The Science of Racing Series

Activities Created by Ten80 Education
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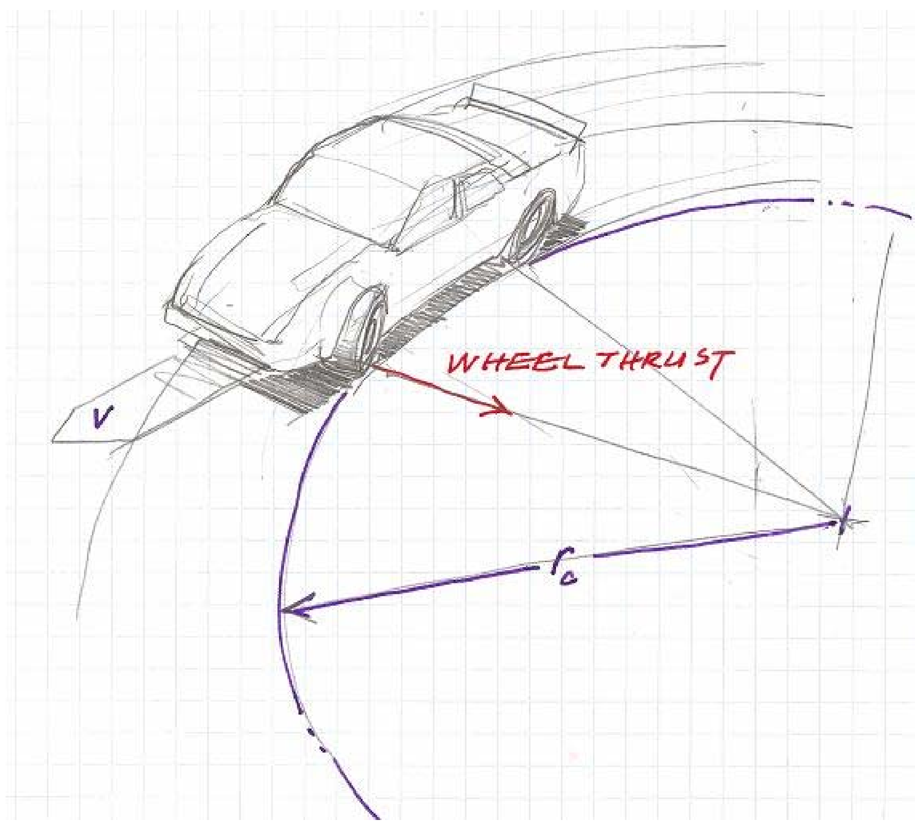


Activity 1: Time Laps

The Science of Racing

Time Laps

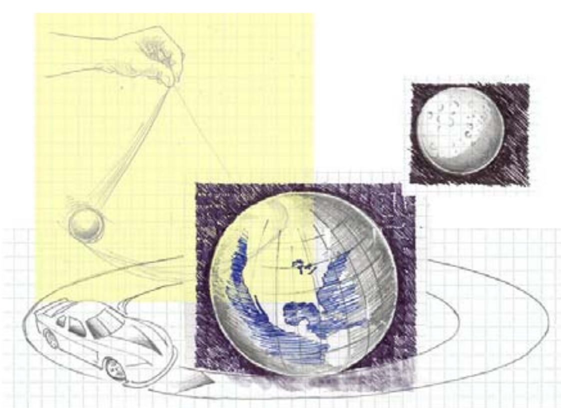
Activity Overview

It's All About Time

Modern car races are won by hundredths of a second, often using cameras to determine which car actually crossed the finish line first. Race teams measure their performance in terms of time and not in speed, counting how many seconds it takes to complete each lap. They don't care how fast the car travels in that lap which is why there are no speedometers in race cars.

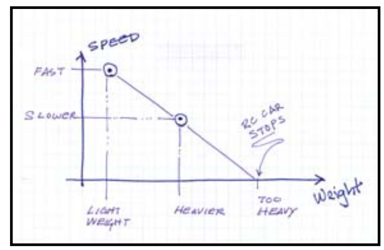
Since running a race car is VERY expensive, race engineers have learned to collect data and make computer models of how the car reacts to changes in its set-up. They do this to maximize performance.

In this activity, you will create a picture of time and speed as they relate to changes in the weight of a radio controlled race car. This picture will be a graph - a mathematical model- that allows to you predict the speed of your radio controlled car at weights you have not yet run. You will collect data on performance then use it to predict future performance.



Activity at a Glance:

Grade: 6-9
Subject: Physical Science
subject: Math
Topic: Speed
Time: 45-minute periods



Materials:

- TI-73 Explorer
- Student Handout
- Transparencies with sample data: TimeLaps_1A and 1B
- Background Paper: Time Article: Science of Racing

Optional for collecting your own data:

- RC (radio controlled) car (1/16th or smaller is suggested)
- Scale to weigh the RC car
- Stop watches
- Tape measure (meter stick, or yard stick, etc.)

Extensions:

Technology Unit 1

The Science of Racing
Time Laps

Student Investigation

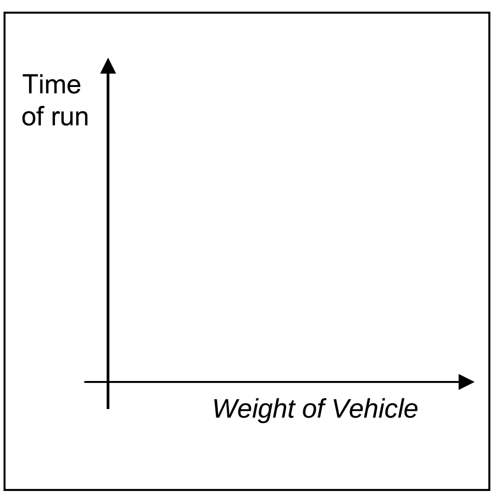
Name __________________ Date__________

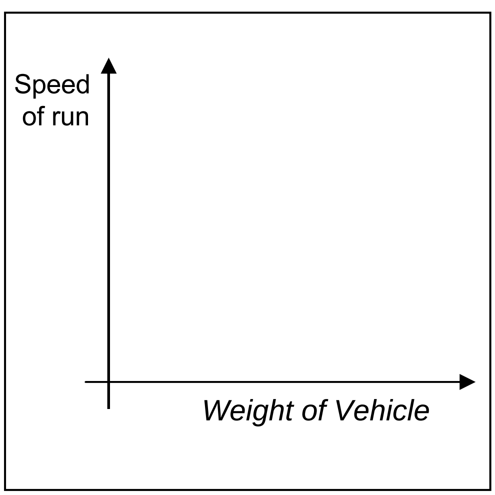
1. **State the Objective:**
   A radio-controlled (RC) car can carry different loads and will run at different speeds depending on its load. The objective is to create a graph (mathematical model) that allows you to predict the speed of a RC car, given only its total weight.

2. **State the Problem:**
   What is the relationship between time, speed and weight for this moving object?

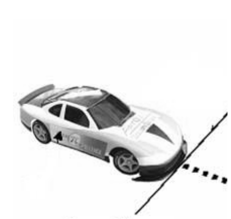
3. **Plan an investigation:**
   Run an RC car at several different weights and record the drive-time of each run. Calculate speed for each run and make a graph of speed versus weight (speed is y-axis and speed is weight is x-axis).

4. **Make a prediction in your Science of Racing Log Book.**
   Draw a graph with time on the x axis and weight on the y axis. Predict qualitatively (without actual numbers) what you think the line for time with respect to weight will look like. In other words, draw the trend-line on your time-weight graph. Do the same for speed with respect to weight. When the activity is completed, you should compare your actual data with the graph you drew as a prediction.





These activities are designed to be used with the TI 73 Explorer but are easily adapted to other TI calculators. Download more Math2Go lessons on the Science of Racing at www.ten80education.com



5. Set up the experiment.

- Identify the independent variable. What will you change with each run of the vehicle? This variable will be placed on the x axis of your graph.

  ____

- Identify the dependent variables. What effect are you measuring as you change the independent variable? Plan to show this result on the y axis. If you are looking at two effects, create two graphs.

  ____

- Identify the variables you will control. What will remain the same with each run of the vehicle?

  ____

- Make a plan for collecting data. Assemble materials and practice so that team members know how to read watches, scales, and tape measures and are familiar with the controls on the vehicle.
- Assign roles: Each team requires a driver, timers, a data recorder, calculator of the human kind and a crew chief who keeps track of all materials and schedules for completion of assignments.

6. Set Up the Car and Track

- From START, measure approximately 120 inches and mark this Start Time Line with tape. The car should be up to full speed as it passes the line and timers will start their watches.
- Mark the Finish Line approximately 180 inches from the Start Time Line. Drivers should not slow the car until they are past the Finish Line. (These are suggested measurements and can be adjusted to meet size constraints of your classroom or hallways).
- Add weights to cars. The weights can be washers taped to the car or soda bottles with water to add weight.
- See transparency Time Laps-1A for track plan

Vocabulary:

Weight:
Mass times the acceleration of gravity or w=mg

Speed:
Distance traveled in some amount of time or
speed = d / t

Velocity:
Speed in some direction.

For technical questions
Phone 704-756-9348

For help with the experiment or to learn more about the Science of Racing, contact Professor Pi at
(a.k.a. engineer-scientist Jeffery Thompson)
ProfPi@ten80education.com

7. Collect Data

- Have three timers time each test run.
- Change the weight of the vehicle for each run.
- Record times for each run on the table below

Data Table A

Distance 180 in.	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
Vehicle Weight in oz.						
Timer # 1						
Timer # 2						
Timer # 3						
Time Totals						
Time Average in sec.						
Speed d/t	In/sec	In/sec	In/sec	In/sec	In/sec	In/sec

Technology Extension:

Use Eagle Tree Data Collection System to collect data.

Notes

The Science of Racing
Time Laps

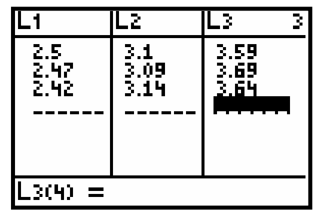
Data Analysis: Use Professor Pi's Data

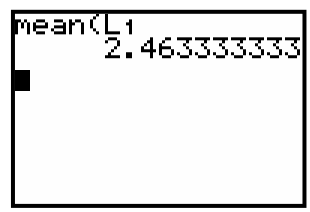
8. Calculate Average Times (mean) for each run.

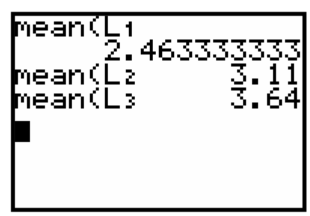
- **Create 6 lists in the List editor.** Set up a list for each car with a different weight. Enter the run times for that car. [LIST]
  - o Under L1, enter three times, Under L2, enter three times. Repeat this step until three times are entered under each list.
  - o Return to the home screen [2nd][QUIT][CLEAR].
  - o Calculate the average time for each run.
    [2nd][STAT][▶][▶]3
    [2nd][STAT][ENTER][ENTER] for the average of run 1 times
    [2nd][STAT][▶][▶]3
    [2nd][STAT][▼][ENTER][ENTER] for the average of run 2 times
    [2nd][STAT][▶][▶]3
  - o [2nd][STAT][▼][▼][ENTER][ENTER] for the average of run 3 times
  - o Repeat these steps selecting lists 4,5 and 6.

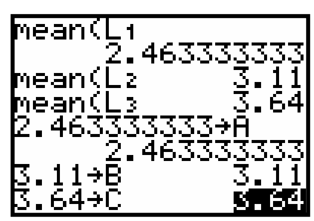
- **Store these average times.**
  - o On the home screen, use the up arrow keys [▲] to scroll up to previous entries and highlight the average for L1.
  - o Press enter [ENTER] to place that number at the bottom of the screen.
  - o Press [STO▶] [2nd][TEXT][ENTER][▼][▼][▼][▼][ENTER][ENTER]
  - o Repeat these steps to store the averages for L2 through L6 selecting a different letter for each value.
  - o The values stored for the average times for 6 runs of increasing weights are A, B, C, D, E and F.

Sample Data Set









Use Transparency TimeLaps_1A for Sample Data Set

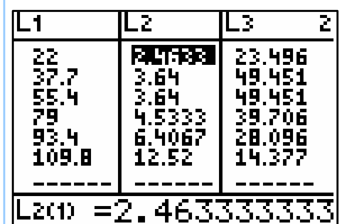
The Science of Racing
Time Laps

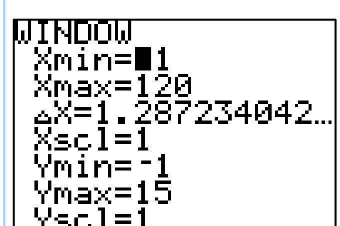
Data Analysis: Use Professor Pi's Data

What do you know and what do you need to know?

You have run cars of different weights and calculated the average time of each run. You still do not know the speed of each car or how it changed with added weight. Use the times to calculate speed.

Sample Data Set





9. Calculate speed: Set up graphs of Time as a function of Weight and Speed as a function of Weight.

- **Clear (or Store) all lists** [2nd][MEM][6][ENTER]
- **Create three lists from your data table**
  - Enter 6 weights in L1
  - Enter stored Average times in L2
  - [2nd][RCL][TEXT][ENTER][▼][▼][▼][▼][ENTER][ENTER] to enter A
  - [2nd][RCL][TEXT][▶][ENTER][▼][▼][▼][▼][ENTER][ENTER] to enter B
  - Continue these steps to enter times C,D,E and F
  - Enter speed formula in L3
  - Highlight L3 [ENTER] 180 ÷ [2nd][STAT][▼][ENTER][ENTER]
  - Your lists have weight in L1, Average time in L2 , Speed in L3
- **Define a Stats Plot for time graph**
  - [2nd][PLOT] Select ON for Plot 1 [ENTER]
  - [▼] Select the scatter plot [ENTER]
  - Select L1 for XList and L2 for YList.
  - Adjust Window value [WINDOW]
  - x min =-1 x max=110 Ymin=-1 Ymax=15
- **Define a Stats Plot for speed graph**
  - [2nd][PLOT] Select ON for Plot 2 [ENTER]
  - Select the scatter plot [ENTER]
  - Select L1 for XList and L3 for YList. [2nd][STAT][▼][▼][ENTER]
  - Adjust Window value [WINDOW]
  - x min =-1 x max=115 Ymin=-1 Ymax=100

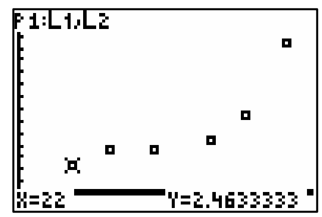
10. Graphs Tell a Story. Use Them to Analyze outcomes.

Look for Patterns in the Data.

Sample Data Set

- Turn ON Plot 1 [2nd] [PLOT] [ENTER]
- Graph Time with respect to Weight.
- [TRACE]

time



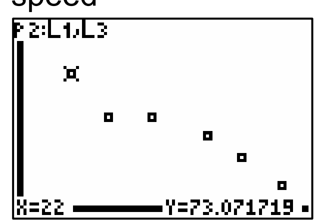
weight

What do you notice about the graph? Does it show a direct or indirect proportion? What relationship between time and weight do you observe in this data set? For example: As weight increased, time _______________.

____

- Turn ON Plot 2
- [2nd][PLOT] [ENTER]
- Graph Speed with respect to Weight.
- [TRACE]

speed



weight

What do you notice about the graph? Does it show a direct or indirect proportion? What relationship between speed and weight do you observe in this data set? For example: As weight increased, speed _______________.

____

The Science of Racing

Time Laps

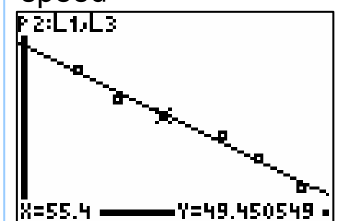
Summary Activity

11. Your graph is a mathematical model.

Sample
Data Set

It is a model of what you observed, just as the radio controlled car models a real car. Scientists and engineers work with mathematical models to make them as accurate as possible so they are effective tools to make predictions.

The next step in creating an accurate model is to test points on your graph to see if the results match reality.

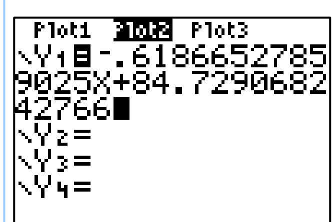


You can accomplish this by adding a trend line to your graph.

[2nd][STAT][▶][▶][▶][5][2nd][STAT][ENTER][,][2nd][STAT][▼][▼][ENTER][ENTER]

[Y=][2nd][VARS][3][▶][▶][ENTER][GRAPH][TRACE]

Pick some weight you have not yet tried and test it to see if it travels at the speed predicted by your model. It may or it may not. The more data you collect and the better you control the variables (like driving consistently), the better your model will become.



The equation that describes any straight line is y=ax+b.

Write the equation under [Y=] that describes your graphic model.

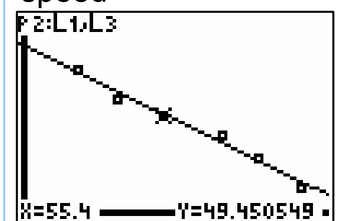
____

In the equation, y is speed, x is weight and a and b are numbers generated from your data.

Assessment:

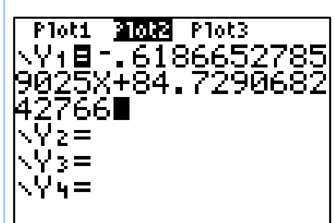
- What is velocity? How did you calculate velocity or speed?

speed



weight

- What happens if you make the car ridiculously heavy?
- What happens when there are NO weights on the car?
- What is represented by numbers on the X axis? Y axis?
- What story is being told by this data?



- How will you decide the optimal weight?
- What is your understanding of a math model and how might it help you to be able to create these models?

Assessment:

- What is velocity? How did you calculate velocity or speed?

  •Velocity=Speed in some direction.

  •Speed = Distance traveled in some amount of time or speed = d / t

- What happens if you make the car ridiculously heavy?

  •Speed goes to 0 since the car does not move

- What happens when there are NO weights on the car?

  •If the car will move in a straight line the time is small and speed is large.

  •On many surfaces, time is huge because the car does not travel in a straight line due to lack of traction between the wheels and the floor. Adding a bit of weight onto the front makes the front wheels steer and the car arrive at the finish line faster.

- What is represented by numbers on the X axis? Y axis?

  •X is weight of the vehicle with added weights attached

  •Y is the speed of the vehicle

- What story is being told by this data?

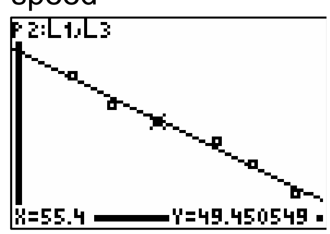
  •As weight increases, speed decreases and Time increases.

  •Quantitatively you can draw a best fit line (a linear regression) through the points, calculate its linear equation that describes the line and use this equation as an explanation of the relationship between speed and weight for this vehicle on this surface.

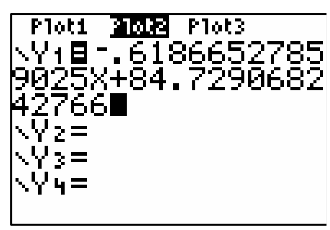
- What is your understanding of a math model and how might it help you to be able to create these models?

  •By creating a math model in the form of a graph, you can predict the speed of objects you have not yet tested.

speed

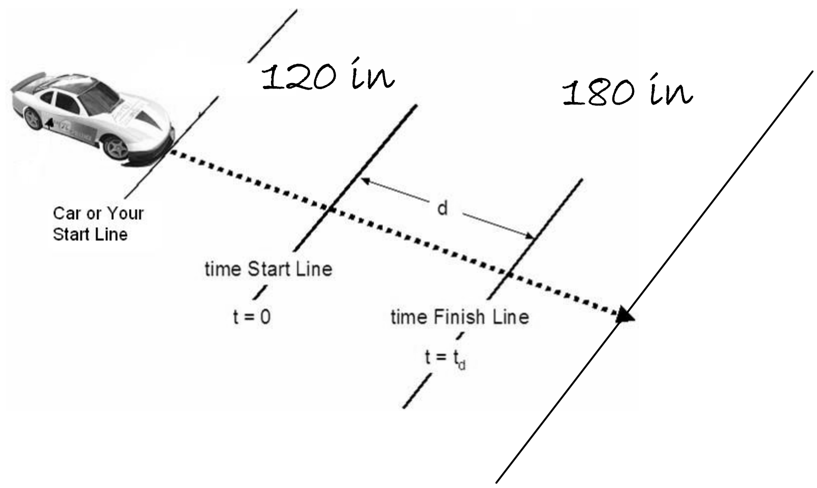


weight



The Science of Racing
Time Laps

Transparency Time Laps 1A



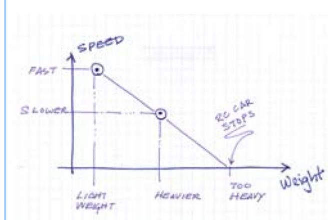
Focus Question:

How does weight relate to speed?

Quantify your observations!

Professor Pi's sample data

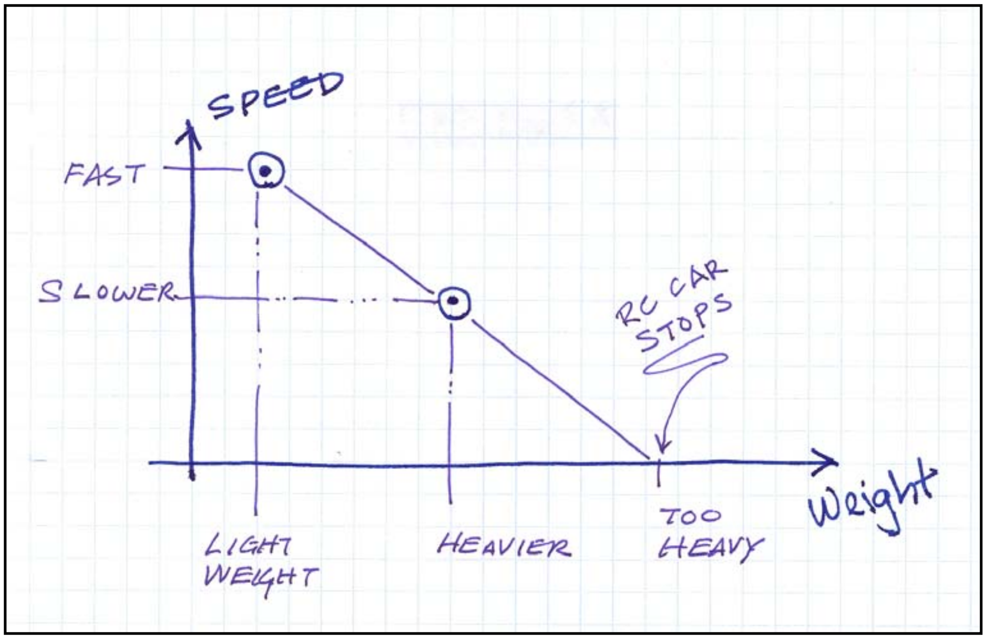
Distance 180 in.	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
Vehicle Weight in oz.	22	37.7	55.4	79	93.4	109.8
Timer # 1	2.5	3.1	3.59	4.75	6.55	12.52
Timer # 2	2.47	3.09	3.64	4.38	6.35	12.82
Timer # 3	2.42	3.14	3.69	4.47	6.32	12.22
Time Totals						
Time Average in sec.						
Speed d/t	In/sec	In/sec	In/sec	In/sec	In/sec	In/sec



Graphic predictions

The Science of Racing
Time Laps

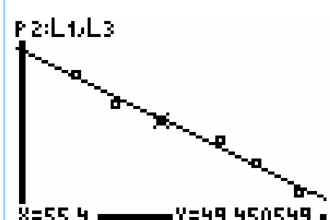
Transparency Time Laps 1B



Graphic predictions

Distance 180 in.	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
Vehicle Weight in oz.	22	37.7	55.4	79	93.4	109.8
Timer # 1	2.5	3.1	3.59	4.75	6.55	12.52
Timer # 2	2.47	3.09	3.64	4.38	6.35	12.82
Timer # 3	2.42	3.14	3.69	4.47	6.32	12.22
Time Totals	7.39	9.33	7.28	13.6	19.22	37.56
Time Average in sec.	2.46	3.11	3.64	4.53	6.4	12.52
Speed d/t	73.07 in/sec	57.88 in/sec	49.45 in/sec	39.71 in/sec	28.10 in/sec	14.38 in/sec

Professor Pi's sample data



Science of Racing Series

Correlations to National Science Standards

Activities 01 - 06

☑ Comprehensive coverage ✓ Partial coverage

PROGRAM STANDARD C:
Mathematics is important in all aspects of scientific inquiry.

The science program should be coordinated with the mathematics program to enhance student use and understanding of mathematics in the study of science and to improve student understanding of mathematics.

ACTIVITIES

1	2	3	4	5	6
☑	☑	☑	☑	☑	☑

PROGRAM STANDARD B:
Properties & changes of properties in matter , Motions and forces, Transfer of energy

MOTIONS AND FORCES

The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph.

An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.

If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.

ACTIVITIES

1	2	3	4	5	6
☑	☑	☑	☑	☑	
✓	☑	✓	✓	✓	
			☑		

TRANSFER OF ENERGY

Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.

Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.

Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced.

In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers

ACTIVITIES

1	2	3	4	5	6
✓	✓	✓	✓	☑	☑
					☑
				☑	☑
					☑

CONTENT STANDARD D:

Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.

1	2	3	4	5	6
			☑		

CONTENT STANDARD G:

The introduction of historical examples will help students see the scientific enterprise as more philosophical, social, and human. Middle-school students can thereby develop a better understanding of scientific inquiry and the interactions between science and society.

1	2	3	4	5	6
☑	☑	☑	☑	☑	☑

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