

ALGEBRA ARCADE™

User's Guide

Algebra Goes
ELECTRONIC!

User's Guide for

ALGEBRA ARCADE

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**To our families, for their patience and understanding, and for
the many contributions they have made to this project.**

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What Is the Algebra Arcade?

Algebra Arcade is a challenging game for one or two players that combines careful calculation with fast plotting, close calls, and high scoring. The game is played on a screen displaying the X- and Y-axes and features ten little characters called Algebroids, the Whirlwind, a villain called the Graph Gobbler, and the Graph Gobbler's shifty-eyed Ghost.

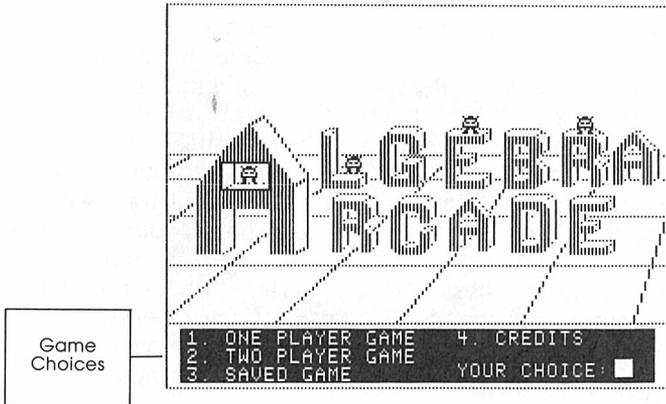
The computer scatters the Algebroids across the screen, and it's up to you to plot a path for the Whirlwind that passes through as many Algebroids as possible. The more Algebroids the Whirlwind hits as it rushes along your graph, the higher your score. But beware! The moment your graph even touches the Ghost, up jumps the Graph Gobbler, who devours your graph and leaves you scoreless.

The programmed features of the basic *Algebra Arcade* can be modified easily to provide a level of play that is entertaining and rewarding to everyone from third graders to college professors. And the more you play, the more you learn about algebra, equations, and graphs.

In the *Algebra Arcade* you score points by designing graphs to outwit the Graph Gobbler and knock off Algebroids. Here's a quick tour of the game to get you started:

1. When you boot up your *Algebra Arcade* diskette, you are soon presented with the choice of a one-player game, a two-player game, or a game you saved earlier (see Figure 1). Enter the number of your choice on the keyboard and press RETURN. (If your computer is equipped with a joystick, see the Joystick Control section of the instructions.)

Figure 1



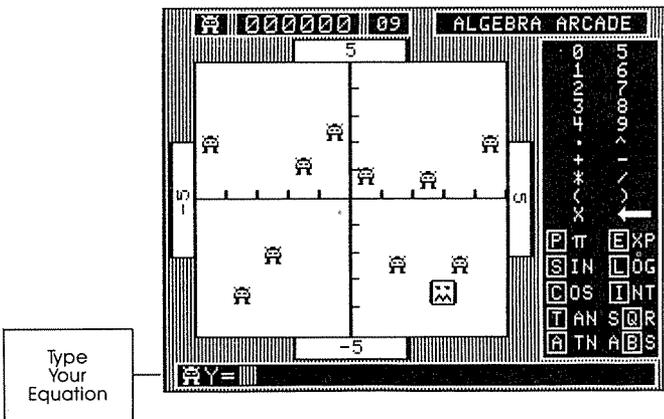
2. The blinking box that now appears in the lower right part of the screen is called the Arcade Control Center. It appears frequently throughout the game and offers you four options that you may wish to use later on: GRS (you type only G) for game reset; ALG (type A) to request a new group of Algebroids; PRC (type P) to shift over to the practice field; and FTR (type F) to modify the features of the game. These options are available only when the Control Center box is blinking. Notice the scoreboard at the top of the screen, which records your point total and tells you how many turns you have left. (See Figure 2.) Now, to continue the tour and begin the game, press SPACE BAR.

Figure 2



3. As the game begins, Algebroids skitter out to take their positions on the screen. Notice that the screen is divided into four squares or quadrants by the X- and Y-axes and that each tick mark represents 1 unit. The X-axis is horizontal and the Y-axis is vertical. When the Algebroids are in place, out gallops the Graph Gobbler, who changes into the shifty-eyed Ghost. Your job now is to plot a graph that will knock off one or more Algebroids without disturbing the Ghost. You type in the equation of your choice in the space at the bottom of the screen (see Figure 3). You can use any of the numbers, letters, and symbols listed on the right-hand side of the screen, but you must be careful to enter them correctly (see Entering Equations in the instructions). For an easy example, try either $Y = 1$ or $Y = X$. When your equation is complete, press RETURN.

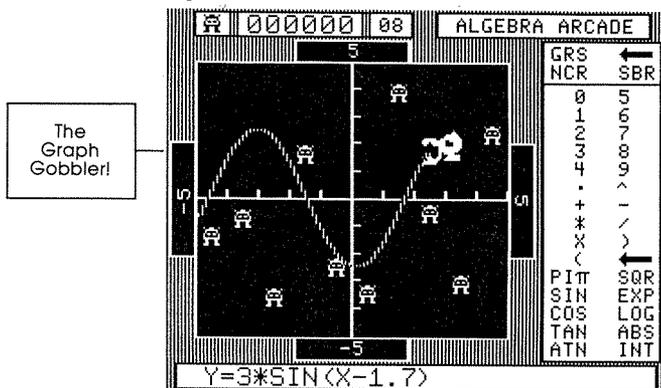
Figure 3



4. The computer now plots the graph of your equation. A moment later, the Whirlwind swoops along the path you have created, looking for Algebroids. The more Algebroids you can blow away with one graph, the higher your score. For example, in the basic game one Algebroid is worth 200 points. But if you knock off two Algebroids with one blow, you score 600 points, and three at once brings you 1,200 points. (If you manage to hit all ten Algebroids with one graph, you score 11,000 points!) Also, each Algebroid is worth more if you play the game with the timer on (see Game Scoring in the instructions). But watch out—if your graph even touches the Ghost, up jumps the Graph Gobbler, who devours your graph, leaves you scoreless, and sends you before the Committee! (See Figure 4.)

When the Whirlwind has passed, the computer tallies your score and the Arcade Control box begins to blink again. Press SPACE BAR to go on to your next turn.

Figure 4



5. Each player starts with ten turns. However, it is possible to earn extra turns or lose turns during the game. You earn an extra turn every time you score 10,000 points. You also earn a turn for knocking off the last of the ten Algebroids. If this happens, the Graph Gobbler gets quite upset and throws a tantrum! He then disappears into a blank screen, and you can earn another extra turn (and score 1,000 points) by plotting a graph that hits his hiding place. You are allowed three tries, but watch out—if you fail all three times you'll be called before the Committee, which may penalize you.

You may lose turns every time you're called before the Committee. This happens when you hit the Ghost before clearing away all the Algebroids or when you fail to find the Graph Gobbler's

hiding place in three tries. As you'll see in the instructions, you also face the Committee if you try a graph that's judged to be too long or if you take too much time when the timer is on. (See Figure 5.)

Each time you clear all the Algebraoids off the screen, the computer will supply ten new ones for your next turn.

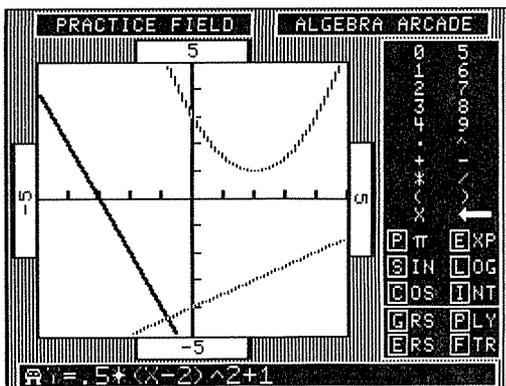
Figure 5



6. Not sure how to create the graph you want? If you want to experiment with new equations, you can choose the PRC (type P) for PRACTICE option when the blinking control box returns. After you press RETURN, you'll find yourself with a blank screen to practice on. You can plot several graphs on the same coordinate system before erasing. (See Figure 6.) You'll find suggestions on new equations and graphs and how to use them later in this manual.

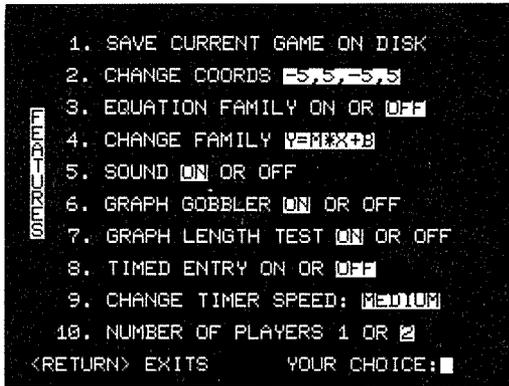
When you finish your practice session, you can return to the game by choosing PLY (type P) for PLAY when the blinking box returns. Then press RETURN.

Figure 6



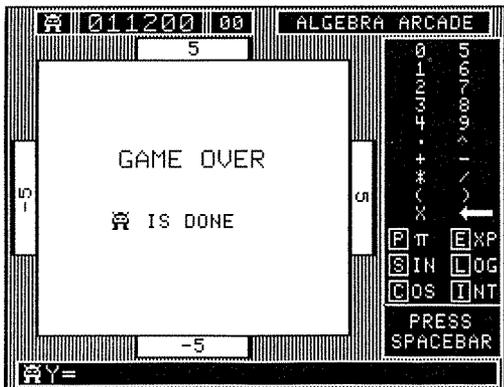
7. As you get craftier at plotting graphs, you may want to make the *Algebra Arcade* more challenging by changing some of the features. Choose the FTR (type F) for FEATURES option from the blinking box, then hit RETURN, and you'll see your choices. You can change the coordinate system, lock in one special family of equations to play with, adjust the game-timer speed, or save a game in progress (see Figure 7). These modifications are described later in this manual. Press RETURN to get back to the game.

Figure 7



8. You can go on plotting graphs, knocking off Algebroids, and scoring points until you run out of turns. At that point, the computer will signal GAME OVER (see Figure 8). Press the SPACE BAR to begin another game, head for the practice field, change features, or sign off.

Figure 8



This ends our quick tour of the *Algebra Arcade*. On the following pages you'll find complete instructions, graphing tips, and interesting equations to try. Happy plotting!

Setting Up

To play *Algebra Arcade*, you need an *Algebra Arcade* diskette designed for use with your microcomputer, one disk drive, and a suitable television set or monitor. Color is preferred but not required.

Insert the diskette into the disk drive and turn on the monitor, and then the computer. If the computer is already on, turn it off, then back on. The program takes about 40 seconds to load. Do not write-protect your diskette or it won't work.

Keyboard Control—Keys, Prompts, and Menus

When using keyboard control, you tell the *Algebra Arcade* program what to do by pressing appropriate keys on your keyboard. The program tells you when to press keys by sending visual and, sometimes, audible signals to you called *prompts*. Most often, you select the keys to press by choosing from a *menu*, or list, of choices on the screen.

To complete your entry, always press RETURN. To correct or change an entry, use the backspace key (←) before pressing RETURN.

The first menu you find in *Algebra Arcade* appears with the title display, where you see four choices at the bottom of the screen as in Figure 1 in the last section. The computer is waiting for you to choose an *Algebra Arcade* game. For more details on Choice 3, Saved Game, see the section on the Features Menu.

Joystick Control

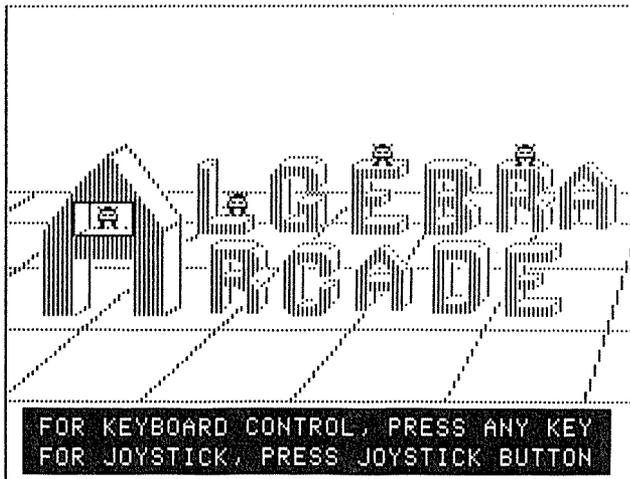
If you do not have joysticks or paddles attached to your computer, skip this section and go on to Entering Equations.

If you have a joystick or paddles connected to your computer, you will see a menu like Figure 9 on the title display after you have selected a game. You must choose keyboard control by pressing a key or choose joystick control by pressing a button. (If *paddles* are connected, choose the keyboard.)

The instructions in this booklet refer to keyboard control of the *Algebra Arcade*. It is a simple matter to use these same instructions for joystick control also.

With joystick control, each menu has a cursor that you move between selections with the joystick. Be sure the joystick is oriented properly.

Figure 9



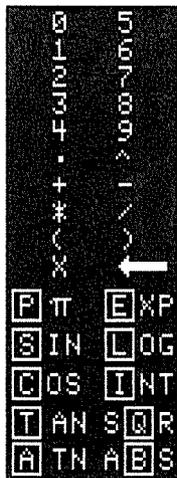
1. Use the **BUTTON** instead of **SPACE BAR** for Next Turn.
2. Move the stick in the direction you want the cursor to move. When the cursor is adjacent to a symbol you want to select, stop. This step is like finding a key on the keyboard.
3. (a) In the Equation Entry Menu and in Arcade Control, to select the symbol you have stopped at, move the stick in the direction of the symbol. This corresponds to pressing a key. The symbol (except \leftarrow) is printed on the screen just as if you typed it. Then move the cursor to the next symbol you want. To complete an entry, press the **BUTTON** (rather than **RETURN**). To correct or change an entry, use the cursor to select the backspace symbol (\leftarrow) before pressing the **BUTTON** to complete the entry. (b) In the Features, Timer, and Equation Family Menus there is only one selection to make each time, so just line the cursor up with your selection and press the **BUTTON**. You don't have to move the stick toward your selection as in part (a).

Using the joystick adds variety to the *Algebra Arcade*. It also is easy to pass the joystick among players who are not close enough to use the keyboard. You might want to try a Timed Entry game with the joystick just for the fun of it.

Entering Equations

When you press the SPACE BAR to start a turn, the blinking Arcade Control box disappears and you see a larger menu of numbers and symbols on the right side of the display. See Figure 10. This is the Equation Entry Menu. It contains the symbols used to enter equations. You probably recognize some of these as arithmetic or algebra symbols. Don't worry if you don't recognize all of them. You can play the *Algebra Arcade* with those you do know. And you can learn to use new symbols with just a little practice.

Figure 10



Each symbol in the Equation Entry Menu is selected by pressing just one key. For multiple character symbols you only need to press the boxed character of the symbol to enter it. Usually that is the first character. For example, to use SIN, just press S, and all three letters are printed in the area at the bottom of the display. But to use SQR (square root) press Q. If the symbol has only one character, that is the key to use. Note that P is the key to use for the number π .

During equation entry, the computer accepts only those characters in the Equation Entry Menu. Others are ignored. If you are experienced with computers, you may find yourself typing the complete symbol (for example, S-I-N for SIN). But with a little practice, you will remember to use only S. This one-key entry saves time and avoids some errors.

When you have typed in the equation of your choice, press RETURN to complete the entry. Before pressing RETURN, you can use the backspace (\leftarrow), to change your equation. The computer will tell you if it does not understand your equation and will give you a chance to try again.

**IMPORTANT
NOTE**

When you press the SPACE BAR to start a game or to continue to the next turn, the Algebroids will take the field and you will hear the familiar prompt sound signaling that the computer is ready to take your entry. Entries made before this signal are ignored. It is especially important to listen for this signal if you are playing with the Timed Entry feature on. Starting your entry too soon can cause loss of valuable time for corrections.

The *Algebra Arcade* uses the notation of the BASIC computer language for its equations. In most cases, the symbols and their uses are the same as those used in algebra. There are, however, two special cases:

- * is used for multiplication (and cannot be omitted).
- ^ is used for exponents.

Listed below are some equations written in both algebra notation and BASIC notation. You might try these on the Practice Field of your *Algebra Arcade*.

ALGEBRA NOTATION	BASIC NOTATION
$Y = 4X + 5$	$Y = 4 * X + 5$
$Y = X^2$	$Y = X \wedge 2$
$Y = .3(2X - 1)^3$	$Y = .3 * (2 * X - 1) \wedge 3$
$Y = -X^2$	$Y = -(X \wedge 2)$

The next two sections of this User's Guide tell you more about specific kinds of equations to use and how to change them for effective play.

Calculations are usually performed in standard order:

- 1.** Exponents
- 2.** Multiplication and division
- 3.** Addition and subtraction

When in doubt, you can control the order by using parentheses, "(" and")," as grouping symbols.

Valid operators and functions that can be used in BASIC expressions to build equations are listed below. If you know about some of these functions from your study of algebra, you can use them in the *Algebra Arcade*. You can learn about the functions you don't know by experimenting and practicing with the Equation Families Feature explained elsewhere in these instructions. Note that the notations for some (for example, square root and absolute value) are different from those you may have used in algebra.

+ ADDITION
 - SUBTRACTION
 * MULTIPLICATION
 / DIVISION
 ^ EXPONENTIATION
 SIN(ARG) SQR(ARG)
 COS(ARG) LOG(ARG)
 TAN(ARG) EXP(ARG)
 ATN(ARG) ABS(ARG)
 INT(ARG)

The functions in the preceding display are defined as follows:

Function	Definition
SIN	Trigonometric sine
COS	Trigonometric cosine
TAN	Trigonometric tangent
•ATN	Arctangent or inverse tangent
SQR	Square root
LOG	Logarithm base e
EXP	Exponential base e
ABS	Absolute value
INT	Greatest integer

ARG is any valid expression with variable X formed using the operators +, -, *, /, ^, and a composition of the functions listed above. For example, ARG could be SQR (X + ATN(X)). When in doubt, include grouping symbols. For example, $-X^2$ is sometimes evaluated as $(-X)^2$, not $-(X^2)$. For the latter, use $-(X^2)$.

Game Scoring and Rules

Each player starts a game with ten turns and zero points on the scoreboard. Hitting Algebroids while avoiding the Graph Gobbler scores points. A player can get ten new Algebroids before any turn, but this costs one turn. New Algebroids appear automatically when the last one is cleared. Points earned and adjustment of turns are summarized in the table that follows.

Points per Turn		Turns	
Event	Points Scored	Event	Change
Hit 1 Algebroid	200	Start Turn	- 1
Hit 2 Algebroids	600	Committee	- 1 or - 3
Hit 3 Algebroids	1,200	Choose new Algebroids	- 1
Hit 4 Algebroids	2,000	Score 10,000 points	+ 1
Hit 5 Algebroids	3,000	Clear 10 Algebroids	+ 1
Hit 6 Algebroids	4,200	Find invisible G.G.	+ 1
Hit 7 Algebroids	5,600		
Hit 8 Algebroids	7,200		
Hit 9 Algebroids	9,000		
Hit 10 Algebroids	11,000		
Find invisible G.G.	1,000		

Timed Entry: If the Timed Entry feature is ON and set at MEDIUM, FAST, or VERY FAST, the points awarded per turn are multiplied by a factor of 0, 1, 2, 3, or 4, depending on the location of the time arrow when RETURN is pressed.

The Committee: If you appear before the Committee, the Committee will choose to penalize you one turn, three turns, or not at all. You must appear before the Committee for the following reasons:

1. Hitting the Graph Gobbler's Ghost before clearing all ten Algebroids.
2. Missing all three attempts to find the invisible Graph Gobbler after you clear ten Algebroids. You may avoid the Committee's visit by pressing RETURN and not entering your third try. (The Graph Gobbler feature must be ON.)
3. Exceeding the graph length limit when the Graph Length Test feature is ON. This also applies to graphs used to find the invisible Graph Gobbler, but only when you find him. Misses that exceed the length limit are not penalized.
4. Not entering an equation in time when the Timed Entry feature is ON.

Getting the Graph Gobbler: Before long, you will probably blow away the last Algebroid on the coordinate system, which will earn you an extra turn. Now, get ready for a special event. The Graph Gobbler gets a little upset when you get all the Algebroids. In fact, the Graph Gobbler has a small fit and disappears. But now's

your chance! You get three free tries to find the invisible Graph Gobbler. If your graph hits the Graph Gobbler's hiding place, your reward is 1,000 points, and another turn is added to your total. But if you miss all three times, you pay a visit to the Committee. You can avoid a visit to the Committee by pressing RETURN to skip your third try.

Each time you score 10,000 points, a turn is added to your total. And, as mentioned earlier, you can earn a turn for the last Algebroid and another for the Graph Gobbler. So, if you play well, you earn more turns and a chance for higher scores.

Rules for Practice and Features: Before starting a two-player game, the players should agree on whether or not changing features (using FTR) or going to the Practice Field (using PRC) will be allowed during the game. The *Algebra Arcade* program allows unlimited use of the Practice Field and the Features Menu before each player's turn. For some games you might want to limit the use of the Practice Field or not allow certain features to be changed. Be sure to agree on any limitations before play begins.

The Arcade Control Center

After selecting a game, you hear a few musical notes and the border blinks on the Arcade Control Center. When the border blinks, you must choose from this menu. Other symbols, except SPACE BAR and (←), are ignored. To see what the symbols mean and what keys to use, read the information in the center of the screen. This information appears at the beginning of each game as a reminder (see Figure 2).

SPACE BAR Pressing the space bar starts the game or continues the game with the next turn. *No RETURN needed.* Pressing RETURN has the same effect as SPACE BAR.

**IMPORTANT
NOTE**

Pressing G, A, P, F, or E immediately prints out the choice at the bottom of the screen. Use RETURN to complete the choice or (←) to correct it.

G Pressing G for GRS, GAME RESET, ends a game and takes you to the Arcade Control description to start over.

A Pressing A for ALG, ALGEBROIDS, allows you to play against a new group of ten Algebroids whenever you choose, but it costs you one turn. If you have only one turn left, you can start your next turn *and* get new Algebroids for that turn.

- P Pressing P for PRC, PRACTICE, takes you to the Practice Field before your turn starts. You can test a graph before using it. At the Practice Field, pressing P for PLY, PLAY, returns you to the playing field for your turn.
- F Pressing F for FTR, FEATURES, takes you to the Features Menu to change game features.
- E Pressing E for ERS, ERASE GRAPHS, erases practice graphs and appears there in place of ALG (used only on the Practice Field).

**IMPORTANT
NOTE**

When the border blinks, use the Arcade Control Center. Use only symbols currently appearing there. All others, except SPACE BAR and (←), are ignored.

The Features Menu

The Features Menu in Figure 7 is used to choose or change *Algebra Arcade* game features. Changing features can affect the difficulty of the game dramatically.

When you turn your computer on and choose a one- or two-player game, the *Algebra Arcade* program automatically selects the features for that game. But changing these default features before play starts by choosing FTR, FEATURES, from the Arcade Control takes you to the Features Menu. A quick scan of the menu tells you which features are included in your game and how they are set. On the Features Menu, the prompt is a flashing cursor next to YOUR CHOICE at the bottom of the display. To make a selection, press the corresponding number. Use RETURN to complete a selection. To correct or change an entry, use the backspace (←) before pressing RETURN. An entry other than a number from 1 to 10 is ignored.

**IMPORTANT
NOTE**

Each time you complete an entry with RETURN, the Features Menu reappears so that you can make another selection. To return to your game, press only RETURN.

1. SAVE CURRENT GAME ON DISK

You can save the game you are currently playing on the disk for use at another time. The next time you turn your computer on with the *Algebra Arcade* diskette in the disk drive, you can select Choice 3, SAVED GAME, from the Game Selection Menu, and your game will resume at the point at which you saved it. The features, scores, turns, and number of Algebraoids will be just as you left them. If you like to play with a favorite set of features, you can save a game in which you have selected those features. Then, you won't have to reset the features each time you turn on the machine. With keyboard control you get the last saved keyboard game. With joystick control you get the last saved joystick game. However, you will only be able to save one keyboard game and one joystick game. The next game you save will erase the previously saved game.

2. CHANGE COORDS.

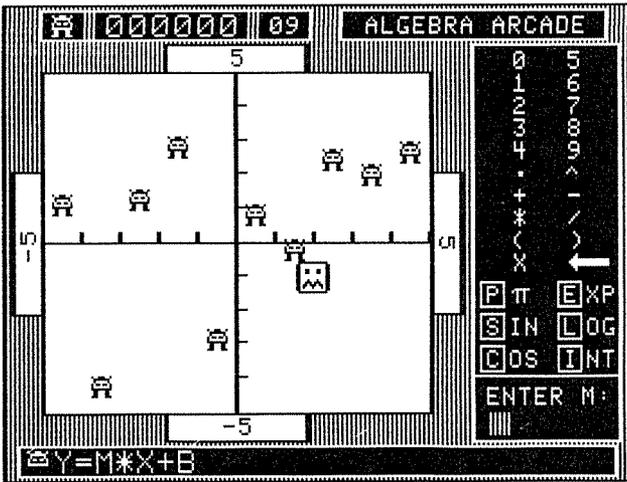
This feature lets you play or practice on the coordinate system of your choice. The current left, right, bottom, and top of the coordinate system are displayed in Feature 2. Entering 2 takes you back to the game coordinate system where you are prompted to enter LEFT SIDE, RIGHT SIDE, BOTTOM, TOP, X-TICK DISTANCE, and Y-TICK DISTANCE. If you press only RETURN in response to a prompt, that quantity is *not* changed. You may use up to seven characters for each entry. You can use the digits 0 to 9 and π , ,, - , * , and / as characters. The coordinate system is labeled with your entries, which also replace the old values on the Features Menu. (There, the symbol % is used instead of π .) If you ask for tick marks too close together, you won't get any. If you don't want tick marks, enter zero for tick-mark distances.

3. EQUATION FAMILY ON OR

Features 3 and 4 work together. By limiting graphs to a specific family of equations, entry can be faster and simpler. Also, game difficulty can be varied by restricting the graphs to be used.

Suppose you want to play only with equations of the form $Y = M \cdot X + B$, where you choose values for M and B . If this equation is highlighted in Feature 4, you can switch the Equation Family feature from OFF to ON by entering 3. Then, press RETURN to return to the game and press (SPACE BAR) to start the game as usual. Your equation, $Y = M \cdot X + B$, appears at the bottom of the display in the usual place next to the flashing Algebraoid prompt. See Figure 11.

Figure 11



The words "ENTER M" are in the Arcade Control area. So type your value for M (up to 5 characters) and complete the entry with RETURN. Then, you are prompted to ENTER B in the same way.

You can use digits 0 to 9 and π , ., -, *, and / as characters. Each time you press RETURN, your value replaces the parameter in the equation at the bottom of the screen. When the last parameter has been entered, your equation is graphed as usual, just as if you had typed the whole thing. If you make a mistake and want to start over with the *first* parameter, press RETURN before typing any character for the *current* parameter. Pressing RETURN before a character for the *first* parameter skips that turn.

Be sure you don't start entering your values until the familiar prompt sound is given or you might miss a character. This could result in an entry that you didn't want, or you may have to start over. This is important if you are playing with the Timed Entry ON.

4. CHANGE FAMILY $Y = M * X + B$

The family of equations that you use with Feature 3 (as described above) is highlighted in Feature 4. To change this family, enter the number 4. This takes you to the Equation Family Menu to select another equation family. If you make a choice from this menu, the Equation Family is turned on in Feature 3 and you enter your equations as described there. For more details see the Equation Family Menu instructions that follow.

5. SOUND ON OR OFF

The game sound can be switched ON or OFF with Feature 5.

**IMPORTANT
NOTE**

If you are at the Practice Field and choose F for FTR, FEATURES, there are only six selections on the Features Menu. The first five are the same as the five just described, and the sixth is WHIRLWIND ON OR OFF. The additional features described below do not apply to the practice field, so they do not appear on the Features Menu.

6. GRAPH GOBBLER ON OR OFF

If the Graph Gobbler is switched OFF, he is not in the game, making the game easier. But this also takes away your chance to search for the hidden Graph Gobbler each time the last Algebroid is cleared from the coordinate system.

7. GRAPH LENGTH TEST ON OR OFF

This feature deters the use of very long, oscillating graphs, since such graphs make the game very easy. When the Graph Length test is ON, the computer calculates estimates of the length of the graphs that are plotted. If the estimate exceeds the limit, you face a possible penalty by the Committee. Most beginners will not encounter the Committee for violations of graph length. But when you learn about periodic graphs and space filling curves (and you soon will if you try a few Equation Families), the Committee might pay you a visit.

8. TIMED ENTRY ON OR OFF

This feature adds some pressure to the game, and offers the opportunity for higher scores. But, more skill is required. When the Timed Entry is on, a timing arrow counts down 4, ...3, ...2, ...1, ...0 in the Equation Entry Menu. If it reaches zero before a successful entry is made, you pay a visit to the committee. If the speed is set at MEDIUM, FAST, or VERY FAST, your regular score for the turn is multiplied by the number pointed to by the timer arrow. The arrow stops when you press RETURN to enter your equation. With timed entry, Algebroids change position on the screen between *each* turn. Entry is *not* timed when you try for the invisible Graph Gobbler. You can set the timer at several different speeds using Feature 9.

9. CHANGE TIMER SPEED: MEDIUM

The Timed Entry timer has several speeds. The current setting is highlighted in Feature 9. To change it, enter 9. Then select a relative speed from the menu that appears. You will

learn from experience which speeds are reasonable for various games and modes of equation entry. Notice that Algebroids change position *each* turn with timed entry. If you want to play a game without timed entry, turn the Timed Entry OFF using Feature 8.

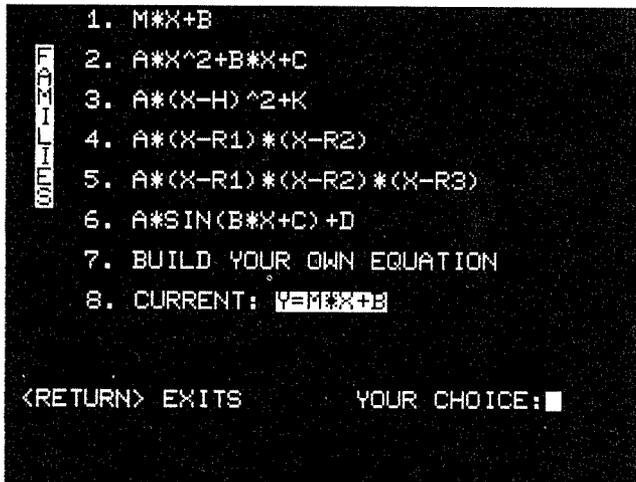
10. NUMBER OF PLAYERS: **1** OR 2

You can change the number of players at the beginning or during a game. If you start with one player and change to two players later in the game, the new player starts with ten turns, a score of zero, and plays with inverted Algebroids. Changing from two players to one player removes the player with the inverted Algebroids from the game. But, the score is saved and reappears if the second player reenters the game.

The Equation Family Menu

Instead of entering your own equation from scratch each time, you can tell the computer to preset a special family of equations for you. The preset equation will appear at the bottom of the screen in standard form (for example, $Y = M \cdot X + B$). To build a particular graph, you enter values for the constants in the standard equations (for example, M and B). The Equation Family Menu is reproduced in Figure 12.

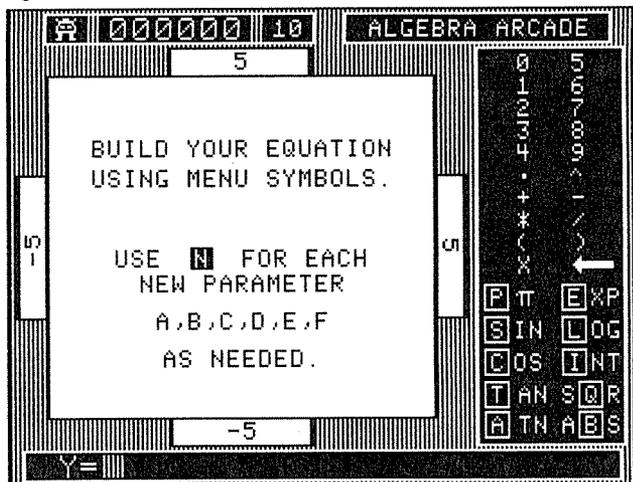
Figure 12



Selections are made here by entering the number of your choice. The first six choices are equations with three or four constants. For example, Choice 4, $Y = A \cdot (X - R1) \cdot (X - R2)$, has constants A, R1, and R2. These constants are sometimes called parameters. The independent variable is always X. After choosing one of these equations and pressing RETURN (or after pressing RETURN with no entry), you return to the Features Menu.

Choice 7 on the Equation Family Menu lets you define your own equation with up to six parameters. When you enter 7, you see the display in Figure 13.

Figure 13



You define your equation just as you enter an equation during game play. Use the symbols in the Equation Entry Menu on the right side of the display. See the Entering Equations instructions for specific details. The only difference is that you can use the key N for NEW PARAMETER. The first time you press N, the parameter A appears in your equation at the bottom of the display. The second time you get B. The six parameters available are A, B, C, D, E, and F. Your equation can be 40 characters long but usually should be shorter. Otherwise, when you are playing, there won't be room to replace A, B, C, and so forth, by several characters each. You must use correct BASIC rules of construction just as you would when entering equations during game play.

When you have entered your equation with its parameters (by pressing RETURN), the program checks your work. If it doesn't understand your equation, it tells you to try again. If everything is okay, the program returns you to the Features Menu. To return to the Equation Family Menu without building an equation, press RETURN with no entry.

Each time you make a selection from the Equation Family Menu, that selection becomes the Current Equation Family and is displayed on both the Equation Family Menu and the Features Menu. (Since π is not a keyboard symbol, it is represented by % on these menus.)

Graphing suggestions

You can increase the enjoyment, and the challenge, of the *Algebra Arcade* by using many different types of equations in your games. This section explains how to draw lines using the linear equation family. It also includes some tricks for stretching and shrinking graphs and for placing them in different positions on the screen.

Lines

To begin, go to the Practice Field where there are no Algebroids. You can now concentrate on your graphs. Next, go to the Equation Family Menu from the Features Menu and choose 1 for the equation family $Y = M \cdot X + B$. This is the family of lines. Press RETURN to return to the Practice Field. When Arcade Control flashes, press the SPACE BAR and prepare to enter numbers. Try this example:

Enter 0 for M and 1 for B.

The graph is a horizontal line that intercepts the Y-axis at 1. That is why B is called the Y-intercept.

Horizontal Lines

When you choose 0 for M, the line is horizontal and intercepts the Y-axis at B. Here are some more examples to try:

Press the SPACE BAR to enter new values.

Enter 0 for M and -2 for B.

This horizontal line crosses the Y-axis at -2 .

Press the SPACE BAR.

Enter 0 for M and $5/2$ for B.

This horizontal line crosses the Y-axis at $5/2$.

Lines Through the Origin

If you choose a number other than zero for M, the line will slant up or down. That is why the number M is called the slope of the line. If M is positive, the line slopes upward, and if M is negative, the line slopes downward.

Before you try these examples, erase any old graphs. (Enter E when the Arcade Control is flashing.) Each of the following examples chooses 0 for B, so each line passes through the origin (0,0).

Press the SPACE BAR to start each entry.

Enter 1 for M and 0 for B.

Enter 2 for M and 0 for B.

Enter 5 for M and 0 for B.

Enter $-1/2$ for M and 0 for B.

Enter -3 for M and 0 for B.

Can you draw a horizontal line that covers the X-axis? Can you draw a (nearly) vertical line that covers the Y-axis?

Other Lines

Now try different values for the slope, M, and the Y-intercept, B. See what happens if you use 1 for M and choose several different values for B.

Erase the graphs and then try using several values for M while using the same value, say 1, for B.

Next, try using the same number for both M and B. For example, choose 2 for M and 2 for B. Then, try -1 for M and -1 for B. Make your own choices and see if you can discover something about these lines.

Lining Up the Algebroids

You can draw a line that hits two or more Algebroids if you can predict a value for the slope M and the Y-intercept B. Let's demonstrate this with an example. In Figure 14, there are two Algebroids on the screen. You can get from the Algebroid on the left to the other Algebroid by going UP 5 units and OVER 4 units. Count them. Dividing these numbers gives the slope:

$$M = (\text{UP } 5)/(\text{OVER } 4) = 5/4$$

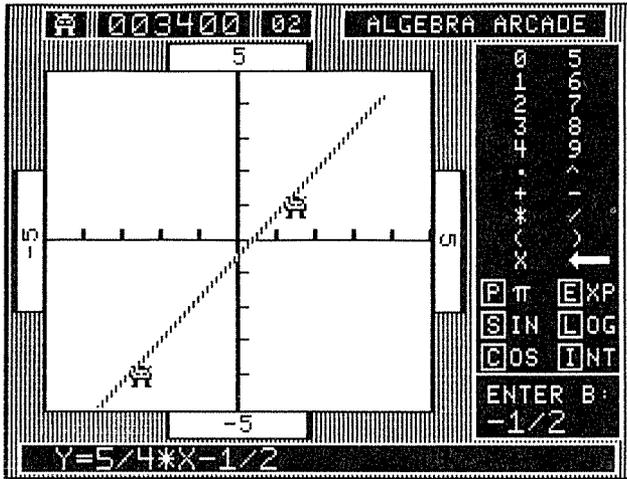
In Figure 15, the second Algebroid is lower than the first Algebroid. So, you count DOWN 4 units and OVER 3 units. DOWN 4 units is written as -4 . Once again, dividing these numbers gives the slope:

$$M = (\text{DOWN } 4)/(\text{OVER } 3) = -4/3$$

Once you find the slope, you can determine the Y-intercept. Place the edge of a card or a soft ruler against the screen. Line it up through the two Algebroids. Then, estimate where the line intercepts the Y-axis. Use this number for B. For Figure 14, the line crosses at $-1/2$. So, you would use $-1/2$ or $-.5$ for B. The equation for the line is

$$Y = 5/4 * X - 1/2$$

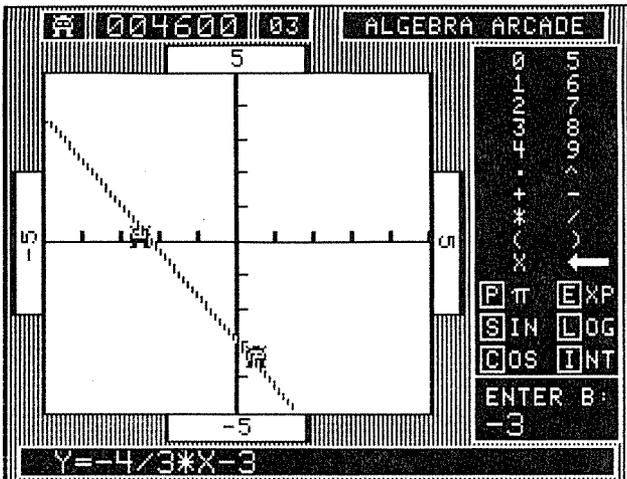
Figure 14



In Figure 15, the line crosses at about -3 . The equation for this is

$$Y = -4/3 * X - 3.$$

Figure 15



You'll find that Algebroids are often very cooperative and line up for a straight shot. With a bit of practice with linear equations, you will be able to score well.

One final note on lines: sometimes the Y-intercept may be off the screen. In this case, you will have to estimate the value for B.

Hints for Other Graphs

Only a very large book could show all the equations possible with the *Algebra Arcade*. And, after all, much of the enjoyment is using the *Arcade* to experiment with graphs. Here are a few simple tricks you can use to modify the graphs.

Stretching and Shrinking

Multiply your entry by a number larger than 1	to stretch the graph in the Y-direction.
Multiply your entry by a number between 0 and 1	to shrink the graph in the Y-direction.
Multiply your entry by a negative number	to reflect the graph in the X-axis.
Multiply each X in the equation by a number > 1	to shrink the graph in the X-direction.
Multiply each X in the equation by a positive number < 1	to stretch the graph in the X-direction.
Multiply each X in the equation by a negative number	to reflect the graph in the Y-axis.

Moving Up, Down, Left, and Right

Add a positive number to your entry	to move the graph up.
Add a negative number to your entry	to move the graph down.
Add a positive number to each X	to move the graph to the left.
Add a negative number to each X	to move the graph to the right.

Be sure to use parentheses for correct grouping of characters.

Examples Go to the Practice Field with the Equation Family OFF. Enter each pair of equations in turn. Erase the screen before moving to the next pair.

$$Y = X*(X-3)$$

$$Y = 2*X*(X-3)$$

$$Y = X*(X-3)$$

$$Y = .4*X*(X-3)$$

$$Y = X*(X-3)$$

$$Y = -X*(X-3)$$

$$Y = X^2$$

$$Y = X^2 - 3$$

$$Y = X^2$$

$$Y = (X-2)^2$$

Try your own variations of these and other equations. Then, try them out against the Algebroids and the Graph Gobbler.

Playing Tips

1. Sometimes it pays to sacrifice a turn in exchange for a new and, hopefully, better group of Algebroids. You can use the ALG, ALGEBROID, command for ten new Algebroids. Recall that this command reduces your number of turns by 1. But if you have only one turn left, you can use it for both your next turn and for new Algebroids.
2. If you have a good grouping of Algebroids but the Ghost is in the way, it might pay to leave them alone for one turn. After the Ghost moves, you might be able to get them all in one turn. You get more points that way. (This does not apply to timed entry because the Algebroids move each turn.)
3. You can skip the third attempt at the invisible Graph Gobbler by pressing RETURN before typing an equation. You then avoid a visit from the Committee. There is less risk in the first two attempts.
4. With practice, you should be able to get a rough estimate of what the limit is for the length of a graph when the Graph Length Test is ON. In some situations (for example, your last turn with several Algebroids left) you have nothing to lose by exceeding the graph length limit. The Committee might be lenient. Remember, when trying for the invisible Graph Gobbler, the length is only tested for a graph that hits the Graph Gobbler, and then, *only the part drawn* is measured. So, you can gamble with longer graphs here.
5. With timed input, listen carefully for the sound prompt and start entering quickly. Also, use the time between entries to get ready. When a new group of ten Algebroids takes the field, the timer is not running. Use this free time to plan your equations.
6. Use the Equation Family feature with Timed Entry set at VERY FAST for a high-scoring, fast-paced game.
7. Try different coordinate systems to get experience. For example, you can play in the first quadrant by using the Change Coordinates feature to choose 0, 10, 0, 10.
8. Experiment with many equation families (and build some of your own) so that you can use them when you need them.
9. In an expression that is complicated, count parentheses. There should be as many right ones as left ones. Try counting parentheses in the equations in the next section, for example.
10. Keep a record of useful and interesting equations so that you can try them again. You may wish to add the following equations to your list.

Some Interesting Equations

In addition to those included on the Equation Family Menu, here are a few more interesting equations. This discussion assumes that you have not changed the coordinate setting from $-5, 5, -5, 5$. Use the Practice Field to try these. Notice how the graph shapes affect the Whirlwind sound.

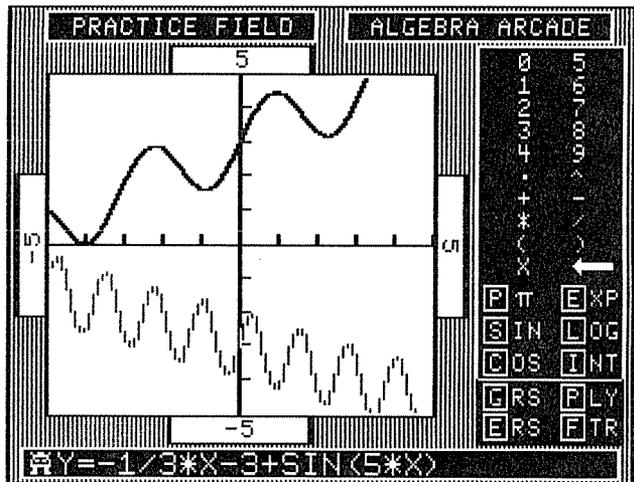
1. $Y = A*(X - B)$

This is a line with slope A that intercepts the X -axis at B . This family is useful when the Y -intercept is off the screen.

2. $Y = A*X + B + \text{SIN}(C*X)$

The $\text{SIN}(C*X)$ puts a wiggle in the line $Y = A*X + B$. See Figure 16. Be sure to try the value 26 for C .

Figure 16



3. $Y = \text{EXP}(A*X)*\text{SIN}(6*X)$

Choose A between $-.5$ and $.5$. This graph oscillates more at one end. Adding on $(C*X + D)$ will tilt it along a line. See Figure 17.

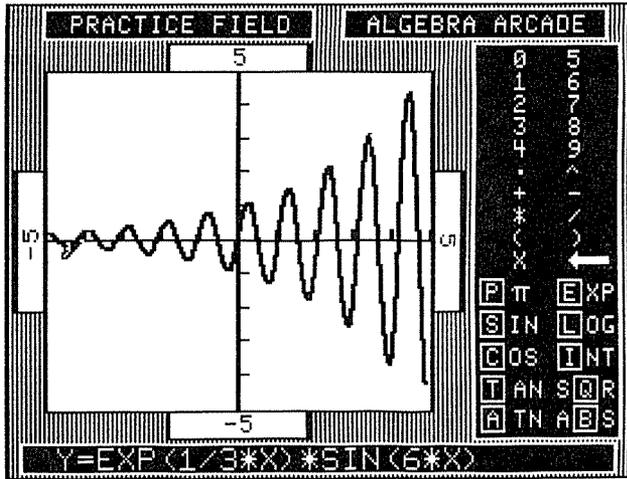
4. $Y = 10*\text{SIN}(57*X)*\text{INT}(X - A)$

This fills a lot of space except between A and $A + 1$. It will exceed the graph length limit.

5. $Y = A + 1/(.3 + (X - B)^2)$

This graph has a peak in it near $X = B$.

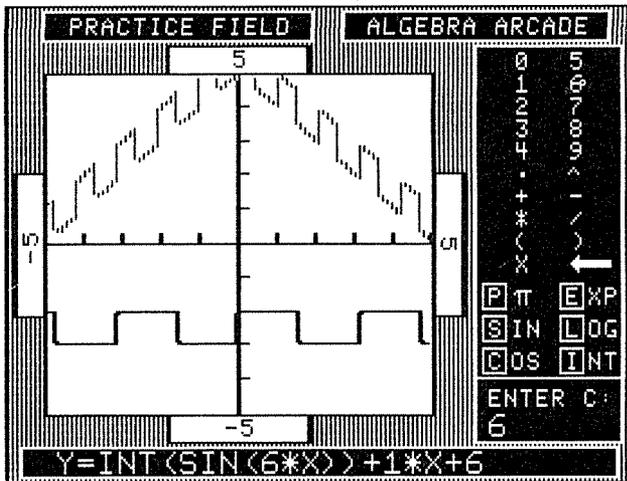
Figure 17



6. $Y = \text{INT}(\text{SIN}(A*X)) + B*X + C$

Try some different values for A with $B = 0$ and $C = 0$. Then vary B and C . Try large and small values of A , and notice the interesting sound variations. See Figure 18.

Figure 18



7. $Y = A * \text{ABS}(X - B) + C$

Try some large or small values of A .

8. $Y = A * \text{ABS}((X - B) * (X - C)) + D$

References

There are many mathematics books that contain information on equations and their graphs. Books on algebra, trigonometry, and precalculus treat these topics. Here are a few suggested references.

Swokowski, E. W., *Fundamentals of Algebra and Trigonometry*, Fifth Ed., Prindle, Weber and Schmidt, Boston (1981).

Dobyns, R. A., *Programmed Guide to Accompany Fundamentals of Algebra and Trigonometry*, Prindle, Weber and Schmidt, Boston (1981).

There is a nice presentation of linear equations and graphs of lines in the following text:

Wood, M., Capell, P., Hall, J., *Introductory Algebra*, Prindle, Weber and Schmidt, Boston (1982).

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Dugdale, Sharon, "Green Globbs: A Microcomputer Application for Graphing of Equations." *Mathematics Teacher* 75 (March 1982).

Dugdale, Sharon, "Prototype Microcomputer Courseware for Teaching High School Algebra." Presentation, NSF-NIE Regional Meeting, Chicago (June 1981), Grant No. SED80-12449.

Isaacs, G., "Geometric Visualization: Dynamic Graphics to Develop Mathematical Perception and Intuition in Pre-calculus Students." NSF Grant No. SED80-12457.

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