compare the results with the previous race times from Activity 3.

7 Using the "Lab Report Template," organize your information, observations, data, and conclusions into this report form. Be sure to communicate your ideas and information clearly and effectively. Write this as if the reader had no prior knowledge of the subject.

Teacher Procedure

Objective

Students consider various materials for use as axles and bearing surfaces, make decisions on the effectiveness of various combinations, and use experimental procedures to analyze their effectiveness in reducing friction.

Background

Much of the friction incurred as dragsters go down the track is created from the contact between the axle and the bearing surface used within the blank. Minimizing this source of friction can help decrease the race times for dragsters – a definite competitive advantage.

One way to minimize this friction is by wisely choosing combinations of materials for the axle and bearing surface. Steel axles are included in the standard dragster kit, and a plastic straw is used for the bearing surface. While these do an admirable job, frictionwise, there may be better alternatives. Listed below are some common materials used for axles and bearing surfaces.

Axle Materials

- Steel
- Aluminum
- Delrin
- Brass rod

Bearing Materials

- Plastic straw
- Brass tubing
- Laminate axle tubes

Another method of reducing friction between the dragster body and the axle is to use bushings or ball bearings. In this method, a larger hole is drilled through the body that will fit the outside diameter of the bushing or ball bearing. The bushing or ball bearing is inserted into the hole, and the axle is slid (in the case of bushings) or pressed (in the case of ball bearings) into the devices.

Another source of friction is between the wheels and the dragster body. Typically, washers are included between the interior hub of the wheel and the body. Brass washers are included in a standard dragster kit. However, nylon washers are also available.

Teacher Notes

Photocopy the Student Procedure and its resource page for students and assign them to read the pages. This is an open-ended activity, so not much procedural instruction is provided. Develop an assessment rubric for the activity and share it with the students before they begin.

Though a bench pulley, string, and hanger may be the recommended equipment, similar set-ups will work – even having the string going over a smooth rod at the corner of a tabletop will suffice. Students will use paper clips for adding mass to the paper clip hanger on the string. If more precision is warranted, use brass or nylon washers as masses. Students can measure the total mass used.

When working with the roll test ramp, students measure how far the dragster rolls with each combination. The less friction, the farther the dragster goes.

The Ultimate Axle Bushings require a 3/16" hole, and the Precision Bearings require a 3/8" hole. Students should use a drill press to ensure perpendicular holes. This portion of the activity can be eliminated if you so desire, as the level of difficulty for this procedure is fairly high.

Investigating Bearing Surfaces

Vocabulary

- bearing
- bushing

Materials

- Aluminum axles
- Steel axles
- Delrin axle material (will need to cut to length)
- 1/8" brass rod for axles (will need to cut to length)
- Metal saw
- Tubing cutter
- Brass washers
- Nylon washers
- 3/32" brass tubing
- Laminate axle tubes
- Plastic straws
- Ultimate Axle Bushings
- Precision Bearings (ball bearings) (optional)
- Bench pulley
- String
- Small paper clips
- Roll test ramp
- Measuring tape
- Built basswood dragster (from Activity 5)
- "Lab Report Template"
- "Frictional Forces" resource page from Activity 4

Procedure

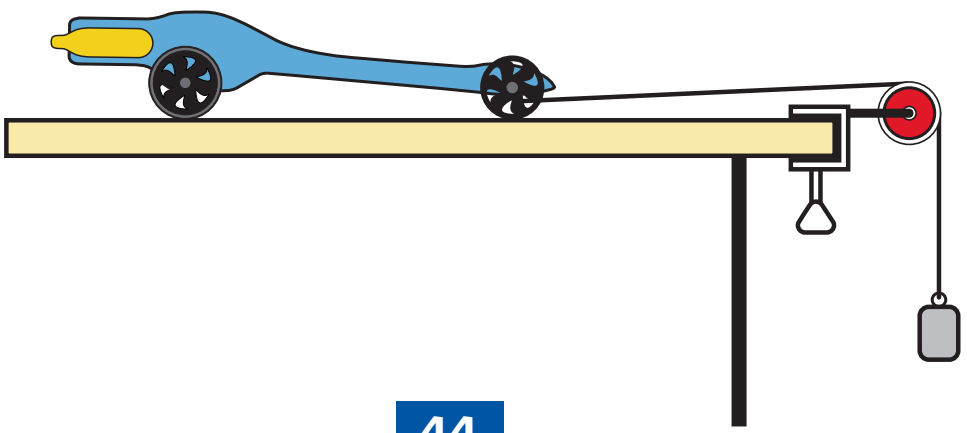
1 Read the "Frictional Forces" resource page.

2 Set up a bench pulley, string, and hanger as shown in the diagram at the bottom of the page.

3 Set up an area for dragster testing using a roll test ramp. Be sure plenty of space is available in front of the roll test ramp for dragsters to roll.

4 Determine as many different possible combinations of axle and bearing material combinations that you can.

5 Test the combinations using the bench pulley setup and the roll test ramp setup. Formulate a data table to record your data. The image below will give you a general idea for each setup. You may have to modify the setup to obtain the best results with your equipment.



Student Procedure

6 Also test the Ultimate Axle Bushing and ball bearing bushings. (This is optional; check with your teacher.) These will require you to drill larger holes to accommodate the bushings or bearings.
Note: Drilling larger holes at this point will be difficult since the blank is no longer flat on both sides. Care must be taken to drill the holes exactly perpendicular and at the same location on the dragster.

7 Using the "Lab Report Template," create a report comparing the frictional forces of the various combinations. Record as your conclusion the best option that will optimize your dragster's performance.

Lab Report Template

Your Report Title

Abstract

The abstract is a short paragraph that summarizes your experiment. Include applicable information about your experimental subjects, materials and methods, results, and conclusions. The abstract is the part of the report that others will read to see if they are interested in the topic.
Introduction

The introduction should give background information on the experiment. It should include an explanation of the general problem or area being investigated. The introduction should outline what information is already known about the problem. In building this part of your report, you might want to consult references or, at the very least, reread the text. Be sure to keep track of the information and list all references used.

The introduction should also present the question you are trying to answer or the hypothesis you are testing. Include what outcome you expect and how it would help support or disclaim your hypothesis or answer your question. Distinguish between the hypothesis and the experiment you will do to test the hypothesis.

Materials and Methods

This section should include a concise, step-by-step numbered description of the material, procedures, and equipment used. Clearly describe the experimental situation, the control situation(s), and the type of observations you made. This should be detailed so that someone else could repeat your work. Do not include the rationale for your work in this section. Be sure to write this report as a past event, not as a set of instructions for the reader.
Results

This section should describe what happened. Include your raw data sheets or refer to the reference section of the report where they can be found. Present your findings in a logical order, not a chronological order. Give the results that you found, not what you think you should have found. Do not explain your results in this section. Results can be reported in the form of graphs, tables, or drawings. Be sure that the data recorded are single readings or averages.

Lab Report Template continued

Conclusion/Discussion

Give your interpretations of the data and relate them to the questions posed in the introduction. Avoid making this section a repetition of the introduction. If you have data to explain or a new hypothesis of why the results were unexpected, list that here.
Draw some conclusions, supporting them with your data. Did the results answer your question? Did they support or disprove your hypothesis? What is the significance of your results? Should further experiments be performed to clear up discrepancies or ambiguities in your results?
References

In this section, list the data that was concluded during the experiment. This could include graphs, charts, drawings, or data tables. In the Results section you explained what happened; in this section provide quantitative proof that your results are accurate.

Glossary

acceleration – the measure of the rate of change in velocity

analyze – to examine methodically by separating into parts and studying their interrelations

bearing – a rotating part placed between moving parts to reduce friction

brainstorming – to generate creative ideas spontaneously

bushing – a lining used to reduce friction

criteria – a set of standards or rules on which a judgment or decision can be based

design – to create or construct according to a plan

design brief – a document that provides specific information regarding the problem to be solved and any criteria associated with the solution

force – the capacity to do work or cause physical change; energy, strength, or active power

friction – the force that resists motion, typically between the surfaces of two objects in contact

iteration – the act or process of repeating, often of a sequence of operations

lubricant – a substance that is used to reduce friction between two objects

mass – the amount of matter within an object

maximum – the greatest quantity possible

minimum – the least quantity possible

model – a small object, usually built to scale, that represents in detail another, often larger, object

motion – the act of moving from one place to another

net force – the combination of all forces acting on an object

observation – an act of recognizing and noting a fact or occurrence often involving measurement with instruments

problem – a question or task that requires a solution

prototype – a first full-scale and functional form of a new design

research – an organized study to find information

solution – an answer to a problem or task

specification – a detailed, precise presentation of something or of a plan or proposal for something

surface area – the extent of a two-dimensional surface enclosed within a boundary

trade-off – an exchange that involves a compromise

weight – the force of gravity pulling downward on an object