Algebraic Expressions

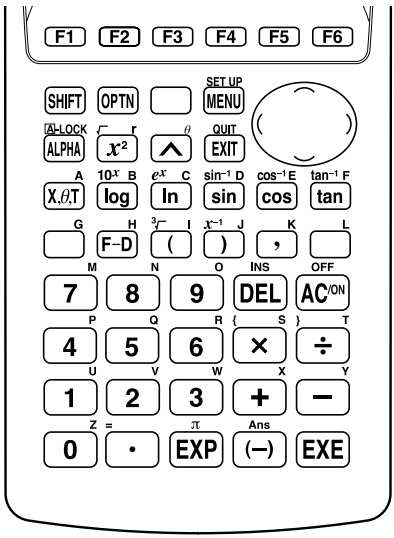
The ALGBR Mode (Algebraic Mode) provides tools for expansion of algebraic expressions, factoring, etc. In this mode, differential and integration calculation results are displayed as mathematical expressions instead of decimal values.

20-1 Before Using the Algebraic Mode

In the Main Menu, select the **ALGBR** icon to enter the ALGBR Mode and display its initial screen, which contains the following items.

- {**expn**} ... {expansion}
- {**fctor**} ... {factorization}
- {**diff**} ... {differential}
- {∫**()**} ... {integration}
- {**SOLV**} ... {Solve function}
- {**tExp**} ... {expression transformation using the addition theorem}
- {**tColl**} ... {product-to-sum transformation using the addition theorem}
- {**comb**} ... {combination}
- {**PTS▶**} ... {function for line passing through specific points}
- {**CPLX**} ... {complex function transformation}
- {**appr**} ... {convert to numeric value}
- {**collc**} ... {collection}
- {**tanL**} ... {tangent expression}

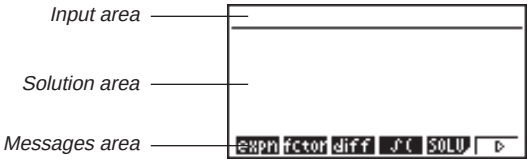
The following table shows the keys that can be used in the ALGBR Mode.



- The F⇔D key performs its screen shot send function only. It does not perform its fraction-decimal conversion function.

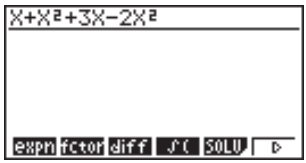
20-2 Inputting and Executing Calculations

The ALGBR Mode display is divided into three areas: an input area, a solution area, and a message area (used for display of menus and error messages).

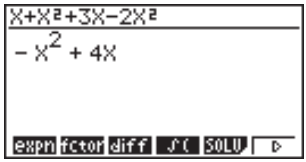


Example $X + X^2 + 3X - 2X^2$

X,θ,T + X,θ,T x² + 3 X,θ,T − 2 X,θ,T x²



EXE



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- Solutions are displayed in natural display notation.
- Solutions produced in the ALGBR Mode are also stored in Ans memory and can be recalled by pressing SHIFT Ans.
- You can input up to 255 bytes of data for each ALGBR Mode calculation.
- If a solution does not fit within the solution area, use ▲, ▼, ◀, and ▶ to scroll the screen.
- Inputting more data while there is data in the input area and solution area causes the previous data to be cleared from two areas automatically.
- If you clear the display by pressing AC, you can recall the previous operation by pressing ◀ or ▶ (Replay Function).
- The Angle item of the set up screen can be set to either **"Deg"** or **"Rad"** for ALGBR Mode operations.

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- The Display item of the set up screen can be set to **"Fix"**, **"Sci"**, or **"Norm"** for ALGBR Mode operations. Note, however, that this setting is applied for the **approx** command only.
- A displayed solution can be stored in function memory by pressing OPTN F6 (FMEM) F1 (STO). Next, press a function F1 (f_1) to F6 (f_6) to select a specific function memory.

20-3 ALGBR Mode Commands

In the ALGBR Mode, results are calculated in accordance with commands and expressions you input. This section describes each of the commands available in the ALGBR Mode.

■ Conventions Used in this Section

The following conventions are used in the command descriptions of this section.

Item	Description
<expression>	This item indicates a mathematical expression input by you. The actual expression you should input depends on the type of operation you are performing. One example of an expression is: X+1.
<variable>	This item indicates a variable input by you. The actual variable you should input depends on the type of operation you are performing. One example of a variable is: A.
[ ]	Anything enclosed within square brackets is optional, which means you can skip it if you want. Note the following: expand (<expression>[)] The above example means that the final closed parenthesis to the right of <expression> does not need to be input for the command to execute properly.

■ Commands

●Expansion —— (expn)

This command expands an expression.

Syntax: expand (<expression>[)]

Example **To expand the expression $(X + 2)^2$**

F1 (expn) (X,θ,T + 2) x^2 EXE $X^2 + 4X + 4$

●Factorization —— (fctor)

This command factorizes an expression.

Syntax: factor (<expression>[)]

Example **To factorize the expression $X^2 - 4X + 4$**

F2 (fctor) X,θ,T x^2 − 4 X,θ,T
+ 4 EXE **$(X - 2)^2$**

- You can also factorize a value into its prime factors.

Example **To factorize 64 into its prime factors**

F2 (fctor) 6 4 EXE **2^6**

●Addition Theorems —— (tExp)

This command uses trigonometric addition theorems to transform an expression.

Syntax: tExpand (<expression>[)]

Example **To transform sin(A+B) using addition theorems**

F6 (▷) F1 (tExp)
sin (ALPHA A + ALPHA B EXE **cos(B) • sin(A) + sin(B) • cos(A)**

●Product-to-Sum Transformation —— (tColl)

This command uses addition theorems to perform product-to-sum transformation.

Syntax: tCollect (<expression>[)]

Example **To perform product-to-sum transformation on sin(A)cos(B) using addition theorems**

F6 (▷) F2 (tColl)
sin ALPHA A cos ALPHA B EXE **$\frac{\sin(A + B)}{2} + \frac{\sin(A - B)}{2}$**

●Integration —— (∫( )

This command can be used to determine the primitive function or calculate the definite integral for an expression.

Syntax 1: ∫ (<expression>, <variable> [, <integration constant>] [)]
Syntax 2: ∫ (<expression>[, <variable>, <integration constant>] [)]
Syntax 3: ∫ (<expression>, <variable> , <start>, <end> [)]

<integration constant> ..... Integration constant
<start> ..... Start point of the integration interval
<end> ..... End point of the integration interval

- A default variable of X is used when specification of a variable is skipped in Syntax 2.
- Syntax 3 calculates the definite interval in accordance with the specified integration interval.
- Multiple integral calculations can also be performed.

Example **To integrate the expression X^2 for variable X**

F4 (∫ ( ) X,θ,T x^2 ▶ X,θ,T EXE $\frac{X^3}{3}$

- A default value of 0 is automatically assumed for the integration constant. Inputting a symbol name such as C for the integration constant produces a result in a form that is the same as the indefinite integral.

●Differential —— (diff)

This command can be used to determine the derivative or calculate the value of the derivative for an expression.

Syntax 1: diff (<expression>, <variable>, <*n*th>[, <differential coefficient>] [)]
Syntax 2: diff (<expression>, <variable>[, <*n*th>, <differential coefficient>] [)]
Syntax 3: diff (<expression>[, <variable>, <*n*th>, <differential coefficient>] [)]

<*n*th> ..... Specifies differential of *n*th order. *n* must be a positive integer.
<differential coefficient>
..... Any value specified as the differential coefficient is substituted in the function for calculation of the result.

- Syntax 1 determines the derivative in accordance with a specified expression, variable and order. Specifying a differential coefficient calculates a result in accordance with the input value.
- A default order of 1 is used when specification of the order is skipped in Syntax 2.
- A default variable of X is used when specification of a variable is skipped in Syntax 3.

Example **To differentiate the expression X^6 for variable X**

F3 (diff) X,θ,T ^ 6 EXE **$6X^5$**

●Tangent Expression —— (tanL)

This command calculates the tangent expression of another expression.

Syntax: tanLine (<expression>, <variable>, <contact point>[])

<contact point>

..... The contact point is specified using the <variable> name.

Example **To calculate the tangent expression when X = 2 for the expression X^3**

F6 (▷) F6 (▷) F3 (tanL)

X,θ,T ^ 3) X,θ,T) 2 EXE **12X – 16**

●Solve —— (solve)

This command calculate solutions for an expression. Solutions are displayed as mathematical expressions.

Syntax: solve (<expression> [=<expression>] [, <variable>] [])

The second expression can be preceded by any of the following operators: = (equals), < (less than), > (greater than), ≤ (less than or equal to), or ≥ (greater than or equal to).

- A default variable of X is used when specification of a variable is skipped.

Example **To solve AX+B = 0 for X**

F5 (SOLV) F1 (solve) ALPHA A
X,θ,T + ALPHA B , X,θ,T EXE $\left\{ X = \frac{-B}{A} \right\}$

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- Other solve functions are available that produce numeric calculation results .

●Convert to Numeric Value —— (appr)

This command converts an expression to a numeric value.

Syntax: approx <expression>

Example **To convert the expression $\sqrt{2}$ to a numeric value**

F6 (▷) F6 (▷) F1 (appr)
SHIFT √ 2 EXE **1.414213562**

- Any command to the left of **approx** causes an error.

Example **1+ approx ($\sqrt{2}$) (Causes an error.)**

- Inputting another ALGBR Mode command or the **signum(** function into the **approx** command causes an error.

Example **approx approx $\sqrt{2}$ (Causes an error.)**

■ Difference Between "approx" and Standard Calculations

approx differs from standard calculations (calculations that do not use natural display notation) in the number of display digits and handling of variables. With standard calculations, calculation results are displayed without using exponential notation.

Example 9 ^ 2 0 EXE **12157665459056928801**

When part of the expression includes a variable, the variable is processed as a variable regardless of whether or not it has been assigned a value.

Example 5 × ALPHA A + 3 EXE **5A + 3**

With **approx**, calculation results are displayed using exponential notation. As with the RUN Mode, the mantissa can have up to 10 digits and the exponent up to two digits. The number of digits that can be input for **approx** depends on the setting of the set up screen's Display item.

Example F6 (▷) F6 (▷) F1 (appr) 9 √ 2 0 EXE **(Display: Norm1)**

1.215766546E + 19

When part of the expression includes a variable, the calculation is performed by substituting the value for the variable. The following shows the calculation when A = 0.

Example F6 (▷) F6 (▷) F1 (appr) 5 × ALPHA A + 3 EXE

3

●Collection —— (collc)

This command arranges the terms of an expression, focusing on a particular variable.

Syntax: collect (<expression>[, <variable>] [)]

- A default variable of X is used when specification of a variable is skipped.

Example **To arrange the terms of the expression $X^2 + AX + BX$, focusing on the variable X**

F6 (▷) F6 (▷) F2 (collc) X,θ,T x^2 +
ALPHA A X,θ,T + ALPHA B X,θ,T EXE

$X^2 + (A + B)X$

●Combine —— (comb)

This command produces a fraction made up of a fully expanded numerator over a fully expanded denominator.

Syntax: combine (<expression>[)]

Example **To combine the expressions (X+1) / (X+2) + X × (X+3)**

F6 (▷) F3 (comb) (X,θ,T + 1)
÷ (X,θ,T + 2) + X,θ,T ×
(X,θ,T + 3) EXE

$$\frac{X^3 + 5X^2 + 7X + 1}{X + 2}$$

●Sequence —— (sequ)

This command creates the function that describes the relationship between the variable and the value of the expression, if the value of the expression is entered when the variable is assigned the first specified <value>, the second specified <value>, and so on.

- The function is a linear algebra expression.

Syntax 1: sequence ({<value>, <value>, ...} [,<variable>] [)]

- A default variable of X is used when specification of a variable is skipped.

Example **To obtain the expression when 1 through 4 is {23, 30, 37, 45}**

F6 (▷) F4 (PTS▶) F1 (sequ)
SHIFT { 2 3 , 3 0 , 3 7 ,
4 5 SHIFT } , ALPHA N EXE

$$\frac{N^3}{6} - N^2 + \frac{53N}{6} + 15$$

- If List 1 = {23, 30, 37, 45}, the same result can be obtained by inputting the following: sequence(List 1, N).

Syntax 2: sequence ({<value>, <value>, ...},{<value>, <value>, ...} [,<variable>] [)]

The values input with this syntax are handled as lists, with the first value of the first list paired with the first value of the second list, the second value with the second value, and so on. This syntax creates a function using this relationship.

Example **To obtain an expression for variable values {2, 4, 6, 8} and expression values {23, 30, 37, 44}**

F6 (▷) F4 (PTS▶) F1 (sequ)
SHIFT { 2 , 4 , 6 , 8
SHIFT } , SHIFT { 2 3 , 3 0
, 3 7 , 4 4 SHIFT } ,
ALPHA N EXE

$$\frac{7N}{2} + 16$$

- If List 1 = {2, 4, 6, 8} and List 2 = {23, 30, 37, 44}, the same result can be obtained by inputting the following: sequence(List 1, List 2, N).

●Sum of Sequence —— (smSq)

This command obtains a function that expresses the sum up to the *n*th term of a sequence of numbers.

- The function is a linear algebra expression.

Syntax: sumSeq ({<value>, <value>, ...} [,<variable>] [])

- A default variable of X is used when specification of a variable is skipped.

Example **To obtain an expression that expresses the sum up to the *n*th term when terms 1 through 4 are the following sequence of values: {23, 30, 37, 45}**

F6 (▷) F4 (PTS▶) F2 (smSq)
SHIFT { 2 3 , 3 0 , 3 7 , 4 5 SHIFT } , ALPHA N EXE

$$\frac{N^4}{24} - \frac{N^3}{4} + \frac{95N^2}{24} + \frac{77N}{4}$$

- If List 1 = {23, 30, 37, 45}, the same result can be obtained by inputting the following: sumSeq(List 1, N).

●Complex Exponential-to-Trigonometric Transformation —— (expTo)

This command transforms an exponential function whose exponent includes an imaginary number to a trigonometric function.

Syntax: expToTrig (<expression>[])

Example **To transform the following function to a trigonometric function: e^{iX}**

F6 (▷) F5 (CPLX) F1 (expTo)
SHIFT e^x (F3 (i) X,θ,T) EXE

cos(X) + i • sin(X)

●Complex Trigonometric-to-Exponential Transformation —— (trgTo)

This command transforms a trigonometric function whose argument is an imaginary number to an exponential function.

Syntax: trigToExp (<expression>[])

Example **To transform the following function to an exponential function: cos iX**

F6 (▷) F5 (CPLX) F2 (trgTo)
cos (F3 (i) X,θ,T) EXE

$$\frac{e^X + \frac{1}{e^X}}{2}$$

20-4 Signum Function

The signum function described in this section is available in the ALGBR Mode.

Syntax: signum (<expression>[)]

• A solution can be obtained only when <expression> is a numeric value.

Definition:

$$signum(A) \begin{cases} 1 \text{ (real number, } A > 0) \\ \text{Undefined } (A = 0) \\ -1 \text{ (real number, } A < 0) \\ \dfrac{A}{|A|} \text{ (} A \text{ = imaginary number)} \end{cases}$$

Example **To solve signum (3.1)**

OPTN F5 (sign) 3 • 1 EXE **1**

Example **To solve signum (–4)**

OPTN F5 (sign) (–) 4 EXE **– 1**

20-5 Natural Display Notation

Most calculators use their own symbols, such as ABS for absolute values and ^ for powers, in place of standard mathematical notation. Expressions in the ALGBR Mode are displayed using "natural display notation," which uses standard mathematical notation as shown below.

Absolute Values	$\lvert A \rvert$
Powers	X^4
Fractions	$\frac{5}{3}$
Square Roots	$2\sqrt{2}$
Roots	$\sqrt[3]{X}$
Integration	$\int_{A}^{B} \sin(\cos(X))\,dx$
Differentials	$\frac{d^n}{dx^n}(X^3)$

20-6 ALGBR Mode Error Messages

A number of error messages are unique to the ALGBR Mode. The following lists the error messages and explains the meaning of each one.

- Error messages unique to the ALGBR Mode appear in the message area of the display.

● Undefined

No solution exists for the operation being performed.

Example **1/0**

● Overflow ERROR

The result of the operation being performed exceeds the range of the calculator.

Example **99999^99999**

● Domain ERROR

Input value is outside the domain of the operation being performed.

Example **(–4)!**

● Non-Real ERROR

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Only real numbers have been input and the result is a complex number while the set up screen's Answer Type item is specified as **"Real"**.

Example **(–1)^(1/2)**

● No Solution

No solution can be obtained using the Solve Function.

Example **solve(X^2 = –1, X), when Answer Type = "Real"**

● Ma ERROR

Attempt to use **approx** with an expression that generates an error unique to the ALGBR Mode.

Example **approx(1/0)**

● Other Errors

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Stk, Syn, Mem, Arg, and Dim errors have the same meanings as they do in the RUN Mode. See "Overflow and Errors" for details.

20-7 ALGBR Mode Precautions

- When an input expression cannot be processed any further, the expression displayed as the result of an operation will be identical to the input expression.
- It may take a considerable amount of time for a result to appear. This does not indicate malfunction.
- Note that there may be a variety of different formats that can be used to express a result. Because of this, even if the format of a result may displayed by the calculator does not match the format that you need for your purposes, it does not necessarily mean that the result is wrong.

Regardless of whether intervals are continuous or discontinuous, this calculator performs definite integral calculations by first obtaining an indefinit integral. Based on this result, it then obtains a definite integral.

$f(x)$

$F(x)$: primitive function of $f(x)$

$$\int_a^b f(x)dx = F(b) - F(a)$$